NLP-based assessment of reading efficiency in early grade children

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Abstract

Assessing reading skills is a laborious and time-consuming task, which requires monitoring a variety of interlocked abilities, ranging from accurate word rendering, reading fluency and lexical access, to linguistic comprehension, and interpretation, management and inference of complex events in working memory. No existing software, to our knowledge, is able to cover and integrate reading performance monitoring, instant feedback, personalised potentiation and intelligent decision support to teachers and speech therapists, assessment of response to intervention. NLP and ICT technologies can make such an ambitious platform an achievable target.

Reading is not just the ability to assign the correct pronunciation to a sequence of written symbols making up a word (or word decoding), but the joint product of decoding and deep linguistic comprehension (Gough and Tunmer, 1986; Hoover and Gough, 1990). Effective linguistic comprehension relies on language skills such as semantic and syntactic awareness. Both decoding and linguistic comprehension are necessary for reading comprehension, and neither is by itself sufficient (Hoover and Gough, 1990). However, current protocols for reading assessment measure decoding (reading accuracy and speed) and reading comprehension separately (Cornoldi and Colpo, 2012; Shinn and Shinn, 2002; Wagner et al., 2009). This does not allow evaluation of reading efficiency (Cappa et al., 2016), defined as the ability to fully understand connected texts by minimising reading time, a cognitive ability that lies at the roots of students' academic achievement (García-Madruga et al., 2014; Speece et al., 2010).

Better support to children with reading difficulties requires substantial advances in our understanding of the basic mechanisms involved in learning to read connected texts, as well as better modelling of the dynamic interaction of these mechanisms and their impact on linguistic comprehension in natural reading conditions. All these requirements call for bigger and better data to be collected in naturalistic tasks, in different environments and through multiple modalities. Here I describe an on-going, self-funded project of the CNR Institute of Computational Linguistics in Pisa, which intends to leverage the full potential of ICT and NLP technology to put in place a ubiquitous infrastructure with a simple tablet as terminal equipment. Early graders at school can read a one or two page text displayed on a tablet touchscreen, either silently or aloud. Children are asked to slide their finger across the words as they read, to guide directional tracking. After reading, the child is prompted with a few multiple-answer questions on text content. Questions are presented on the tablet one at a time, while the text remains displayed on the screen for the child to be able to retrieve relevant information. In the process, the tablet keeps track of time-aligned multimodal data: voice recording, finger sliding time, time of reading, time of question answering, and number of correct answers. Data are recorded, stored locally, sent to a server through an internet connection, and processed remotely by a battery of cloud-based services, analysing data automatically to produce a detailed quantitative signature of each reading session. A server-based database aggregates anonymised data to make them available for specialists. Also individual's longitudinal profiles are stored, for them be queried and inspected upon authorised access.

The project will avail itself of sophisticated Natural Language Processing (NLP) techniques aimed at the automatic modelling and assessment of text complexity, with a view to providing an estimation of text readability, and the development of advanced readability measures (Collins-Thompson, 2014; Dell'Orletta et al., 2011). A children's speech recognition system (Cosi, 2015; Gerosa et al., 2007) will be able to check if a specific read word is rendered correctly, and offer an overall accuracy score for text decoding. Text annotation and formatting tools will also help teachers select and deliver text stimuli with controlled and gradually increasing levels of linguistic difficulty, thus supporting more targeted potentiation. We expect this to improve response to treatment, reduce downtime between successive intervention steps, minimise repetition of overlearned tasks, and increase motivation.

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