Impact of Handwriting Training on Handwriting Fluency, Spelling and Text Quality in Primary School Children

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University of Teacher Education Lucerne (PH Luzern)
- Handwriting in Switzerland (German speaking part)
- Theoretical background
- Research questions
- Research design
- Participants
- Methods
- Results
- Discussion
1942 – 2001/2014

Deutschschweizer Basisschrift
Beginners’ Alphabet
Aa BbCc Dd Ee Ff Gg Hh Ii
Jj Kk Ll Mm Nn Oo Pp Qq
Rr Ss Tt Uu Vv Ww Xx Yy
Zz 123456789 !?

2nd grade
Manuscript letters, but...

3rd grade
Joining letters by garlands
on the baseline

Michel machte fast jeden Tag Unfug. Und davon will ich dir nun ein bisschen erzählen. Einmal feierte man...
Theoretical Background

The Not so Simple View of Writing Model
(Berninger & Winn, 1996 / 2008)

Working memory functions as a «bottle neck» in the process.
Theoretical Background

- Transcription skills have an influence on text quality

- In case of young people, handwriting training leads to longer texts with higher text quality. (Christensen 2005)

- Writing fluency and text quality of children are influenced by hitherto acquired transcriptions skills and can be improved through training. (Alves & Limpo 2015)

- The developmental process does not end with the acquisition of the letters of the alphabet. An ongoing training throughout the school time leads to better legibility and fluency of Handwriting. (Santangelo & Graham 2015)
Main Research Question

- What impact does a combined handwriting and spelling training have on the fluency of the handwriting, on the spelling and on the quality of texts produced in case of third graders?
Participants

- 175 Children in the third Grade (primary school)
- 11 classes
- German-speaking areas of Switzerland, Canton Lucerne
- Active consent
- Age 107.9 months (Mean), SD = 5.3 months
- 50.9 % females
- 89.7 % right-handers
- 26.2 % two or more languages spoken
- 11.4 % German as a second language
- 12.6 % with special needs education
- 6.3 % in psychomotor therapy

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Intervention

Preparation (6 months)
- Training of the teachers (standardized teaching units)
- Preparatory units based on the curriculum focusing on the introduction of principles how to connect the letters

Implementation
- Each group got a teacher assigned for the daily trainings
- 4x 15 minutes / week over 5 weeks
Design

**Intervention 5 weeks**
- Combined group: Handwriting & Spelling
  - N=23

**3 x 3rd Grade Classes**
- Comparison group: Handwriting
  - N=34

**4 x 3rd Grade Classes**
- Combined group: Handwriting & Spelling
  - N=28
- Comparison group: Spelling
  - N=36

**4 x 3rd Grade Classes**
- Combined group: Handwriting & Spelling
  - N=29
- Control group: Reading fluency
  - N=28

**no Intervention 5-6 weeks**
- Post-test

**Follow-up**
Intervention Groups

Combined handwriting and spelling training
- Training of the most typical connections based on garlands
- Goal: reaching a high level of automaticity and the transfer to written language

Handwriting training
- Training of the most typical connections based on garlands
- Goal: High control of initial graphomotor skills and reaching a high level of automaticity

Spelling training
- Focusing on morphemic structures

Reading fluency training
- Focusing on reading words and paragraphs faster
<table>
<thead>
<tr>
<th>Measures</th>
<th>Prompts and Tests</th>
<th>Methods of Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Handwriting fluency: automaticity, stroke frequency and pressure</td>
<td>17 Items on a digitizing WACOM-Tablet</td>
<td>Computer aided segment analysis with CSWin 2012, Mai &amp; Marquardt 2007</td>
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<tr>
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<tr>
<td>Working memory</td>
<td>AGTB 5-12 (3 components) Hasselhorn et al. 2012</td>
<td>Scoring through software</td>
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<td>Gender, handedness, spoken languages, age etc.</td>
<td>Extracts from pupils' files</td>
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Method - Measures of Fluency

NIV – Number of Inversions in Velocity (Marquardt, 2011, S.383-384)
Measure for the level of automaticity of a movement

- Instrument: Strega (CSWin - Version 2012)
Method – Items of the Handwriting Analysis

<table>
<thead>
<tr>
<th>Code: 2217-03</th>
<th>PH Luzern / Sibylle Hurschler / Werner Wicki / Péter Falmann</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name: Z217</td>
<td>Untersuchung 19.06.2016</td>
</tr>
</tbody>
</table>

### grundbewegungen

<table>
<thead>
<tr>
<th>Grundbewegungen</th>
<th>Kennwerte</th>
</tr>
</thead>
<tbody>
<tr>
<td>01. Kirzeln</td>
<td>Freq: 5.22 Hz, NV: 1.86, Drud: 0.24 N</td>
</tr>
<tr>
<td>03. Fingerbewegung</td>
<td>Freq: 3.65 Hz, NV: 1.06, Drud: 3.36 N</td>
</tr>
<tr>
<td>05. Handgelenk</td>
<td>Freq: 2.35 Hz, NV: 0.96, Drud: 1.00 N</td>
</tr>
<tr>
<td>07. Kreiseln</td>
<td>Freq: 3.60 Hz, NV: 0.96, Drud: 3.48 N</td>
</tr>
</tbody>
</table>

### Muster

<table>
<thead>
<tr>
<th>Muster</th>
<th>Kennwerte</th>
</tr>
</thead>
<tbody>
<tr>
<td>08. Gifanden</td>
<td>Freq: 4.02 Hz, NV: 1.51, Drud: 2.27 N</td>
</tr>
<tr>
<td>Silben</td>
<td>Freq: 5.95 Hz, NV: 1.98, Drud: 2.12 N</td>
</tr>
</tbody>
</table>

### Nonsens

<table>
<thead>
<tr>
<th>Nonsens</th>
<th>Kennwerte</th>
</tr>
</thead>
<tbody>
<tr>
<td>11. Sprache</td>
<td>Freq: 2.46 Hz, NV: 0.83, Drud: 1.15 N</td>
</tr>
<tr>
<td>Worte</td>
<td>Freq: 2.90 Hz, NV: 1.20, Drud: 1.76 N</td>
</tr>
</tbody>
</table>

### Dictated Sentence

<table>
<thead>
<tr>
<th>Dictated Sentence</th>
<th>Kennwerte</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wörter</td>
<td>Freq: 3.04 Hz, NV: 1.26, Drud: 1.47 N</td>
</tr>
<tr>
<td>Silben (x3)</td>
<td>Freq: 2.92 Hz, NV: 1.38, Drud: 1.24 N</td>
</tr>
</tbody>
</table>

**Double Loops**

```
le le
```

**Dictated Sentence**

```
Das war ein schöner Tag.
```

```
Die Kinder fingen nach Anweisung.
```
**Results: Tablet Measures**

**Pre-, Post- and Follow-up Tests**

**Double loops: stroke frequency**

The development is significant over time but not over the intervention groups.

---

**Table: Measures Pre-, Post- and Follow-up Tests**

<table>
<thead>
<tr>
<th>Group</th>
<th>F_{Time}</th>
<th>df</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combined handwriting and spelling training</td>
<td>41.989</td>
<td>2/171</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Handwriting training</td>
<td>1.034</td>
<td>3/171</td>
<td>n.s.</td>
</tr>
<tr>
<td>Spelling training</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reading fluency training</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- \( F_{Time} = 41.989, \ df = 2/171, \ p < 0.001 \)
- \( F_{Group} = 1.034, \ df = 3/171, \ p = \text{n.s.} \)
- \( F_{Group*Time} = 2.354, \ df = 3/171, \ p = 0.074 \)

(N=175; Mean age=107.9 m., Range = 90 – 122 m.)
Results: Tablet Measures
Pre-, Post- and Follow-up Tests

Double loops: automaticity of handwriting movements - NIV

There is a significant development over time and also a significant interaction effect between the intervention groups over time.

\[ F_{\text{Time}} = 31.214, \, \text{df} = 2/171, \, p < 0.001 \]
\[ F_{\text{Group}} = .890, \, \text{df} = 3/171, \, p = \text{n.s.} \]
\[ F_{\text{Group} \times \text{Time}} = 3.103, \, \text{df} = 3/171, \, p = 0.028 \]

(N=175; Mean age=107.9 m., Range = 90 – 122 m.)

NIV values were ln-transformed to compensate for skewedness.
Results: Tablet Measures
Pre-, Post- and Follow-up Tests

Dictated sentence: stroke frequency

There is a significant time effect yet there is no interaction effect as regards groups and time.

<table>
<thead>
<tr>
<th>Time</th>
<th>Combined handwriting and spelling training</th>
<th>Handwriting training</th>
<th>Spelling training</th>
<th>Reading fluency training</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-test</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-test</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Follow-up test</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

F_{Time} = 47.570, df = 2/171, p < 0.001
F_{Group} = 0.917, df = 3/171, p = n.s.
F_{Group*Time} = 0.213, df = 3/171, p = n.s.

(N=175; Mean age = 107.9 m., Range = 90 – 122 m.)
The development over time was significant, however none of the trainings yielded significant advantages regarding automaticity.

Results: Tablet Measures
Pre-, Post- and Follow-up Tests

Dictated sentence: automaticity of handwriting movements - NIV

<table>
<thead>
<tr>
<th>Group</th>
<th>Automaticity of handwriting movements (NIV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combined handwriting and spelling training</td>
<td></td>
</tr>
<tr>
<td>Handwriting training</td>
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</tr>
<tr>
<td>Spelling training</td>
<td></td>
</tr>
<tr>
<td>Reading fluency training</td>
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F<sub>Time</sub> = 16.508, df = 2/171, p < 0.001
F<sub>Group</sub> = 1.257 , df= 3/171, p= n.s.
F<sub>Group*Time</sub> = 0.346, df = 3/171, p = n.s.

NIV – Values transformed through $1/X^2$ to compensate for skewedness

(N=175; Mean age = 107.9 m.,
Range = 90 – 122 m.)
Results: Level of automaticity (NIV)
Pre-test (Baseline)

Comparing double loops, copied and dictated sentences regarding automaticity (NIV)
The double loops are not automatized. However, the sentences show a high level of automaticity.

Combined handwriting and spelling training
Handwriting training
Spelling training
Reading fluency training
Results: Text quality
Pre-, Post- and Follow-up Tests

Text quality (analytical score)

There are significant differences over time. The different trainings did not lead to significant differences in the quality of the texts produced by the students over time.

<table>
<thead>
<tr>
<th>Group</th>
<th>F</th>
<th>df</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combined handwriting and spelling training</td>
<td>3.209</td>
<td>2/167</td>
<td>.043</td>
</tr>
<tr>
<td>Handwriting training</td>
<td>2.234</td>
<td>3/168</td>
<td>.086</td>
</tr>
<tr>
<td>Spelling training</td>
<td>1.694</td>
<td>6/336</td>
<td>n.s.</td>
</tr>
<tr>
<td>Reading fluency training</td>
<td>1.086</td>
<td>2/167</td>
<td>n.s.</td>
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</table>

(N=175; Mean age = 107.9 m., Range = 90 – 122 m.)

The covariates in the model were calculated based on the following value: Gender = 1.49
Results: Influences on Text Quality
Follow-up Test

Hierarchical regression analysis for variables predicting text quality (Model 3)

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>SE B</th>
<th>β</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>-0.23</td>
<td>0.07</td>
<td>-0.25**</td>
</tr>
<tr>
<td>WM wordspan</td>
<td>0.15</td>
<td>0.05</td>
<td>0.20**</td>
</tr>
<tr>
<td>WM visuo-spatial sketch pad</td>
<td>0.00</td>
<td>0.03</td>
<td>0.02</td>
</tr>
<tr>
<td>VMI</td>
<td>0.02</td>
<td>0.01</td>
<td>0.09</td>
</tr>
<tr>
<td>Handwriting speed</td>
<td>0.00</td>
<td>0.00</td>
<td>0.02</td>
</tr>
<tr>
<td>NIV Composing</td>
<td>-0.35</td>
<td>0.15</td>
<td>-0.17*</td>
</tr>
<tr>
<td>Spelling</td>
<td>-0.02</td>
<td>0.00</td>
<td>-0.23**</td>
</tr>
<tr>
<td>R²</td>
<td>.20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F for change in R²</td>
<td>6.03*</td>
<td></td>
<td></td>
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*p < .05. **p < .01.
The groups with handwriting training outperformed the spelling and the reading groups regarding the automaticity of double loops from pretest to posttest. However, the differences did not persist over the follow-up period.

5 weeks might be short to solidify the differences.

Students` handwriting, regardless of the groups, showed a high level of automaticity when it came to writing sentences at the pre-test.

The training might be too late at this point of time.
Discussion: Text Quality

► Though there are significant differences over time, no interaction effects were found.

► No correlation between automaticity of texts written on the tablet and the quality of the texts written in a pen-and-paper task, but...

![Diagram showing no correlation between automaticity and text quality.](image-url)
References