Phontasia - a Phonics Trainer for German Spelling in Primary Education

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Abstract

Dyslexia has increased manifold over the last few years and may in part be due to unstructured teaching of spelling. For the English language, decades of research have gone into the study of phonics, the systematic instruction of letter to sound connections in context, culminating in the National Reading Panel in 2000. It has affirmed that phonics is an important ingredient in standard teaching methodologies for English. No similar research has been done to such detailed degree for elementary school L1 spelling instruction in German. One reason may be that German orthographic depth is shallow compared to English. However, the high complexity of the syllabic structure in German may well warrant a closer look at specific systematic sequencing of skill instruction. While such sequencing using phonics was present in primers until the end of the 19th century, it is not present in contemporary primers. In this paper phonics categories are proposed for the German language that build on basic German word patterns in analogy to the English progression. Based on the theoretical development of the first levels an extensible mobile app prototype has been developed.

Index Terms: Orthography, Phonics, German, Text Analysis, Educational Application

1. Introduction

The National Reading Panel (NRP) in 2000 and follow-up studies [1, 2] have shown that phonics is one viable method for teaching spelling in a very systematic manner that supports all students. For many years the whole word method had taken the place of boring, mechanical phonics work that preceded this approach. The dichotomy of boring (pattern drill) and fun (being able to read little stories immediately) led to a long and emotional war in the Anglophone community. This same kind of argument can be seen in various forms for teaching of the German spelling system today. A debate was recently spawned by a rapid increase in the number of children who are diagnosed with Dyslexia [3, 4]. While some blame the intake of media, there seem to be many similarities to the situation that lead to a large number of quantitative studies, culminating in the NRP, fourteen years ago in the US. Various research in that area can be summarized to say that structure in language teaching helps all students [5, 6, 7]. A mix of methods is important, meaning there is a place for studying whole words and there is a place for looking at orthographic patterns through grapheme-phoneme translation and blending and combining these connections with context clues for decoding. Most important in systematic instruction is explicit focus and sequential steps to acquisition of well-defined skills [8]. This is especially true for weak students or second language learners, of which Germany has a significant number in schools [9].

One reason why there is little focus on skill sequences in the German language may be that German orthographic depth is shallow compared to English and easier to master [10, 11]. However, the high complexity of the syllabic structure in German may be worth a closer look at specific systematic sequencing of skill instruction. While English must focus on both grapheme and syllable structure, German is mostly based on the syllable structure [12, 13] with a few orthographic particularities, mainly focused on trigraphs and bighraphs as well as multi phoneme-multigrapheme correspondences. The phonics approach for German therefore must focus on the syllable because the orthographic principles are derived from the position of the letters/graphemes both at syllable and morpheme boundaries [14, 15].

This paper presents a systematic theoretical approach to sequencing of phonics skills for the German language. Based on the theoretical background developed here, a game was designed for the first two levels of the proposed phonics sequence. Future work will study whether working with this interactive tool will improve children’s reading and spelling skills and validate or revise the proposed sequence.

The rest of this paper is structured as follows. After a brief review of the Phonics Method in Section 2, Section 3 describes the structure of the basic German word. Section 4 proposes a list of phonics categories and their sequencing based on the structure of the German language. Sections 5 and 6 describe the resulting iPad game and some preliminary results with a case study. Section 7 gives an outlook for the work that builds on this theoretical background and the game implementation.

2. Phonics

Phonics is a method for teaching reading and writing that takes into account phoneme-grapheme correspondence as a function of the patterns in which they occur. Through minimal pairs, analogy and the study of roots, regular words in English spelling can be mastered. Phonics explicitly sensitizes students to language patterns to help them generalize orthographic skills to new words. In contrast, the whole-word method requires students to memorize words as a means of achieving correct spelling, which has its place for high-frequency and other irregular orthographies.

The Phonics method cannot be equated to the analytic-synthetic method popular in most German schoolbooks that looks at 1-1 grapheme-phoneme correspondence and does not take patterns into account [16]. In general, the Phonics method looks at a broader context to find patterns between sequences of graphemes and sequences of phonemes and their variations. Scope and sequence is part of the definition of phonics progression. Scope defines patterns that are to be mastered at a certain stage and sequence determines in which order the patterns
are to be taught. Patterns reflect certain groups of words that adhere to a given pattern. Sequence therefore sorts words by their pattern according to their complexity. After mastery of the alphabet, the first English spelling skill is usually the exchange of consonants in patterns by analogy for 1-syllable words to practice letter sound correspondence for that particular pattern. An example is *cat, hat, mat* in a CVC constellation where consonants are exchanged in the context of a following *<at>*. Starting in this manner with consonant sounds, letter sound correspondence for that particular pattern *<at>* are practiced.

The contrast between short and long vowels is usually the next important phenomena to study (*cut, cute*). This step builds on the previous skill of understanding the sound pattern relationship for exchanging consonants in rhymes. Subsequently the student is shown Diphthongs (*day, head*) and double vowels (*heat*). Consonant blends are treated explicitly and not assumed to be naturally decodable; the same holds for R-Controlled Vowels. Compound Words are also explicitly studied. Suffixes and prefixes are a topic as are their Latin and Greek roots. Thus the learner moves from letters in context to complex letter combinations before moving on to morpheme level phenomena in a well defined progression. While this progression is ubiquitous in English textbooks, this kind of empirically studied progression is neither implicitly nor explicitly included in first-grade textbooks in Germany.

In analogy to English, similar word categories can be described in German. There are some significant differences between the two languages that have to be taken into account. At the center of the German language is the 2-syllable word (*"Betten"*) instead of the 1-syllable word as in English (*"Beds"*). The next section first defines the architecture for the three types of trochee before moving on to proposing a progression for German phonics.

### 3. The German Trochee

The German language distinguishes three major classes of trochee. The trochee form has two syllables with the first one stressed and the second a reduction syllable containing a schwa *ə*. Examples of the three different forms are *"beten"* (tense vowel preceding one consonant phoneme and grapheme), *"Betten"* (lax vowel preceding single consonant phoneme and doubled grapheme), *"besten"* (lax vowel preceding two consonant phonemes and two consonant graphemes). Thus, the consonant in the center of the trochee plays a pivotal role in influencing the pronunciation and the duration of the vowel in the stressed syllable. Just as the silent <e> in English affects the preceding vowel duration in "cut" vs. "cute". These trochee forms, their 1-syllable derivative and their extensions with prefix and suffixes (*"be+gehören"*) or additions are treated explicitly (*"Be+stā.tigen"*) cover the basic non-imported German word patterns.

In the following, *C* and Δ stand for the pronunciation of a consonant and *v* and *V* stand for short/lax and long/tense vowels. The grapheme <e> in the reduction syllable occurs in several contexts denoted by the set *red* that corresponds to the various pronunciations of the following multi-graphemes: *\'e/,\'er,\'em,\'en,\'el,\'erl,\'erln*, etc.

**Type 1:** *C−v−Δ−red (b-e-t-en)*: This type of trochee is the simplest form. The 1-syllable form CVC derives directly from the 2-syllable Trochee (*gab* as past tense of *geben*). In this case, the morpheme boundary is within the Trochee. Not all CVCred will reduce to 1-syllable words, such as the word for *bird* *Vogel* if the morpheme boundary does not occur within the Trochee. Identifiable features of the stressed syllable is the tense (long) vowel (V) followed by a single consonant phoneme.

**Type 2:** *C−v−Δ−red (B-e-tten)*: The second type of trochee distinguishes itself from the first type by the vowel feature lax, perceived as shortness in this form. As in the first type, there is only one consonant phoneme in the center of the word. Laxness of the preceding vowel is denoted at the orthographic level by duplicating the central letter resulting in a new grapheme: (<t> becomes the new grapheme <tt>). Orthographically, there are regularities such as <a> or <nn>, and irregularities such as *ng*, *sch*, *ch*, *ck*, and *te*, that need to be mastered. The 1-syllable form *CvC* derives directly from the 2-syllable trochee by removing the inflectional morpheme (*Betten* plural *Bett* singular). In this case, the morpheme boundary is within the Trochee. Not all *CvCRed* will reduce to 1-syllable words, such as the word for rattle: *Rassel*. Identifiable features of the stressed syllable are the lax/short vowel (v) followed by a single consonant phoneme.

**Type 3:** *C−v−Δ−red (r-a-s-e-t-en)*: The third type has two distinct consonant phonemes and graphemes in the center of the word to help denote the laxness of the preceding vowel. The 1-syllable form *CvξΔ* derives directly from the 2-syllable trochee (*rasten* verb *Rast* noun). In his case, the morpheme boundary is within the trochee. Not all *CvξΔRed* will reduce to 1-syllable words, such as the word for Asparagus: *Spargel*. Identifiable features of the stressed syllable are the lax/short vowel (v) followed by two distinct consonant phonemes.

Figure 1 depicts the three forms and their derivation of the 1-syllable form. These forms are at the center of the word classification scheme that is described next.

### 4. Progression for German Phonics

This section proposes a progression of Phonics for German. Each step in the progression is characterized by introducing only one new concept to the already mastered orthographic rules. This is a novel approach and the theoretical derivation will have to be adjusted and validated empirically through use. For this reason, Section 5 proposes an iPad app that will eventually help collect and evaluate the success of skills acquisition given a particular progression.
The Alphabetic Principle As in English, a first step after learning the alphabet is to discover the pronunciation of various consonants in the same context ('cat' vs. 'hat') and the words' corresponding semantic change. The ability to manipulate sounds relates to phonemic awareness [17] and by itself as well as in relation to graphemes is an important sub-skill to practice and master. To achieve this same result, the minimal pairs for consonants in German can be performed on a simple 2-syllable word, for example the Type 1 trochee ("bieten", "lesen", "reden", "bieten", "Duden", "Ioben").

Basic Level: Categories of 2-Syllable trochee The trochee is the key to word segmentation in early language acquisition [18]. Many orthographic decisions are based on the 2-syllable form. For these reasons, the first levels of the German phonics progress consist of consonant and vowel minimal pair changes in simple trochee words. A choice that will need to be verified experimentally. The first sub-list of categories is directly related to the 2-syllable regular and irregular forms with and without morpheme boundaries.

Once the 2-syllable form has been mastered completely the 1-syllable form can be approached. The orthographic particulars directly derive from an understanding of the trochee patterns. For example Blatt or satt are the 1-syllable derivation of a Type 2 trochee Blätter and satter, in whose form the double <tt> grapheme can be explained. In contrast to English, single-syllable derivations are therefore treated in categories that constitute a higher skill level.

Categories of Shorter Words (1-Syllable) This list of categories consists of three different subgroups. These are 1-syllables words that are either derived from the 2-syllable trochee ("Lob", "Vieh"), prefixes that can stand alone ("vor"), or a defined set of the top 137 high frequency words that cover around 45% of any German text (listed below). Some prefixes can also have more than one syllable ("über").

Morpheme Boundaries Once the above two concepts have been mastered, the morpheme boundary can be introduced as an isolated new concept building on the solid foundation of orthography rules mastered so far. The morpheme boundary does not coincide with the syllable boundary. However, it does coincide with the red graphemic units described above: 'baden' (bad.en) vs Boden (Bo.den). By changing the red graphemic unit in minimal pairs of units, the semantics of the words can be changed at the grammatical level. It can be shown in analysis of spelling errors from grades 1-8 that students retain problems up to higher grades regarding correct transcription of grammatical endings. One cause may be that the corresponding phonemes in red are almost silent [19].

Complex Onset, Diphthong Further complexity of word structure can be achieved by moving to more complex vowels or onset consonants.

- **Complex Onset** Schlau, Stau, Spau, Schrau, Schnau with complex multi-Graphemes in the stressed syllable (Schl, Sp, St, Schr, Schn) for phoneme sequence */f l/.
- **R-Colored Vowels** Just as in English, German has r-colored vowels that are often not pronounced clearly and can lead to spelling errors. For example, Berg, Burg, harte, Starten.
- **Diphthongs** Long vowels as diphthongs, such as <ei>, <oa>. For example: 'Beine', 'Häuser', and so on.
- **Sightwords** Exceptions are made explicit. They become sight words not memorized as whole words. These are not high-frequency words as described below. Examples include unusual ways of spelling long vowels. There are around 50 words in the top 10.000 that include vowel length marked with an <i> (eh, oh, ah, uh) (ca. 50) as in Huhn. There are around another 50 words in the top list that include double vowel graphemes as notation of length (aa, ee, oo, uu), such as Boot.

Suffix and Prefix Increasingly complex words can be constructed by adding prefix and suffixes to trochees, such as 'aus-ge-treten', 'aus-ge-gessen', 'ver-drehen', or 'sport-lisch'. Students' orthography shows that there are difficulties with generalizing trochee spelling patterns to these words. It is therefore important to render this information explicit.

Imported Words Finally, imported words follow a variety of rules depending on their origin. 'Banane' (from the Spanish with a German adopted ending), 'Auto' (Greek), 'Fotografie' (Greek), 'cool' (English) and so on build a final set of words whose spelling can in part be derived based on their language origin. This kind of root analysis is taught explicitly in the phonics method.

Frequent Words High frequency words usually include one-syllable words containing less than five letters [20]; they tend to belong to conjunctions, prepositions, particles and personal pronouns as well as articles with a few non-one-syllable exceptions. Usually the words do not follow rules and are prime candidates for the whole word method. To define the categories, words are used from the German corpus study [21] as shown below.

Top 30 Words making up 31.9% of words in German text: die, der, und, in, zu, den, das, nicht, von, sie, ist, des, sich, mit, dem, dass, er, es, ein, ich, auf, so, eine, auch, als, an, nach, wie, im, für.

Next 70 Words making up 15.3% of words in German text: man, aber, aus, durch, wenn, nur, war, noch, werden, bei, hat, wir, was, wird, sein, einen, welche, sind, oder, zur, um, haben, einer, mir, über, ihm, diese, einem, ihr, uns, da, zum, kann, doch, vor, dieser, mich, ihn, du, hatte, seine, mehr, am, denn, nun, unter, sehr, selbst, schon, hier, bis, habe, ihre, dann, ihnen, seiner, alle, wieder, meine, Zeit, gegen, von, ganz, einzelnen, wo, muss, ohne, eines, können, sei.

Together, the above categories make up the various construction patterns of words in the German language. By separating them into categories, their patterns or characteristics are made explicit. The learner is able to distinguish between patterns and exceptions to be memorized or derived as patterns from other languages. The student learns how to manipulate patterns in larger word structures. The proposed list of some of the lower level phonics categories for German is given in Table 1.

5. Phontasia - Training the Trochee Phontasia is an app for the iPad and is set in the magic world of letters. The lowest levels are intended to be used by a preschool and first grade child without prerequisite of knowledge of letters. As the game is interactive, the sound of the grapheme within the given context becomes clear. There will be a number of levels that progress the learner through the sequence described in the previous section. At the moment, the levels correspond to a variety of games that promote the principle of letters in the context of Type 1 and Type 2 trochee, regardless of morpheme boundary as shown in Figures 2 and 3 respectively. Clicking are remembered as whole words, these are not high-frequency words as described below. Examples include unusual ways of spelling long vowels. There are around
position. The grapheme is therefore not acquired in isolation but only within the context of a simple trochee. Through experimenting, the user can learn the sound for a number of selected graphemes. The tubes have the colors of the rainbow. The length of the tubes represent syllable stress that decreases after the middle consonant with the unstressed last short orange tube that contains the multi-graphemes that occur in reduction syllables (see Section 3 definition of red). (Capitalization has not been taken into account at this moment.) The user of this interface will not confuse the pronunciation of the \(<e>\) in the stressed syllable with the pronunciation in the reduction syllable for the same grapheme. Likewise, the student should begin to realize the grammatical function of the grapheme-clusters in the last tube.

Minimal pairs of graphemes are practiced by changing the graphemes in each of the tubes and listening to the resulting sound of the word. The first simple graphemes are chosen based on a school book sequence of grapheme introduction. Realizing however, that few words were constructable from the inventory, the choice of first graphemes was aligned with phoneme acquisition of infants [22]. This resulted in a larger set of constructable words with a small subset of the grapheme inventory.

Level 1 is shown in Figure 2 implementing **Type 1** trochee with grapheme selection in four tubes representing the sound pattern $C V C$ red as in for example i-e-i-e. The vowels in the tubes are long vowels in Level 1. Note that the grapheme \(<i>\), which is an exception (example: ”Tiger”), does not occur in the (blue) vowel tube because the system is designed to train only regular patterns.

Level 2 is shown in Figure 3 implementing **Type 2** trochee with grapheme selection in four tubes, where the orange tube is now wider, including double graphemes representing the sound pattern $C v C$ red as in for example M-a-t-t-e. Here the vowel tube represents the short vowel. As in the first type, there is only one consonant sound in the center of the word. However, in the orthography the tenseness of the preceding vowel is denoted by duplicating the center consonant letter. The single sound of the two letters and corresponding new grapheme is denoted by connecting the bubbles together.

**Table 1: Some Word Categories and Examples.** *(MB = Morpheme Boundary denoted by |)*

<table>
<thead>
<tr>
<th>2-Syllable Words</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>$L_1$: Type 1 w/o MB</td>
<td>Vogel</td>
</tr>
<tr>
<td>$L_{12}$: Type 1 w/ MB</td>
<td>Bad[en, bieg]en</td>
</tr>
<tr>
<td>$L_2$: Type 2 w/o MB</td>
<td>Watte</td>
</tr>
<tr>
<td>$L_{22}$: Type 2 w/ MB</td>
<td>Bett[en]</td>
</tr>
<tr>
<td>$L_3$: Type 2 w/ special graphemes</td>
<td>trocken</td>
</tr>
<tr>
<td>$L_{34}$: Type 2 w/ special graphemes and morph.</td>
<td>back[en]</td>
</tr>
<tr>
<td>$L_4$: Type 3 w/o MB</td>
<td>Spargel</td>
</tr>
<tr>
<td>$L_{42}$: Type 3 w/ MB</td>
<td>tast[en]</td>
</tr>
<tr>
<td>$L_{5-8,13,16,17}$: All types</td>
<td>special characters r-colored vowels complex Onset complex Rhymes open stressed syllable</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>1-Syllable Words</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>$L_{10}$: Type 1</td>
<td>tief</td>
</tr>
<tr>
<td>$L_{11}$: Type 2,3</td>
<td>trif, Lis</td>
</tr>
<tr>
<td>$L_{15}$: Prefix</td>
<td>durch, weg, ...</td>
</tr>
<tr>
<td>$L_{18}$: High Frequency 30%</td>
<td>die, der, und</td>
</tr>
<tr>
<td>$L_{19}$: High Frequency 15%</td>
<td>man, aber, aus</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Longer Words and Imports</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>$L_8$: Prefix/Suffix</td>
<td>abgeben, sportlich</td>
</tr>
<tr>
<td>$L_{14}$: Composita and Foreign</td>
<td>Fotograph, Hausboot</td>
</tr>
</tbody>
</table>

Level 3 will eventually practice moving between the two levels as minimal pair to change tense/laxness of the vowel by adding or removing a consonant letter/grapheme in the middle.

Two games have been implemented so far. The first one, rewards students for creating a list of 5 real words with the provided graphemes at each level (trochee Types 1 and 2). By clicking on ”Bestätigen” the word is submitted for checking. Once five correct words have been submitted, the reward is a star. The second game is a word ladder. Here, the student may only change one grapheme at a time in order to create a new existing word. If it is wrong or more than one grapheme changed, the chain restarts. A full chain results in a star. The subsequent levels open up in this order:

- Obtaining five stars for Type 1 words (each star is obtained after finding 5 correct words). (see Figure 2)
- Obtaining five stars for Type 2 words (each star is obtained after finding 5 correct words) (see Figure 3)
- Obtaining 5 stars for chaining Type 1 words (each star is obtained after finding a chain of 15 real words by changing only one grapheme. With each star additional letters become available. (see Figure 4.)
- Planned: Level 3, toggling between Type 1 and Type 2 words. The game is to create as many pairs as possible by changing only consonant in the third position, including leaving it out. (ie. the $\xi$ in $C - v - \xi - \Delta - red$)

Gamification elements include cool sound effects (bubbles for moving letters), immediate feedback (listening to created words, fail sound if submitted word does not exist), rewards (stars, high-score, next level, new graphemes), fun fail (cool sound for incorrect word), and stress, making it difficult to achieve the star (the word chain is quite difficult). After each star, more graphemes are added to the tubes as a reward. Further gamification elements will be added as the interaction of the children with the tools is observed further. Only through recorded data analytics can the gamification elements be tuned properly. The advantage of these types of games is that the learners can progress at their own speed and move on to more difficult games and constructions as soon as the lower levels have been mastered. A preliminary case study is be described in the next section.

**6. Case Study - Preliminary Results**

The Phontasia prototype was used during therapy sessions by a speech therapist with one of the patients. The following is a description of the child’s situation followed by preliminary results showing qualitative and quantitative improvements.

**6.1. Diagnostic**

During the time of the study, a 6-year old boy Moritz\(^1\) is attending the last weeks of first grade. He had earlier been diagnosed with delayed speaking, which has since been successfully treated. His spontaneous speech still shows traces of devoicing consonants /b/, /d/, /g/ and fricatives /v/ and /z/. There are

\(^1\)Name changed for the purpose of this publication.
and 2. In the beginning he had difficulties that reflect his deficiencies of reading and writing described above. Very quickly, through the interaction between letters and sounds while creating words, Moritz was able to grasp the alphabetic concepts in context. More importantly, he was able to use inflectional morphemes, using conjugation and plural form endings in the last tube in order to create new words quickly. When he first started to use the app, it took 20 minutes and some frustration to earn a single star for creating five words. After three days of practice, he was able to finish four stars in Level 1 within 10 minutes.

The systematic interaction between sound and alphabet within the context of the trochee in the game improved his explicit understanding of phonemes and their usage in conjunction with letters. He was able to manipulate sounds at the beginning (stressed syllable) and end (unstressed syllable) of the 2-syllable word and figured out how to create words that rhyme. Moritz is now able to understand the difference between tense and lax (long and short) vowels. The original score for the "RAN" test of T-value 58 improved to 62.6 after the seven days elapsed. The reported improvement indicates that the skill is trainable with the app. Clearly, more data is required to study the skill acquisition and sustainability in more detail and compare it to other methods.

The qualitative feedback from the speech therapist as described above provides valuable feedback for the design. Regarding the gamification aspect, several children enjoyed working with the app. One boy in 2nd grade was so stressed by the inability to reach the star by creating the chain that he came back to play until he was able to finally finish the chain, resulting in the ultimate "fiero" moment for gamers. With respect to the theoretical sequencing, kids consistently asked to be given more letters. Additionally, the use of inflectional morphemes was grasped much earlier than expected.

The preliminary results in this case study have shown that it is very interesting to pursue the usage of Phontasia and the principles behind its design in order to see how it affects the child's skills. When looking for standardized test to show improved spelling capability of the basic word forms, it became evident that there is no standardized test for this type of skill so we expect some difficulty with proving effectiveness of the method.
7. Future Work

This kind of study about phonics is important. Today, no explicit, comprehensive and detailed concept of skills and their sequencing exists for German reading or writing instruction in any of the major school books for first grade. Clearly, much more work in this area is necessary to fully understand sequencing of steps for Phonics in German and their training effect.

A preliminary sorting was described building on basic principles of the German language and moving from simple words (trochees and their derived one-syllable forms) to more complex words (suffixes, compounds). We argued that there is a sequence analogous to the English sequencing of word complexity when making some adjustments to the structure of the German language. Following the theoretical model, a game was built to allow children to play with graphemes for the first two basic trochee structures. A first case study shows promising reactions.

This work serves as the foundation for analyzing an optimal sequencing of word groups and structures. Additionally, the presented system is the basis for research that supports dyslexic children in improving orthographic skills. Collected data can serve as a basis for validating or adjusting the presented model.

At this point no such quantitative studies in this area have been published and this work presents a significant step in the direction of studying and evaluating progression in orthography instruction.

8. Acknowledgements

Thanks go to many discussions with Christa Röber regarding the structure of the German language. This work was sponsored by Inline, Internet Online Services GmbH who owns the copyright for Phontasia.

9. References


