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Acquisition of output irregular orthographic representations in normal adults: An experimental study

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Abstract

Twenty normal controls without previous knowledge of French were asked to learn 12 French words that could not be written by Italian correspondence rules. After acquisition of the phonological representations, participants were presented the pictures and asked to write the corresponding words (baseline). They were then presented 3 times with the pictures and the corresponding written words. After a filled delay of 10 min, they were re-presented the pictures and asked to write the corresponding words (testing). A week later, participants were again requested to write the words (follow-up). Number of words correctly written at testing and at follow-up significantly differs from baseline, as well as number of words correctly written at testing and at follow-up. These results are discussed and it is suggested that acquisition of irregular output orthographic representations can be supported by knowledge of orthographic representations for reading and that rehabilitation of patients with damage to output orthographic representations can utilize input orthographic representations. (*JINS*, 1999, *5*, 405–412.)

Keywords: Spelling, Orthographic representations, Writing disorders, Output lexicon

INTRODUCTION

Until recently neuropsychologists have paid scant attention to writing and spelling, perhaps because spelling was considered parasitic upon speech. It was supposed that in order to write a word, one has first to access the phonology of the word and then translate the word's sounds into a string of letters (Luria, 1970). It was not until Marshall and Newcombe's seminal paper (1973) that neuropsychologists became really interested in reading and spelling disorders. A dual route model of spelling parallel to the dual route model of reading is now widely accepted. The model postulates functionally independent orthographic representations for reading (orthographic input lexicon) and for spelling (orthographic output lexicon), and two functionally independent routes to spelling, a direct or lexical route and a rule-based nonlexical route (see, for instance, McCarthy & Warrington, 1990). When confronted with a word that is not in one's spelling vocabulary, it is possible to generate the correct spelling by applying phonology-to-orthography conversion rules, unless the word has an *irregular* spelling. *Irregular* words can be written only through a lexical semantic route to spelling which relies on an established spelling vocabulary. Languages vary as to the relationship between phonology and orthography. Languages such as English, for instance, contain many irregular words which cannot be spelled through the correspondence rules because their sound and spelling do not relate to one another. Languages like Italian, on the other hand, have a more transparent orthography and the majority of the Italian words have a rule-dependent orthography.

Confirmation of the psychological reality of the lexical and nonlexical routes comes from pathology. Patients have been described with disorders of the sublexical conversion mechanisms and sparing of the lexical–semantic route, or with damage to the semantic route and sparing of the sublexical procedures. Patients in the first group have phonological dysgraphia; they are unable to spell new words and nonwords whereas writing of known words is preserved, although the dissociation is rarely total (Assal et al., 1981; Baxter & Warrington, 1983, 1985; Bub & Kertesz, 1982; Kremin, 1987; Nolan & Caramazza, 1982; Roeltgen et al., 1983; Shallice, 1981). Patients with surface dysgraphia, on

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the other hand, correctly write new words and regularly spelled words but are impaired in writing irregular words, even if previously known (Baxter & Warrington, 1987; Beauvois & Derouesne, 1981; Goodman & Caramazza, 1986; Hatfield & Patterson, 1983; Roeltgen & Heilman, 1984).

The functional components of the reading and writing lexicon are not assumed to be genetically given; it is nonetheless assumed that experience with written words and training with new words ends up with the development of cognitive mechanisms that can function independently of one another. The dual route model specifies the cognitive architecture of an adult lexical–semantic system and it is mute about how the spelling of a new word is established in the spelling vocabulary. More about acquisition should be learned by developmental disorders, but these have often been interpreted in relation to models of the adult procedures and have been attributed to selective failure of an adult component to develop appropriately. As it can easily be imagined this approach has nothing to say about *acquisition* of new orthographic representations.

Models of the *acquisition* of reading and spelling used for interpreting developmental disorders are rare and they are not very detailed. Frith's (1985) model, for instance, only describes the sequence of the different stages of the learning process where each stage is identified with the adoption of a new strategy. The first stage is the logographic one: the child first acquires a small reading sight vocabulary (based on a look-and-say strategy) and then learns to write a few of these words by a holistic strategy. At Stage 2, spelling precedes reading and the child learns to use an alphabetic strategy. The final orthographic stage, Stage 3, is again characterized by a whole-word strategy. Reading reaches this stage before spelling; when orthographic representations are precise enough to be useful for spelling "it is plausible to assume that they would then be 'transferred' to the spelling output system" (Frith, 1985; p. 311). The model does not specify how this transfer takes place; whether, for instance, it occurs automatically or whether the child needs to "practice" each new orthographic representation. A child acquiring reading and writing skills has to face a number of hurdles (how to form and decipher letters, how to convert phonemes into graphemes and *vice versa*, how to read and write any new irregular word); an adult, on the contrary, who has already acquired reading and spelling competence, is only confronted with the problem of acquisition of new representations. It is, however, conceivable that the mechanisms of acquisition of new orthographic representations are not totally different in children and in adults.

Knowledge of the possible mechanisms of acquisition of orthographic output representations in normal controls could be utilized in teaching spelling to children and in planning rehabilitation for dysgraphic patients with damage to the output orthographic representations.

In this research it was explored whether normal individuals with input orthographic knowledge of words with exceptional phonology–to–orthography correspondence can spell them correctly the first time they write them, and whether acquisition of new representations for spelling can be supported by well-established input orthographic representations.

METHODS

Research Participants

Twenty healthy right-handed volunteers (8 men and 12 women; age between 23 and 57 years; $M = 30.9$, $SD = 7.3$) participated in the study. Participants averaged 15.8 ($SD = 1.7$) years of education (range: 13–17). Each gave informed consent. Participants were required to be Italian native speakers and to have no knowledge of French. They were given a questionnaire about their having ever been in a French-speaking country or having in any way been exposed to spoken or written French. Again, only participants reporting no acquaintance with French in any way were admitted to the study.

Procedure

Twelve picturable French words [*oeil* (eye), *seau* (bucket), *bois* (log), *chaux* (lime), *coq* (cock), *renard* (fox), *noix* (nut), *cerf* (deer), *phoque* (seal), *reine* (queen), *feuille* (leaf), and *raisin* (grapes)], which could not be written correctly by using Italian phoneme–to–grapheme correspondence rules, were selected. Some of the French phonemes included in these words, for instance, correspond to different graphemes in Italian and French ($f \rightarrow ph$, $sc \rightarrow ch$) and others, such as /œ/, do not exist in Italian. Moreover, the same phoneme corresponds to two different spelling in five pairs of words (*oe*il–f*eu*ille, co*q*–pho*que*, s*eau*–ch*aux*, r*ei*ne–r*ai*sin, b*ois*–no*ix*), and two words (*renard*, *cerf*) have a different silent final grapheme.

Participants were tested individually in a silent room. The 12 pictures were presented consecutively three times in pseudorandom order to the participant and the examiner clearly said the corresponding French word. The participant was then presented with the 12 pictures and was required to point to the picture named by the examiner. If the participant pointed to an incorrect picture, the examiner pointed to the correct one while repeating the corresponding word. The procedure was continued until the participant correctly pointed to the 12 pictures three times consecutively, demonstrating acquisition of the phonological form of the words. Participants were then shown the 12 pictures consecutively and asked to write the corresponding name (baseline).

The same procedure was then followed with written stimuli: instead of saying the word the examiner showed the written stimulus and the corresponding picture three times, one at a time, in pseudorandom order; she then presented the 12 pictures and asked the participants to point to the picture corresponding to the written word. The procedure was continued until participants correctly pointed to the 12 pictures

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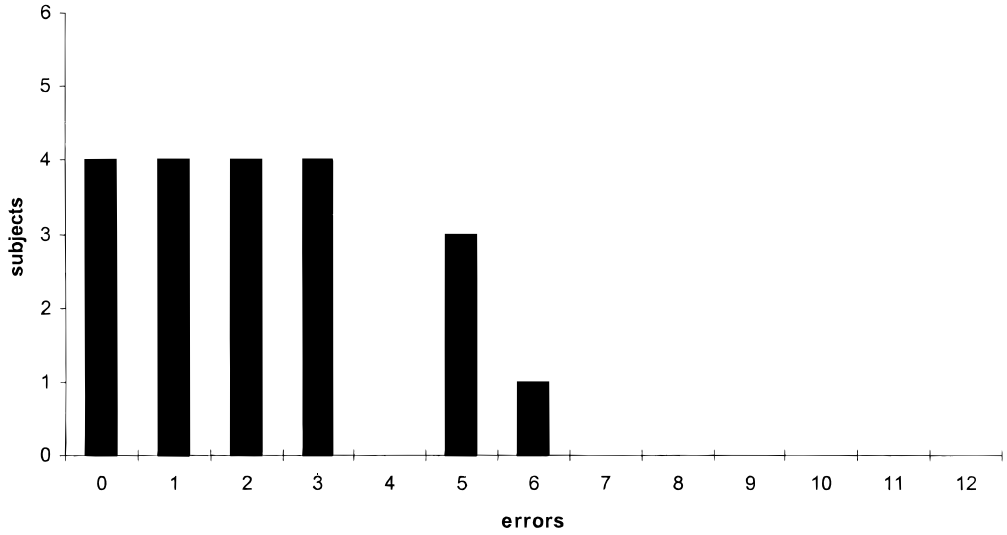

Fig. 1. Frequency distribution of the errors made by the 20 experimental participants at testing.

three times consecutively, demonstrating acquisition of the orthographic form of the word for reading.

After a filled delay of 10 min the participants were again shown the 12 pictures one at a time and were asked to write the corresponding name (testing). Participants were instructed not to correct their response; if they thought that they had made an error, they were asked to write the whole word again.

After a 1-week interval and without previous notice, participants were once again presented with the 12 pictures consecutively and asked to write the corresponding word (follow-up).

RESULTS

Table 1 reports the written responses of the 20 participants at baseline. Correct responses were comprehensibly rare ($M = 0.6$, $SD = 0.8$), participants having never seen the written form of the *irregular* words they were asked to write. Eleven participants gave no correct response, 7 participants gave one, 1 gave two, and 1 gave three correct responses. Table 2 reports the written responses of the 20 participants at testing. When participants gave more than one response, only the last was considered. The number of correct responses varies from 6 to 12. Altogether participants gave 195 correct responses ($M = 9.7$; $SD = 1.9$), they made 44 errors and 1 omission. The difference between number of correct responses at baseline and testing is significant ($t(19) = -20.13$, $p < .00005$). Figure 1 reports the frequency distribution of errors. Four participants made no errors, 12 made between one and three errors each; 3 participants made five errors and only 1 made six errors. No participant made more than six errors. Some written responses were nonwords homophone to the target words by

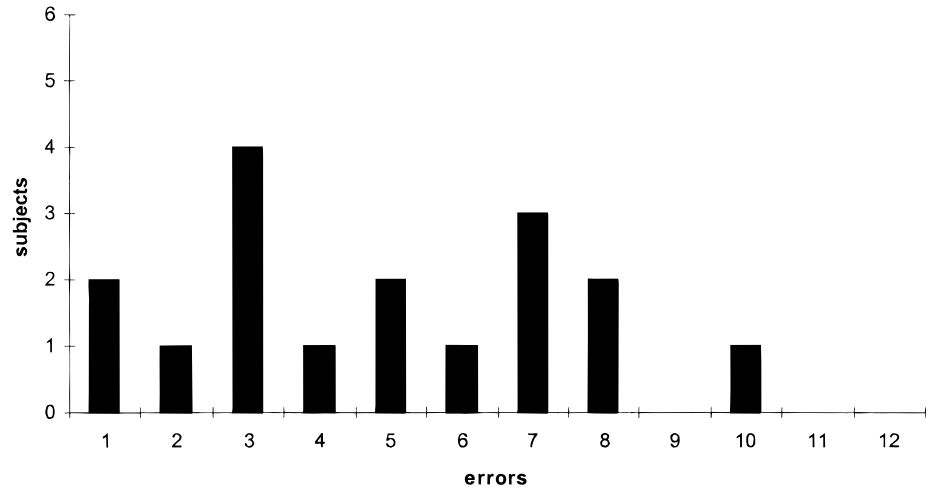

Fig. 2. Frequency distribution of the errors made by the 20 experimental participants at follow-up.

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Table 1. Written responses at baseline

	Participant										
Word	1	2	3	4	5	6	7	8	9	10	
OEIL	OI	OI	OI	OIL	OUI	OI	OUX	OUI	OIL	OIL	
SEAU	SO	SO	S…	SO	SOI	SOU	SHO	SO	SOU	SOU	
BOIS	BUA	BUAL	BUA	BUA	BOUA	BUA	+	BOI	BUA	BOUA	
CHAUX	SHOW	SCIO	SC	SHO	SCIO	CHOU	SHO	SCIO	SHO	SCIO	
COQ	COOC	COOK	COQUE	COK	COOK	COCQUE	COCH	COK	COQUE	COCH	
RENARD	RENUAN	REINAR	RE…	+	RENAR	RENAIR	RENAR	RENUAR	RAINAR	RONALD	
NOIX	NUA	NUA	NUA	NOUA	+	NUA	NOISE	NOUA	NUA	NOUA	
CERF	REUA	SEIN	…	SER	SER	SEER	SER	CERVE	SEER	SEER	
PHOQUE	FOC	FOK	FOQUE	FOK	FOCK	FOOC	FOOK	FOQUE	FOOC	FOCH	
REINE	RENUAN	REEN	REEN	REN	REEN	REIN	REN	RENUAR	REGINE	REER	
FEUILLE	FOI	FOIL	FOIEN	FEAU	FOI	FOI	FOIS	FOI	FOIL	FOIL	
RAISIN	RESEEN	RECINE	RESEN	RECEN	RENAN	RESAN	RENAN	…	+	ROSER	
Correct responses	0	0	0	1	1	0	1	0	1	0	
	Participant										
Word	11	12	13	14	15	16	17	18	19	20	Total
OEIL	OUI	EAUI	OUILLE	OUI	OUX	OI	OI	EOU	…	EOUI	
SEAU	SOI	REEN	SAUX	SHO	SOT	SO	SEC	SOU	SO	CIO	
BOIS	BUA	BUA’	BOIX	BUA’	BOUE	+	+	BAU	BOIRE	BOI	
CHAUX	SHOI	SHER	CHOUX	SHO	CHOUX	SHO	SCIO’	SCIOU	SCO	SHIOU	
COQ	COOK	COQUE	COQUE	COCH	COCQUE	COCK	COCQUE	COCH	COCH	COCK	
RENARD	RENAR	RENAR	RAINARD	RENUARD	RENOIR	+	+	RENAR	RENAR	RENARD	
NOIX	NOUI	NOUE	+	NUAR	+	NOIS	NOISE	NOUA	NOISE	NOICE	
CERF	SER	SEER	CERVE	SER	SERAT	SEER	SEER	SER	CERVE	CERVE	
PHOQUE	FOOC	FOQUE	FOQUE	FOC	FOQUE	FOCK	FOC	FOOC	FOOK	FOC	
REINE	REEIN	REN	REENE	REEN	REEN	REEN	REGINE	REEGEN	REHEN	REGINE	
FEUILLE	FOI	FEAUI	FOUILLE	FOI	FOEU	FOIS	+	FOI	FOI	FEULE	
RAISIN	+	RENAIR	RAISEN	RESEN	RESAN	RENAN	…	REGUARD	RESEG	RESEN	
Correct responses	1	0	1	0	1	2	3	0	0	0	12

… = omission.

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Table 2. Written responses at testing

	Participant										
Word	1	2	3	4	5	6	7	8	9	10	
OEIL	+	+	+	+	+	+	+	+	+	+	
SEAU	SAUC	SOAU	+	+	SAOUX	+	+	+	+	SEAIN	
BOIS	BUOI	+	+	BOIX	+	+	+	+	BOUA	BO…	
CHAUX	+	+	CHEAUX	CHEAU	CHAX	CHEAUX	+	+	+	+	
COQ	COQUE	+	+	+	+	+	+	+	+	+	
RENARD	+	REINAR	+	+	+	+	+	RENOIRD	+	RONALD	
NOIX	+	+	+	+	+	+	+	NOX	+	+	
CERF	+	+	+	CHERF	CARF	+	+	+	+	+	
PHOQUE	+	+	PHOCQ	+	+	+	+	+	+	+	
REINE	+	+	+	RAINE	+	+	+	REIN	+	+	
FEUILLE	FOUILLE	FOILE	+	FAUILLE	PHOILLE	+	FOEUILLE	FEILLE	FOULEIL	+	
RAISIN	RISEIN	+	+	RAISEN	REZIENNE	RAISINE	+	RAINSE	RASENNE	+	
Correct responses	7	9	10	6	7	10	11	7	9	9	
	Participant										
Word	11	12	13	14	15	16	17	18	19	20	Total
	+	+	+	+	+	+	OIL	+	+	+	
	+	+	+	+	+	+	SEC	+	+	+	
BOIS	+	+	+	+	+	+	+	+	+	+	
	+	CHEAUX	+	+	+	+	+	+	+	+	
	+	+	+	+	+	+	+	+	+	+	
	+	+	+	+	+	+	+	+	RENAIR	+	
	+	+	+	+	+	+	+	+	+	+	
	+	CERV	+	+	+	+	+	+	+	+	
	+	+	+	+	FOQUE	+	+	+	+	+	
	+	+	+	+	+	+	+	+	+	+	
	+	+	+	FUILLE	+	+	+	+	FEAUILLE	+	
RAISIN	+	+	+	+	+	RAISEN	…	+	+	+	
Correct responses	12	10	12	11	11	11	9	12	10	12	195

… = omission.

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Table 3. Written responses at follow-up

	Participant										
Word	1	2	3	4	5	6	7	8	9	10	
OEIL	+	+	+	…	+	+	OIEUX	OIEL	+	+	
SEAU	SAUX	SAUP	SEAL	+	…	CEAU	+	+	…	SOU	
BOIS	+	BAUX	+	BOIX	+	+	+	VOAL	BUIT	BOUA	
CHAUX	SAUCH	…	+	CHEAU	…	+	+	+	+	+	
COQ	COQUE	+	+	+	COKE	+	COCQ	+	+	COC	
RENARD	+	RAINAUD	+	+	REINARD	+	+	REIEN	RENAIRD	RONALD	
NOIX	+	+	NOIS	NOISE	NOIS	NOI	+	NOX	+	NOQUE	
CERF	+	+	+	CHERF	CHERF	CERV	+	+	CERT	CER…	
PHOQUE	+	PHOQ	PHOUQUE	+	PHOKE	+	+	PHOQE	+	+	
REINE	+	+	+	+	REIGNE	+	+	RAIN	REIENNE	+	
FEUILLE	FUOILLE	FOEIL	FEILLE	+	FOILLE	+	FOIULLE	FOUILLE	FOEILLE	+	
RAISIN	RAISEINE	RAISEN	RAISINE	RAISEN	REIZENNE	+	+	RAINSES	…	RAISEN	
Correct responses	7	5	7	6	2	9	9	4	5	5	
	Participant										
Word	11	12	13	14	15	16	17	18	19	20	Total
	OUI	+	+	+	+	+	+	+	OIE	OUEIL	
	+	+	+	SEAH	+	+	SEC	SOU	C…	+	
	+	+	+	+	+	+	+	+	BOISE	+	
	+	+	+	+	+	+	+	+	C…	+	
	+	+	+	+	+	+	+	+	+	COCQ	
	+	+	+	REINARD	+	+	REINARD	+	R…	+	
	+	+	+	+	+	+	+	+	+	NOIS	
	+	+	+	+	+	+	+	CHERF	+	+	
	+	+	+	+	+	+	+	+	FOQUE	+	
	+	+	+	RIENNE	+	+	+	+	+	+	
	+	+	+	FUELLE	+	+	+	+	FOILLE	+	
RAISIN	+	+	+	+	+	RAISEN	RAICIN	+	RAISIGE	+	
Correct responses	11	12	12	8	12	11	9	10	4	9	157

… = omission.

French correspondence rules (*boix*, *boua*, *cheaux*, *cheau*, *cerv*, *coque*, *phocq*, *foque*, *raine*, *raisen*), and in many cases some correct letters were present (at testing, the double 'll' in *feuille*, for instance, was present in seven of nine incorrectly spelled responses; Table 2).

Self-corrections were rare: 5 participants corrected themselves once (in 2 cases the second response was correct: *sau* → *seau*, *poque* → *phoque*) and 1 participant corrected himself twice.

A week later, participants were once again asked to write the names of the 12 pictures. Table 3 reports their responses and Figure 2 reports the frequency distribution of errors. Compared with their previous results, the participants showed mean forgetting of 1.9 ($SD = 2.1$; M correct responses = 7.8, $SD = 3.0$). The difference between number of correct responses at testing and follow-up ($t(19) = 3.95$, $p < .0005$), and between baseline and follow-up ($t(19) = -11.04$, $p < .00005$) was significant.

DISCUSSION

In most writing systems and particularly in deep orthographies, like English for instance, reading seems to be an easier task than spelling. A reason for this can be that there are generally more possible spellings than possible readings for many words. In French, for instance, the phoneme /o/ can be rendered by O, AU, EAU, AUX, among others. In children, acquisition of reading is frequently in advance compared to spelling; in adults, the input orthographic lexicon is richer than the output orthographic lexicon, that is, adults can sometimes read words they cannot spell.

Our data suggests that knowledge of orthographic representations for reading can support correct spelling of irregular words the first time they are spelled. This does not mean that input orthographic representations are *transferred* to the spelling output system, as suggested by Frith (1985). By definition, if the orthographic output lexicon consists of established representations of known words only, new irregular words are not represented in the spelling output system and cannot be spelled lexically. It is however conceivable that, if input orthographic representations are well established, people can conjure up the mental visual image of the written word and *copy* it from the visual buffer (Farah, 1984) by applying grapheme–to–grapheme conversion rules. Once the word is written, they can check whether or not it corresponds to the mental image and, in case, correct it. Number of correct responses varied widely among individuals, which can be due to differences in knowledge of the orthographic representation for reading or to their different capacity to conjure up and use visual images.

The same strategy—copying from a visual buffer—can also have been used by our participants when asked to spell the same words 1 week later. However, the great majority of the correct responses (147 of 157) had been correctly written the first time, and only 10 words that had been incorrectly written the first time were now correct. Although we cannot be certain about how words were spelled, we cannot exclude that output orthographic representations had been acquired and that words were at that time lexically spelled.

Rehabilitation of a few cases of acquired writing disorders appears to have implicitly relied on the possibility to use input orthographic representations to sustain output orthographic representations. C.C.M., for instance, a surface dysgraphic (Behrmann & Herdan, 1987), was asked to select the correct written form of a word from several alternatives. Hillis and Caramazza (1994) discuss the rationale of the therapeutic choice and state that "it is far from obvious to us that simple exposure to the written word (. . .) should have any effect at the level of the orthographic output lexicon" (p. 476), but we think that our data speak in favor of this hypothesis. In other words, we suggest that input orthographic representations can support rapid acquisition of output orthographic representations, and that this mechanism can be advantageously used in rehabilitation of patients with phonological dysgraphia.

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