Exploring a Joint Approach for Analyzing Reading and Writing Errors in Dutch

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Introduction

- Reading and writing are important skills in our literate society
- Both are learned skills, that require:
  - Direct instruction [1]
  - Active practice [2]
  - Feedback
- Analyzing reading and writing errors can provide insights into the processes underlying literacy acquisition.

Introduction

This type of research is now possible:

1. Availability of **large corpora** of children's oral reading and writing data in Dutch

Reading corpora
- JASMIN (1st-6th graders, story reading) [3]
- DART (1st graders, word and story reading) [4]
- ASTLA (2nd and 3th graders, word and story reading)

Writing corpora
- BasiScript (dictations and essays) [5]

2. Language and speech technology to analyze these corpora

Research Aim
Developing a joint approach for automatic analysis of reading and writing errors in Dutch

Error Detection

Error Classification

Background

Reading and writing in Dutch

- Dutch is written using **Latin alphabet**
- Alphabetical principle: letters represent speech sounds
- Dutch is a relatively transparent language

Terminology: PCUs [6]

- Reading errors and spelling errors are recognized at **PCU-level**.
- A **Phoneme-Corresponding Unit (PCU)** is
  a sequence of graphemes that corresponds to one phoneme.

Example of PCU segmentation

school

Dutch (IPA)	s	χ	oː	ɬ
English (IPA)	s	k	u	ɬ
PCUs	**s**	**ch**	**oo**	**l**

The analysis pipeline: inputs

Writing

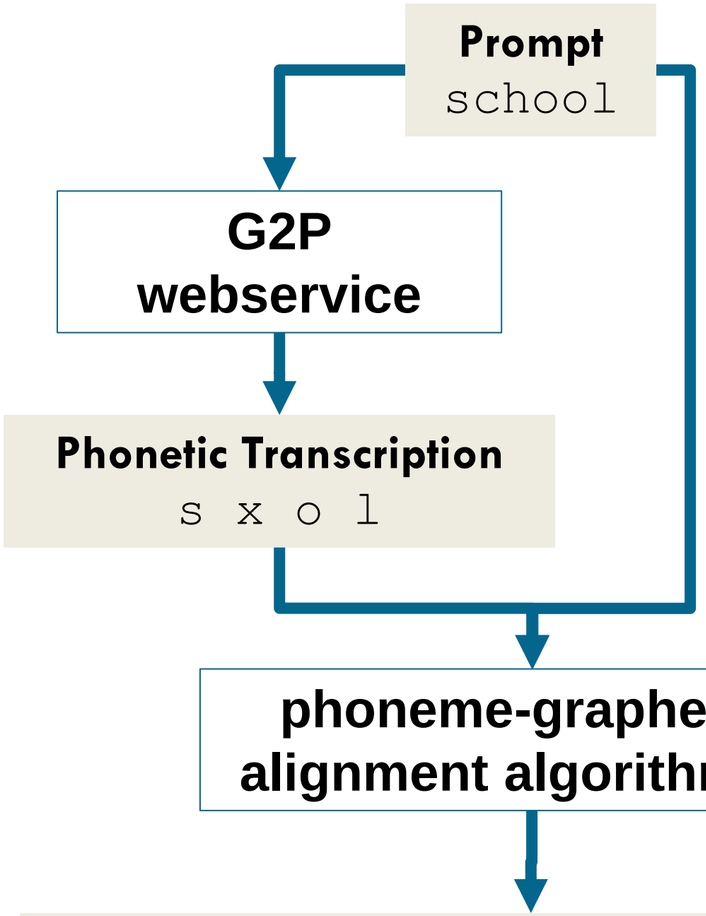
Target	Realized
school	sgool

Reading

Target	Realized
s x o l[1]	s x u l

[1]All phonetic transcriptions are written in the phonetic alphabet of the Spoken Dutch Corpus (version 2).

Step 1: Phoneme-grapheme alignment




```
target_phon      s x  o  l
target_graph     s ch oo l
```

Rule-based algorithm, contains:

All possible PCUs to write a certain phoneme:

```
phoneme   : PCUs
"a"       : ["aa", "a", "ä", "á"]
"A"       : ["a", "e", "ä", "ah"]
"b"       : ["bb", "b"]
"d"       : ["dd", "d", "t"]
…
```

Step 2: ADAGT & ADAPT

WRITING

ADAGT [7]

- Algorithm for Dynamic Alignment of ***Grapheme*** Transcriptions

```
target_graph  school
real_graph    s-gool
```

- Vowels are aligned with vowels, consonants with consonants
- Equal distance between graphemes

READING

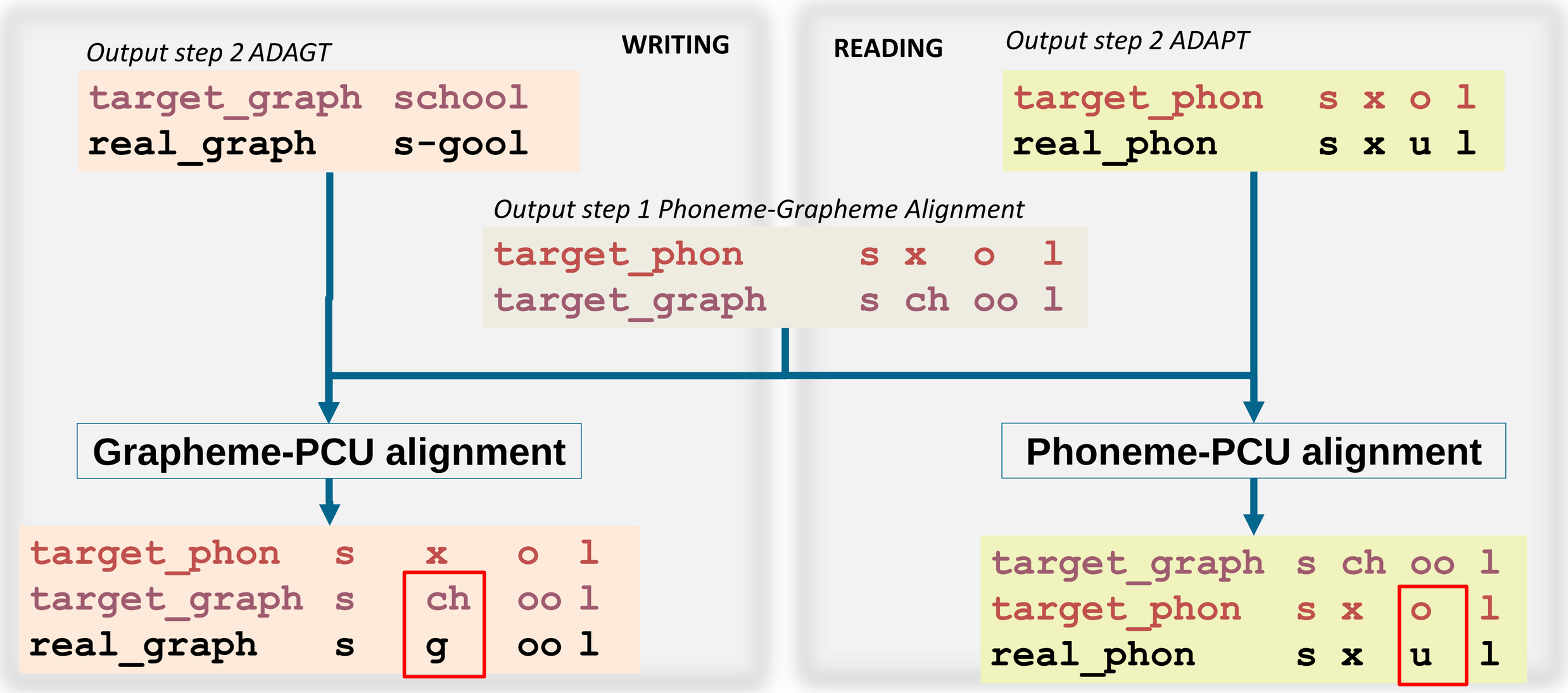
ADAPT [8]

- Algorithm for Dynamic Alignment of ***Phonetic*** Transcriptions

```
target_phon   s x o l
real_phon     s x u l
```

- Vowels are aligned with vowels, consonants with consonants
- Distance between phonemes determined by articulatory feature vectors

Step 3: Error Detection



Step 4: Error Annotation

Annotate each incorrect PCU-phoneme mapping with:

- Which PCU (spelling) or phoneme (reading) was written in the realized transcription

WRITING

target_graph	s	ch	oo	l
target_phon	s	x	o	l
real_graph	s	g	oo	l

“ch”-/x/ -> “g”
Interpretation
“ch” is written incorrectly as “g”. Both “g” and “ch” can be pronounced as /x/.

READING

target_graph	s	ch	oo	l
target_phon	s	x	o	l
real_phon	s	x	u	l

“oo”-/o/ -> /u/
Interpretation
“oo” is read incorrectly as /u/, it should be read as /o/.

Application of Algorithm

Data selection

BasiScript	Dictation words by 2nd graders
DART	Read words by 1st graders

Sound pure words

Words consisting only of primary PCU-phoneme mappings

Primary PCU-phoneme mappings

How initial readers are taught to pronounce certain PCUs at the beginning of primary school

Vowels

PCU	Phoneme
aa	/a/
a	/A/
ee	/e/
e	/E/
ei	/EI/
ij	/EI/
ie	/i/
i	/I/
oo	/o/
eu	/EU/
u	/U/
ui	/UI/
o	/O/
oe	/u/
au	/AU/
ou	/AU/
uu	/y/
u	/U/

Consonants

PCU	Phoneme
b	/b/
d	/d/
f	/f/
h	/h/
j	/j/
k	/k/
l	/l/
m	/m/
n	/n/
ng	/N/
p	/p/
r	/r/
s	/s/
t	/t/
v	/v/
w	/w/
g	/x/
ch	/x/
z	/z/

Application of Algorithm

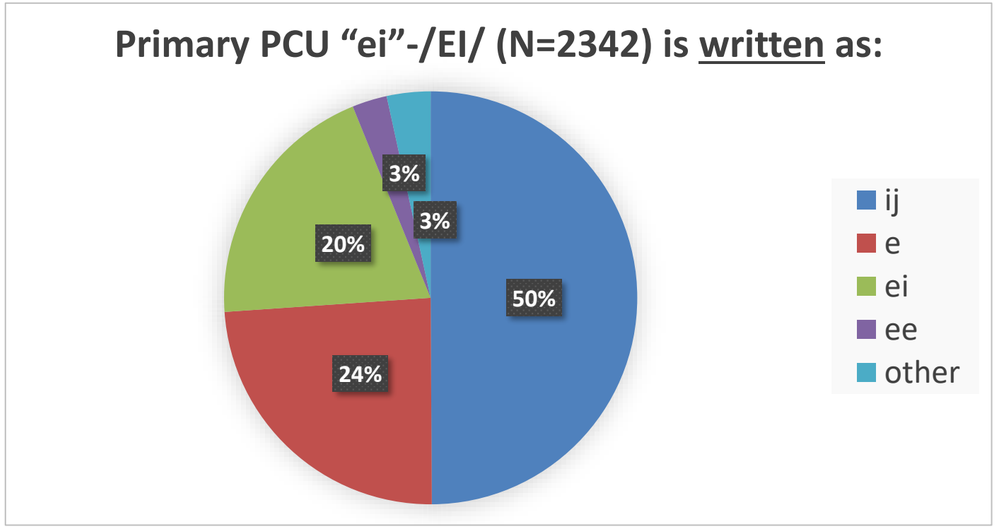
Data selection

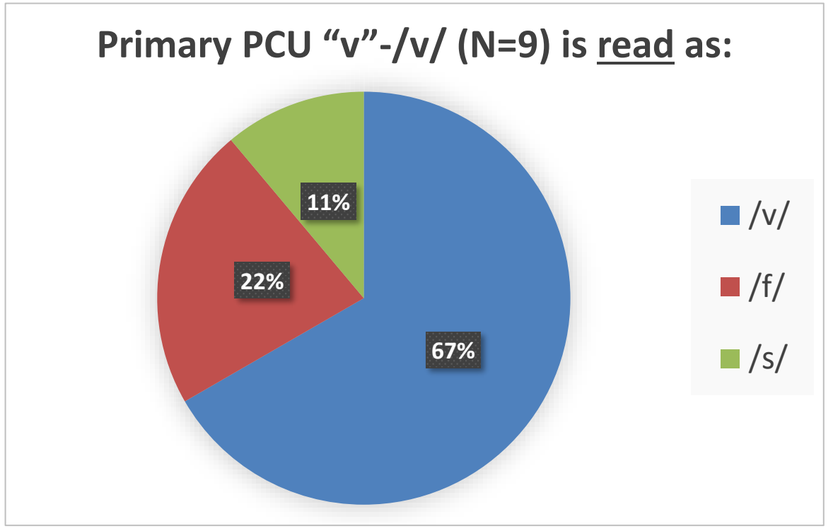
- Sound pure prompts

Corpus	Word types	Word tokens	Tokens Correct	Tokens Incorrect
BasiScript (writing)	9	21168	15323 (72%)	5845 (28%)
DART (reading)	51	323	207 (64%)	114 (36%)

Relatively most frequent incorrect PCUs:

- Spelling: ’ei’, ’eu’, ’g’, ’ij’, ’ch’
- Reading: ’v’, ’ui’, ’ng’, ’a’ , ’g’





Discussion and Conclusion

We presented a first approach for a method to automatically detect reading and spelling errors at PCU-level.

Advantages

- Reading and writing errors are comparable at target grapheme level and target phoneme level.
- Bridge between phonetic and grapheme representations in both reading and writing

Limitations

- Pronunciation variation not taken into account
- Only applicable on sound pure words, otherwise number of target PCU-phoneme mappings will explode and results will be hard to interpret.
- Multiple attempts (typical for reading) not taken into account

Future Directions

- Extent classification scheme
  - Combine current categories in a supercategory
  - Take into account more complex rules, marked by morphology, etymology, semantics
- Use ASR technology to automatically obtain phonetic transcriptions

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Questions?

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