The 12321 model of Dutch spelling acquisition

Anneke Neijt, Mijntje Peters and Johan Zuidema
Radboud University Nijmegen

We propose that Dutch children acquire and use knowledge of Dutch spelling through a series of stages we call the 12321 model. At first, a single phase for the mapping of speech onto writing suffices, but in later stages of instruction, two or three mapping phases are needed. This is one aspect of our hypothesis about spelling development. The other aspect relates to experience, which allows for storage of the mapping relation between larger parts of speech and concomitant larger strings of letters. As a consequence, the necessary number of mapping phases for words or parts of words that are frequently used decreases from three to two, and ultimately to one once more — hence the name 12321 model.

Keywords: models of writing, spelling acquisition, Dutch orthography, storage, computation

1. Introduction

Normal practice in Dutch primary schools suggests that children acquiring the difficult skill of alphabetic writing pass through a number of separate stages to be described below, each characterised by a specific set of mapping phases between speech and letters. On this basis we propose that they start out with a simplified image of the relation between speech and letters and build more complex models along the way, to end up with a model that on the face of it seems as simple as the initial one. This is the hypothesis embodied in what we call the 12321 model.

2. From speech to segments

Categorization is an essential characteristic of human language. Even though the speech stream is continuous and gradual, we learn early on to distinguish meaningful elements and to recombine these into new expressions. On the face of it, it

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ought also to be quite easy to learn to write alphabetically — one merely needs to become aware of phonemic segments. Such segments are the result of synchronization of articulatory movements and presumably also of how perception of speech forms proceeds, as explained by Nooteboom (2007: 139; cf. also Ohala 1992):

> The origin of our skill of alphabetic writing is the inherent segmentability of speech. This segmentability stems from the synchronization of different articulatory gestures during pronunciation, which in its turn may be a function of both the production system, preferring to let different articulatory gestures be "in phase" with each other, and the perception system, preferring optimally discriminable sound forms.

In reality, however, learning to write is notoriously difficult. Our tentative explanation runs as follows. The smallest segments of the speech stream, phonemes, or even the phonological features that indicate articulation instructions, are relevant to infants in their babbling stage, when they train the perception and production of their mother tongue on the basis of syllables or words that differ from one another in just one relevant aspect, such as *pa* and *ta* or *opa* and *oma.* Later on children gain the capacity to process language via larger units, which gives them the speed of fluent speakers. This fluency comes at a cost — the capability to distinguish forms of lesser importance is lost (Werker & Tees 1984). In our view, phoneme-sized segments are among these forms of lesser importance in speech, until it turns out much later that such segments are needed to learn an alphabetic writing system. And herein lies the answer to the question why learning to write is so difficult.

By the time children typically begin to learn to spell, they already use units larger than phonological segments to produce and perceive speech. These are words, which represent meaning, and syllables, which serve to express prosodic differences that in turn carry meaning. Speech segment differences such as between *pa* and *ma* are used of course, but the distinction is one between words, not between segments. And although segments smaller than syllables are needed for special purposes like rhyme and alliteration, these are not central to everyday language use. Alphabetic writing, on the other hand, is an everyday skill that requires a fully-fledged awareness of phonemic segments during all stages of acquisition.

This line of reasoning, if correct, suggests that it might be easier to learn to spell if storing knowledge of letters began right when children are busy learning to articulate sounds, so at the babbling stage, rather than when they become capable of manipulating a pen. Here we develop a hypothesis about what happens when children acquire knowledge of Dutch orthography at the customary later stage of development.

3. The single-phase model of alphabetic and phonemic awareness

In the Netherlands, common wisdom holds that one should not start spelling instruction too early (Kraak 2006: 37–39). Some aspects of alphabetic awareness are learned at kindergarten, but systematic obligatory spelling instruction starts when a child enters primary school (group 3) at age 6. During the first stage, spelling lessons involve only words that are written according to pronunciation and contain only sounds that are easy to spell, of the kind exemplified in Table 1. As the single-phase model of Figure 1 shows, there is no need yet to distinguish between graphemes (mono- or digraphs) and phonemes, since these are related to each other in one-to-one mappings. The close connection between speech and letters, an essential aspect of any alphabetic writing system, is paramount at this stage: graphemes are identical to phonemes.

Notice that learning to spell starts with reading. Children first acquire knowledge of graphemes (the letters and letter clusters available), their visual forms and the order of letters. Notice also that the phonological skill called phoneme awareness is derived from knowledge of graphemes, not the other way around, since the available graphemes determine which sounds to select from speech, and thus which phonemes are available. This aspect of spelling acquisition is nicely illustrated by Dickie (2009: 534): "the tendency to conceive of the English word *cat* as consisting of three 'sounds' (k, a, t) is supported or licensed by English speakers'

Table 1. The kind of words used in the initial stage of spelling instruction

Phoneme	Grapheme	Example
/ɑ/	**a**	**a**l, pak
/a/	**aa**	**aa**p, t**aa**k
/p/	**p**	**p**ot, loo**p**
/s/	**s**	**s**op, roo**s**

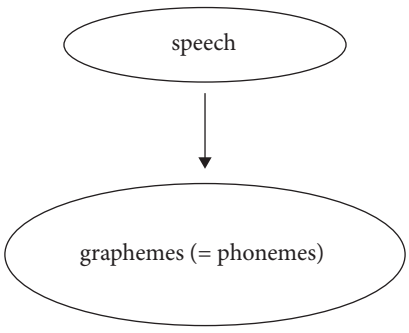

Figure 1. The single-phase model representing initial knowledge of orthography.

familiarity with the convention that this word is spelled with three letters, since from a strictly sound-based counting perspective this word could equally be broken into only two sounds (k, at) or as many as five (k, h, a, t, h)". The set of graphemes (digraphs included) available for a given language thus determines the set of phonemes (cf. also Kraak 2006).

In Dutch, certain segments of speech are represented by two letters: /a/ and /o/ are *aa* and *oo* in order to distinguish them from /ɑ/ and /ɔ/ which are written *a* and *o*. Children are taught that the logic behind doubling /a/ and /o/ is that these are 'longer' than /ɑ/ and /ɔ/. Training includes orally lengthening of words such as *taaaaaak* 'task' and *boooooom* 'tree' to drive home the contrast with *tak* 'branch' and *bom* 'bomb'. Spelling instruction thus reinforces the idea that sounds and letters are similar.

Spelling acquisition is fast at this stage. The most difficult aspect, no doubt, is to get the mapping right of speech onto graphemes, since several partly overlapping many-to-one relations need to be distinguished. The articulation of *strek* 'stretch', for instance, closely resembles that of *strik* 'bow'. Instruction succeeds because of its systematic character, through careful selection of words that are easiest to recognize. Acquisition of the set of easy to learn phoneme-grapheme pairs exemplified by these words paves the way for the more complex mappings yet to come.

4. Morphological and orthographic awareness

Monosyllabic Dutch words are quite often easier to spell than disyllabic words, not only because of the difference in length. The examples in Table 2 illustrate two features of words with more than one syllable that make spelling them more difficult.

According to the rules acquired at the initial stage represented in Table 1, one should write **papaa* and **mamaa*, but the standard spelling of these words is *papa* and *mama* (though Dutch pronunciation would allow *pappa* and *mamma* as written

Table 2. Illustration of the spelling characteristics of words with more than one syllable. The spelling expected on the basis of the earliest stage of spelling acquisition (typical children's errors such as **maa* and **visju*) differs from the actual orthography.

phonetic form	expected	actual orthography	remarks
mɑma	**mamaa*	*mama*	'mom, dad, grandpa, grandma'; vowel letter de-gemination in open syllables.
pɑpa	**papaa*	*papa*	
opa	**oopaa*	*opa*	
oma	**oomaa*	*oma*	
mʏtsə	**mutsun*	*mutsen*	plural and diminutive forms of *muts* 'hat' and *vis* 'fish'.
vɪsjə	**visju*	*visje*	

forms as well). Similarly it is not **oopaa* and **oomaa*, but *opa* and *oma*. The final letter *a* in all four words and the *o*'s in *opa* and *oma* show that /a/ and /o/ are sometimes written with a single *a* or *o*, as if they represented /ɑ/ and /ɔ/. Furthermore, the letter *e* is used instead of expected *u* in certain contexts, a fact which children are quick to catch on to, replacing **mutsun* and **visju* by *mutsen* and *visje*. It is their first confrontation with the element schwa, the most frequent vowel of Dutch.

Although only discriminated by roundness from the vowel /ʏ/, written as *u* in Dutch, the default spelling of schwa is *e*. Disyllabic words in Dutch quite often contain morphemes or morpheme-like elements that contain such a schwa: *be-, ge-, ver-, te-, -en, -er, -el, -je, -tje, -pje, -etje, -de* and *-te*. Also, the highly frequent determiner /də/ is spelled *de* 'the'. These two features of Dutch orthography may help children to establish this unexpected relation between schwa and the letter *e*. Conversely, recognizing that in certain well-defined strings of letters the letter *e* represents /ə/ presumably forms the onset of morpheme awareness. They realize that the spelling system of Dutch is not only based on phonemes (phoneme awareness), but also on morphemes. At this stage, Dutch spelling can still be represented by a single-phase model like that of Figure 1a, since one is explicitly trained to learn the mapping of specific morphemes to letter clusters by heart. Two routes are now available simultaneously, which call for integration of the information processed via these routes (cf. Christiansen & Monaghan 2006 or St. Clair et al. 2009 for syntactic studies showing that integration of information of different kinds makes parsing more successful).

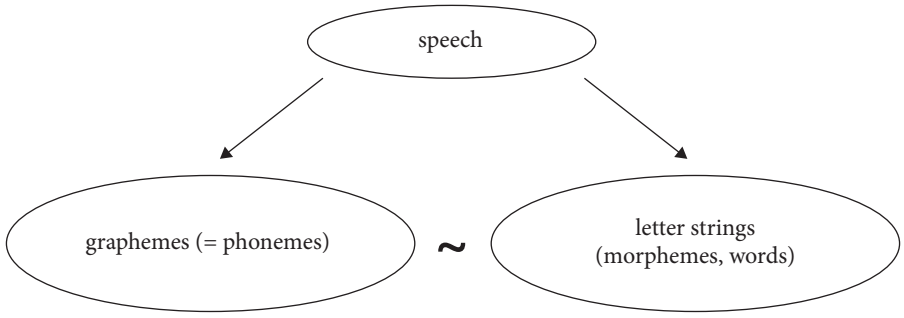

Figure 1a. Extended single-phase model. Meaningful speech fragments (morphemes or words) are mapped onto letter strings, which are stored. This applies to frequent words and morphemes.The tilde indicates the possibility of integration of the outputs.

5. From a single-phase model to a two-phase model

Most children get their first inkling that letters and phonemes are not exactly the same things from learning to identify the two letters *oe* with /u/ and *ie* with /i/.

Seeing schwa written as *e* adds another mismatch: now *e* represents two separate speech segments, /ɛ/ and /ə/. Although at this point the extended single-phase model is still tenable, albeit barely, it breaks down hopelessly when words like *hond* 'dog' enter the stage. Such words illustrate the effect of the Morphological Principle of Dutch spelling, which demands the graphematic constancy of morphemes in the face of variations in pronunciation.

The Dutch word *hond* ends in the letter *d* regardless of the fact that it is pronounced [hɔnt]. The reason lies in the plural form *honden*, pronounced [hɔndən]. Due to the Morphological Principle, the devoicing of the final /d/ in the singular form is not reflected in its written form.

The Morphological Principle does away with any illusion that there exists a complete similarity between phonemes and graphemes. A two-phase model like that of Figure 2 is needed to represent how they are related.

Following up on alphabetic awareness, phoneme awareness and morpheme awareness by which we characterized the earlier stages of acquisition, we might call this the stage of orthographic awareness or graphematic awareness. The term 'orthographic' suggests that learning to spell is to internalize and follow prescriptive rules, which of course holds true.

If Dutch spelling were as simple as sketched in Figure 2, a 121 model of acquisition would form a sufficient hypothesis of the whole system. Initially, learners would work with only a single mapping phase. Once the Morphological Principle came into play they would switch to a two-phase mapping system, which they used

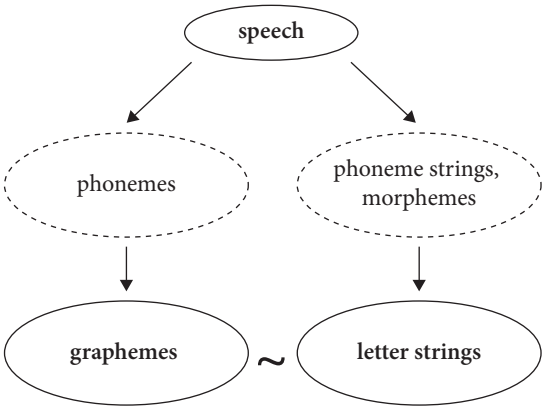

Figure 2. The two-phase model of writing, which illustrates that the spelling system is based on distinct notions for phonological and orthographical aspects of the segments of speech. In- and output representations are bold, in order to distinguish these from the abstract intermediate representations, in dashed lines, that contain systematic knowledge of phonemes, phoneme strings or morphemes. Integration of the outputs is represented by the tilde.

until they became more proficient. Then, their two-phase system would revert to the single-phase system of Figure 1a once more, as they began mapping larger strings of speech directly onto larger strings of letters, in a development analogous to that of speech itself, for the same reasons. More elaborate single-phase mapping allows for faster writing than consecutive mappings do.

6. Autonomous spelling rules

But of course, things just aren't that simple. The Dutch spelling system also comprises a set of so called 'autonomous spelling rules' — see Nunn (1998: Chapter 5) for a detailed account, Neijt (2003) for historical details about these rules and Verhoeven et al. (2006) for psycholinguistic aspects. The rules are called autonomous because they alter the string of letters without affecting the phonology of words. As Nunn (1998: 97) puts it: "it is necessary to apply the relevant rules to letter sequences rather than to sounds". The most frequently occurring examples of these rules are 'Consonant letter gemination' and 'Vowel letter de-gemination', presented in Table 3. According to the first rule, a consonant letter between vowel letters is geminated in order to prevent that a tense vowel is read where a lax one is intended (e.g. *vis+en → vissen*). The spelling rule of de-gemination entails that a vowel digraph at the end of the syllable is de-geminated (e.g. *boom+en → bomen*).

Nunn's framework is a derivational model with phoneme-to-grapheme conversion rules distinguished from the autonomous spelling rules (Nunn 1998: 42). Even though the autonomous rules take place after phoneme-to-grapheme conversion, they need to refer to a grapheme's phonemic status. For instance, although applied to letter strings and mainly guided by letter sequences, the rule of consonant letter gemination needs information about the grapheme-to-phoneme mapping of the letter *i.* When *i* represents a reduced, schwa-like vowel, like it does

Table 3. Examples of gemination and de-gemination of letters in Dutch plural forms.

Rule	**phonological form**	**orthography**	
		expected	**actual**
Consonant letter gemination — double a consonant letter if followed by the plural suffix *-en* (pronounced as schwa optionally followed by /n/) or another vowel initial suffix.	vɪs	*vis*	*vis* (fish)
	vɪsə(n)	**visen*	*vissen*
	pɑn	*pan*	*pan* (pan)
	pɑnə(n)	**panen*	*pannen*
Vowel letter de-gemination — de-geminate vowel letters in open syllables.	bom	*boom*	*boom*
	bomə(n)	**boomen*	*bomen*
	lan	*laan*	*laan*
	lanə(n)	**laanen*	*lanen*

in the plural *dommeriken* 'dunces' of *dommerik* 'dunce', a single consonant letter follows. There is no *kk* in *dommeriken*. Similarly, no gemination of letters takes place when *i* represents a tensed vowel like it does in *liter* 'litre'. The *t* does not double into *tt*. Gemination applies only if *i* represents a lax vowel. So *tikken*, the plural of *tik* 'tick' is written with geminated *kk*.

The distinction between open and closed syllables, by which we mean syllables ending in a vowel or in one or more consonants, respectively, is central to gemination and de-gemination of letters: vowel digraphs are de-geminated in open syllables and if an open syllable ends in a lax vowel, the following consonant letter is doubled in order to close it in the written representation, lest the vowel would be read as tense. Not surprisingly, lax vowels are called covered vowels ('gedekte klinkers') in Dutch, whereas tense vowels are called bare ('ongedekte klinkers').

Children learn how to manage syllables by reading hyphenated words in texts in, as the Dutch use to say, the language of Jip and Janneke, a renowned pair of characters from booklets for beginning readers by Annie M.G. Schmidt. These are texts with only simple words, in which all polysyllabic words are hyphenated. They also receive explicit instruction on how to actively identify syllables along the lines of (i)–(iii).

(i) *Orthographic syllable* — Syllables are parts of words distinguished by counting, as in dipping rhymes, by tapping or by clapping your hands. What is pronounced on a beat constitutes an orthographic syllable in writing.
(ii) *Hyphenation* — Hyphens serve to indicate the boundaries between syllables in writing.
(iii) *Open and closed orthographic syllables* — A syllable that ends in a vowel letter, e.g. followed by a hyphen or space, is called an open syllable. A syllable that ends in a consonant letter is called a closed syllable.

On the other hand, although gemination and de-gemination sometimes need information about which phoneme a vowel letter 'shadows', they largely operate on grapheme strings alone, and do so only after syllables have been identified. So they can only come into play after (phase 1) the conversion from phonemes to graphemes has taken place and syllables have been identified, and (phase 2) the results have been integrated into 'open' and 'closed' grapheme strings. And so a three-phase model emerges of the kind shown in Figure 3.

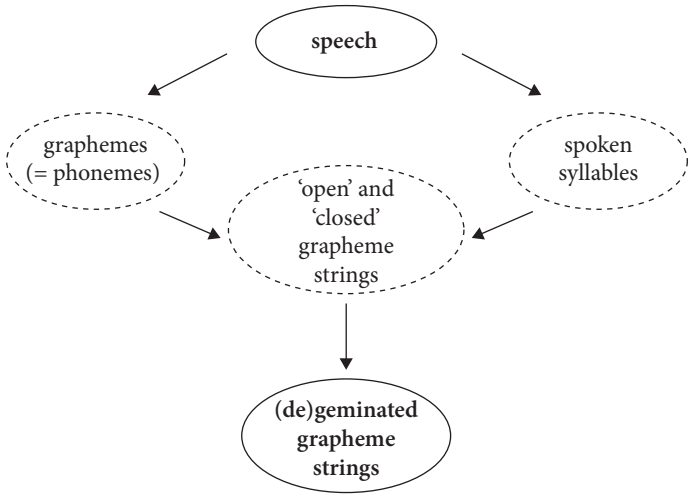

Figure 3. The three-phase model of writing Dutch. Once grapheme strings have been established they are classed as open or closed on the basis of syllabification, only then the rules of (de)gemination apply. In- and output are represented in bold and distinguished from intermediate representations in dashed lines.

More proficient writers of course will collapse the parallel phases of mapping speech onto phonemes and syllables, and use stored information about how to write open and closed syllables. Rules such as (1a) take care of de-gemination of the digraphs *aa, oo* and *uu*. (1b) describes gemination of the consonants following /a/, /ɛ/, /ɔ/ and /ʏ/. For /e/ a slightly more complex rule of de-gemination (2) is used, since *ee* is not de-geminated in morpheme final position.

(1) a. /Ca/$_{\sigma}$→*Ca*; /Co/$_{\sigma}$→*Co*; /Cy/$_{\sigma}$→*Cu*
b. /Ca/$_{\sigma}$→*CaC$_i$*; /Cɛ/$_{\sigma}$ → *CeC$_i$*; /Cɔ/$_{\sigma}$→*CoC$_{i;}$*, /Cʏ/$_{\sigma}$→*CuC$_i$*
when followed by /C$_i$ə…/$_{\sigma}$

(2) /Ce/$_{\sigma}$ → *Ce* in syllables which are not morpheme final

When proficient readers and writers have learned the set of written syllables by heart, they may revert to a model with a reduced number of mapping phases, as in Figure 4.

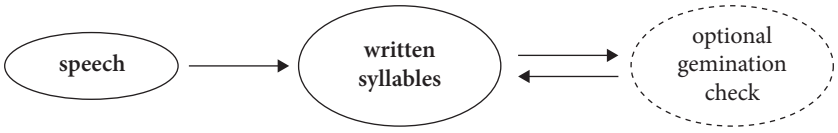

Figure 4. Storage of written syllables followed optionally by a control phase on the well-formedness of geminate letters. In- and output are represented in bold and distinguished from intermediate representations in dashed lines.

Note that condensation of the mapping relation benefits most from the recognition of syllables instead of phonemes. Writers of Dutch may use syllables instead of phonemes also because syllables are more easy to perceive than phonemes. In the end, mapping of larger strings such as syllables may be the most effective way to write Dutch.

We assume that ultimately, by the end of the acquisition process, the expert user will return to a single-phase model on the basis of stored knowledge. Once again, just like at the outset, writing involves a direct mapping of speech on written segments, only with the more elaborate repertoire of Figure 5: not just graphemes, but also orthographic syllables, morphemes, letter clusters and complete words, cf. grain size theory (Ziegler et al. 2005 and the references cited there). Thus learners go from a single-phase model to a three-phase model and back again. The main difference is that, at the final stage, the indirect, rule driven phases of the two- and three-phase models remain available for processing rare and exceptional cases.

7. Conclusion

We have presented a hypothesis about the different stages of becoming competent at technically writing Dutch on the basis of what is learned in school. The hypothesis entails that in the end, children have made the 12321 model their own, having passed through the stages of Figures 1 to 5. To them, both the storage based direct mappings of Figure 5 and the indirect (computed) mappings of Figures 2, 3 and

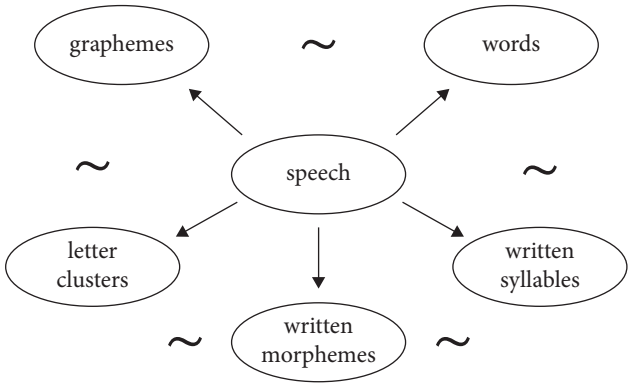

Figure 5. The final stage of spelling acquisition: direct mapping of speech onto the relevant parts of spelling. Integration of the different mappings is represented by tildes. Of course the indirect mapping phases of Figures 2, 3 and 4 remain available.

4 are available. Presumably, becoming competent at technical reading follows a similar path, from direct mapping via indirect mappings to direct mapping again.

It may be relevant to compare our hypothesis about how spelling is acquired with dual route models of reading (e.g. Coltheart et al. 1993). These distinguish a computational route via grapheme-to-phoneme rules from the route via knowledge stored in the orthographic and phonological lexicons. We think that the distinction between rule based grapheme-to-phoneme conversion and stored knowledge in the lexicon is better accounted for by the number of mapping stages in the 12321 model. Direct mapping of speech onto written words no doubt makes use of the lexicon, but the other direct routes available in Figure 5 are also based on stored knowledge, though not exclusively about meaningful elements such as morphemes or words. Hyphenation, gemination and de-gemination are rules. These lead to additional mappings, as sketched in Figures 3 and 4, which experienced users will reduce again, as sketched in Figure 5.

The dual route model of reading includes a semantic component, as does another model often discussed in the literature: the triangle model of reading and writing (e.g. van Orden et al. 1990; Bosman & van Orden 1997). The necessity to include semantic or even syntactic knowledge in a comprehensive model of Dutch orthography is illustrated by homophones such as *pijl* 'arrow' and *peil* 'level' or past tense *vergrootte* from adjectival *vergrote* 'enlarged'. Such examples show that the 12321 hypothesis needs further deepening or extension.

The hypothesis about the developmental path taken by children who learn to spell Dutch sketched above assigns a central role to speech, but we do not presume to exclude any possibility of direct connections between concepts and written words. However, we think it safe to assume that children are too busy discovering the relationships between sounds and letters to pay much attention to semantic considerations in the first phases of spelling acquisition.

Note

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Author's address

Anneke Neijt
Dept. of Dutch Language and Culture, Radboud University Nijmegen
P.O. Box 9103
6500 HD Nijmegen, The Netherlands

a.neijt@let.ru.nl