LESEN DURCH SCHREIBEN – A COMPUTATIONAL INVESTIGATION

1. What is Lesen durch Schreiben?

In Swiss and German primary schools pupils traditionally acquire reading and writing abilities with the aid of a primer (Fibel) – a book in which letters are introduced one after another. Writing and reading tasks with words composed of the recently learned letters are usually presented in an alternating fashion. Needless to say, errors made in both tasks are corrected by teachers instantaneously. Reichen [1988] developed "Lesen durch Schreiben" (LdS, "reading through writing"), an alternative approach where children do not learn from primers but from a phonetic scheme (Anlautabelle, see Figure 1) instead. Rather than learning letter-by-letter, a child writes by proceeding sound-wise through words and uses the phonetic scheme to map a given sound to one or more letters. This mapping, however, is highly dependent on the context and the semantic rules of the language. As a consequence, children write very defectively (e.g. "Varat" instead of "Fahrrad", i.e. bicycle). Reichen postulated that excessive correction by teachers hampers the children's pleasure to learn how to write and read. Accordingly, neither teachers nor parents should correct any orthographic mistake during the first two years of primary school (only thereafter). Utilizing their own faulty writings children learn reading, giving birth to the method's name. Over the last decades the LdS method has become increasingly popular, but due to a lack of supporting evidence, a more and more controversial debate in Swiss and German media has arisen. A meta-analysis by Funke [2014] showed that a number of empirical studies (1990-2010) could not consistently reveal a positive or negative effect for LdS compared to primer-based methods, although LdS children seemed to be equipped with slightly weaker writing skills. The compared studies differ strongly in setup and evaluation techniques, neglect abilities in other school subjects and are sensitive to confounding variables, e.g. parents ignoring the instructions to not correct their children. Problematically, these studies are intensive in time and resources.

2. What is this project about?

Due to the aforementioned difficulties of (and in) empirical investigations, this interdisciplinary project aims to develop the first computational model of LdS, compare it to a primer-based model and answer a research question which could preliminary be formulated as:

Is it, from a statistical perspective, advantageous for a learning system to use the LdS method instead of primer-based methods to learn writing and reading?

As such, the project does not arrogate to reveal which method is better suited for humans or better to be used in schools. Borrowing techniques from Natural Language Processing allows to boil down the writing process to a phoneme-to-grapheme conversion (P2G) and the process of reading to the inverse problem (G2P). The tentative strategy is to built upon the state-of-the-art attempt for self-learning models in sequence-to-sequence learning, namely the encoding-decoding scheme [Cho et al., 2014, Sutskever et al., 2014]. We plan to develop one model for reading and one for writing, with the encoders extended by bidirectional LSTM units (enabling the system to move forward and backward through a spoken or written word) [Graves and Schmidhuber, 2005] and a decoder sharpened by an attention mechanism (allowing the system to focus dynamically only on those phonemes relevant to the generation of the next grapheme) [Bahdanau et al., 2014]. Stacking both components together yields the full model, an **auto-encoding** attention-based encoding-decoding setup with bLSTM units (see Figure 2). This model will exist in two instances, one for the LdS method and one for primer-based learning. Importantly, the instances only differ in the target signal: The LdS model accepts all "phonetically meaningful" writings while the regular model only accepts the correct spelling. The stacking is crucial in order to enable *reading* ***through*** *writing*, i.e. the LdS model will try to learn reading based on its own erroneous writings.

A first comparison of the model instances will be carried out on a canonical German corpus of the Bavarian Speech Archive [Schiel et al., 1997]. To mimic better the true learning process, a corpus with a realistic word vocabulary of children in the age of 6-10 years will be created based on ChildLex [Schroeder et al., 2015]. A third comparison will base on a self-generated corpus with text extracted from primers. The training process will be implemented by a differing target signal for the first two time units ("class years") but by the same, unique target signal for the second two time units (class years 3 and 4). Model performance will be assessed (1) by plain token and word accuracies, (2) by comparing stereotypical errors, (3) by examining whether the initial, semi-corrected learning of the LdS model may irreversibly bias grapheme representations and (4) by exploring whether the learned representations differ (e.g. by plotting embedding vectors or bLSTM hidden states of graphemes with methods like t-SNE [Maaten and Hinton, 2008]).
Pursuing pioneering work by developing the first self-learning model of LdS paves a way towards shining a theoretical perspective onto a divisive debate, which may potentially influence cognitive science, education and didactics.

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Appendix

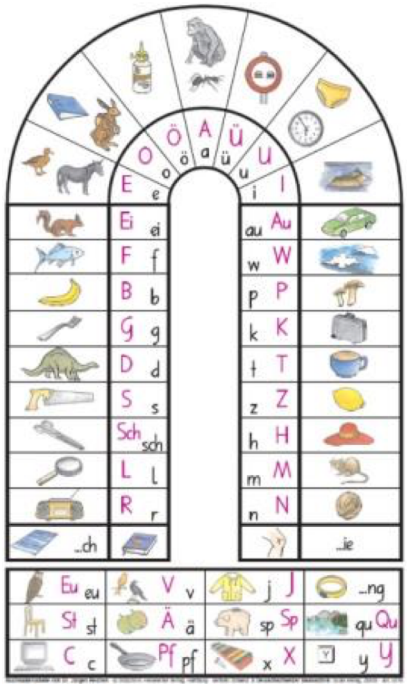

FIGURE 1. An exemplary phonetic scheme.

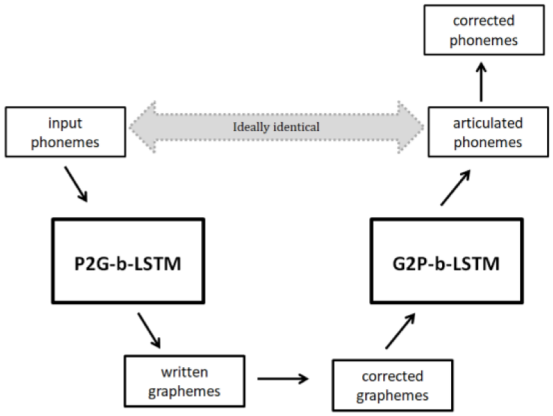

FIGURE 2. Sketch of an auto-encoding sequence-to-sequence model. Both b-LSTMs will follow an encoding-decoding scheme by themselves and the model instances will differ only in the way the graphemes are corrected.

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