The Dimensionality of Writing and Reading Fluency and its Impact on Comprehension and Composition

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Abstract: Based on the theory of automated and controlled processing of fluency and Levelt's theory of speech production, writing fluency and reading fluency were each defined as two-dimensional constructs. Writing fluency is composed of automatised transcription and attention-demanding translation, while reading fluency is composed of automatised reading speed and controlled prosodic reading. The study investigates how these constructs can be measured, how they interact and what influence they have on higher hierarchical processes of writing and reading. For this purpose, different measurement instruments were developed and existing instruments were used. Using these instruments and different variables on cognitive resources such as memory and motor skills, we applied a structural equation model to the data of a total of 145 fourth, sixth and ninth graders. The model showed a good fit to the data. Furthermore, the instruments showed high factor loadings on the respective latent factors. With the use of the model, a medium correlation was found between the two factors of writing fluency as well as between the two factors of reading fluency. There was also a strong influence of writing fluency and reading fluency on higher order skills. The understanding of these relationships is particularly important for the creation of training programs for writing and reading fluency.

Keywords: writing fluency, reading fluency, writing competence, reading competence, structural equation model

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1. Introduction

Reading and writing are two key competencies in our society. One of the main prerequisites for a fully developed reading and writing competence is the effortless mastery of basic skills. Only those who can read and write fluently have sufficient cognitive capacity available for the handling of more demanding tasks such as reading comprehension or conceptual planning while writing a text (McCutchen, 1996). Not all students in primary and secondary school, however, master these abilities well enough to perform tasks in school lessons independently (Artelt et al., 2001; Baumert et al., 2001; Drechsel & Artelt, 2007).

The following sections deal with reading and writing fluency as two of the basic abilities contributing to an understanding of competence in writing and reading. Although reading fluency has already been differentiated to some extent (Kuhn & Stahl, 2003; Kuhn et al., 2010; Rosebrock et al., 2011), the dimensionality of writing fluency and its relationship with writing competence is still unknown (Alves & Limpo, 2015; Sturm, 2016; Sturm & Schneider, 2021). Based on theoretical underpinnings, we present a correlational study depicting the relational structure between aspects of fluency and comprehension and composition variables using a structural equation model (SEM).

2. Writing and Reading Fluency as Components of Language Fluency

Every day we are presented with information that must be analyzed, interpreted and put into use; in other terms, the information must be processed cognitively. We process information in two distinct, yet interacting ways: automatic and controlled. Automatic processing, performed rapidly and efficiently, ensures little demand being put on mental resources. Furthermore, it is less likely to interfere with or to be influenced by other tasks. Controlled processing, on the other hand, demands attention, is relatively slow and open to disruptions (Schneider & Shiffrin, 1977; Shiffrin & Schneider, 1977). A high degree of automatization and flexible interplay with controlled processes will lead to a smooth performance on a specific task (Anderson, 2007). While driving a car, for example, automatic processing, such as pressing the accelerator pedal and activating the indicators, interacts with deliberate and controlled processing, such as changing lanes to overtake. Cognitive fluency can be viewed as an interplay between automatized and controlled processing (Segalowitz, 2003a; Segalowitz, 2003b). Automatized skills free the working memory from low-level concerns in order to allow for performing higher level processes (Anderson, 1990; Anderson, 2007; Sweller, 1999).

Language fluency is a specific type of cognitive fluency. Although there is no general definition of language fluency (Schmidt, 2000), fluent language users can be specified as actants who are engaged in language production and reception in a coherent manner with ease and little hesitation. Levelt (1989) presented a model of incremental processing for speaking. Starting with the conceptualization of an utterance, information in the form of a preverbal message about what will be uttered is passed incrementally to the next unit that formulates this preverbal message, relying on the mental lexicon which provides lemmas and the form. The output of the formulator, a phonetic plan, becomes the input for the articulator, leading to overt speech. A speech-comprehension system analyses this phonetic string and provides feedback. Levelt distinguishes between automatic processes and processes being under executive control. Due to the large variety of communicative intentions and means of expressions, conceptualizing requires highly controlled processing. All other processes such as grammatical encoding, motor programs influencing the vocal tract, retrieval of an articulatory plan or word retrieval, up to a certain degree, are claimed to be largely automatic. According to Levelt, the units operate in parallel. Due to differences in the speed at which individual units operate, Levelt (1989) assumes the existence of buffers temporarily storing information. For example, the articulator produces sound much slower than the formulator producing the phonetic plan; thus, the plan must be stored.

Hesitant processing (lacking fluency) can thus be explained either by non-automatized processes such as a slow encoding of grammatical units, for example in L2-learners, or by an inappropriate transfer of information from one unit to another. More generally, processing lacking fluency is either due to processes that are not automatized, or to automatized processes that do not interact efficiently among each other and with controlled, attention-demanding processes (DeKeyser, 2007; Segalowitz, 2003a; Segalowitz, 2003b).

In line with the four language modalities 'speaking', 'reading', 'writing' and 'listening' we distinguish four fluency skills: (1) oral or speaking fluency (Koponen & Riggenbach, 2000), (2) silent and oral reading fluency (e.g., Kuhn & Stahl, 2003), (3) writing fluency (e.g., Chenowith & Hayes, 2001) and (4) listening fluency. The latter is rarely reported (Schmidt, 2000). These skills are interdependent; their development nevertheless can neither be seen as in parallel nor as dependent upon the same cognitive processes altogether, although they share some processes (Berninger, 2010). People might be more fluent in a skill than in another, for instance, young readers are less fluent in reading than they are in listening or speaking. Furthermore, L2-learners can be more fluent in speaking than in writing (Cummins, 2000; Wolfe-Quintero et al., 1998).

In the following chapters, automatized and controlled aspects of writing fluency and reading fluency will be elaborated in detail. Speaking and listening fluency will not be considered in this paper.

3. Writing Fluency

Writing a coherent text is a stop-and-go activity. Motor activities such as moving the pen or pressing keys on a keyboard are often interrupted, especially when a large amount of text is written. These interruptions neither display disorders, nor are these interruptions unsystematically distributed through the writing process (cf. Baaijen et al., 2012; Linnemann, 2019; Matsuhashi, 1981). Virtually every process in the complex framework of writing, such as planning or revising, can lead to discontinuity. Still, writing fluency touches the very core of writing: regarding the car driving example above, writing fluency is not about planning a road trip or turning around after one has lost his or her way; writing fluency is *the driving itself*.

In recent literature on writing, fluency is associated with two processes within the writing process: translation and transcription, which were summarized in the original model of Hayes and Flower (1980) under *translating*. Berninger and colleagues (Berninger et al., 1994; Berninger et al., 1996; Berninger & Swanson, 1994; Berninger et al., 1992) were the first to differentiate between translation and transcription, McCutchen (1996) differentiated between transcription and text generation. The process of translation transforms thoughts into language; the process of transcription transforms linguistic units into written symbols. Furthermore, transcription deals with handwriting and spelling (McCutchen, 2011). In recent publications, the transcription of linguistic units into symbols that are recalled from long-term memory has been neglected and transcription has been reduced to handwriting and correct spelling (e.g. Limpo & Alves, 2017). In a meta-analysis of handwriting instruction, Santangelo and Graham (2016) do not further define *fluency* and *writing fluency,* but the included studies support this assumption. Particularly in the German-speaking research community, *translation* has been further reduced into mere handwriting (Hurschler-Lichtsteiner, 2020; Mahrhofer, 2004; Nottbusch, 2017; Odersky, 2018).

Both processes, translating and transcribing, seem like to be prone to interruptions and produce substantial variability in the overall temporal structure of the writing process in particular in novice writers. Translating and transcribing will be elaborated in the upcoming section.

3.1 Translating

Writing process models explain how ideas are retrieved from long-term memory or are generated newly, and how a conceptual structure is translated into a linguistic structure. This linguistic structure is subject to specific constraints: new linguistic input must be coherently integrated into the previously written text. An addition, it must satisfy specific requirements, e.g., to have an adequate semantico-syntactic form of the sentence or display a language that is adapted to an addressee. This process is called *translating* (Alamargot & Chanquoy, 2001b), the "translation process turns thought into proposed language" (Chenoweth & Hayes, 2001, p. 93). According to Hayes and Flower (1980) all ideas are in the form of pre-linguistic propositions in working memory. Thoughts are translated under the control of a writing plan and the addressee (p. 15). Although Hayes and Flower (1980) present a flow chart of the translating process containing retrieval as a part of the writing plan and adequate propositions that are to be expressed (p. 15), "the description they made is nevertheless relatively superficial and general" (Alamargot & Chanquoy, 2001b, p. 67).

In Levelt's model of oral language production (1989) and in the writing model of van Wijk (1999), based on this model, the linguistic processes of translating comprise at least grammatical, phonological and morphological encoding by using lemmas/lexemes. These processes can be automatized. However, there is no one-to-one correspondence of propositions to linguistic or lexical units (Levinson, 2000; Halliday & Matthiessen, 2004), i.e., from several lemmas that are activated in long-term memory, the one that is the most adequate will be selected. The process of translating is mainly a controlled one, in particular in unknown task environments, e.g., unknown text forms or addressees, specific decisions must be made about the complexity of the syntax (Crowhurst, 1980 ; MacArthur et al., 2019), the addressee (Becker-Mrotzek et al., 2014; Linnemann, 2019;), the cohesion with the adjoining sentences and the coherence within the whole text (Traxler, & Gernsbacher, 1992; Traxler, & Gernsbacher, 1993; Traxler, & Gernsbacher, 1995; Weinzierl, 2022), and the words that should be used (Read, 2000). A large mental lexicon for example offers the opportunity to pick the words appropriate for the task, the addressee and register (Vitevitch, 2012). This can barely be automatized as the tasks, the goals and addressees differ greatly from one writing occasion to another. Kellogg (1994, 1996) demonstrates that translating content into sentences (lexical retrieval and syntactic processing) is highly effortful and puts considerable demand on working memory.

Controlled processes do not necessarily involve conscious retrieval. They may also involve a conscious review after retrieval or an evaluation of the retrieved item (Hassin, 2005). Controlled processes can also be performed at different speeds. McCutchen et al. (1994) found that high skill of lexical retrieval leads to the production of longer sentences and higher-level writing skills. The explanation for this is that fluent lexical retrieval saves cognitive capacity that can be devoted to text production processes needing more attentional control, such as planning and monitoring. Chenoweth and Hayes (2001) stated that linguistic experience, a larger lexicon and more chunks of language free cognitive resources "so that the translator is able to apply more fully the writer's sense of the grammar while proposing a string of language" (p. 94). According to spreading activation theories (cf. Collins & Loftus, 1975) certain words and phrases can have a high amount of base-level activation and strength of association (Anderson, 2007) in long-term memory, that allows an experienced writer to make some of these decisions very quickly: A rose is a rose is a rose is a rose – there is no need for poking around in the dark long-term memory for a different term (unless you are a rose-grower). The retrieval of less common words with many synonyms, such as 'batch', can take longer because they have less base-level activation and weaker strength of association.

In Hayes' re-revised model of the writing process (2012b) the translating subprocess is located on the process level between the proposer (that is retrieving or creating ideas), and the transcriber (see next chapter). Translating produces a linguistic string of the ideas proposed by the proposer, and it consumes working memory capacity doing this (Kellogg, 1987; Glynn et al., 1982).

3.2 Transcribing

After ideas are formulated by the translator, the linearized linguistic units must be written down by the transcriber (Hayes, 2012b). This means that subsymbolic language must be translated into the symbols of the writing system, such as letters, Chinese characters or syllabaries, or other symbols such as mathematical symbols (+, -) or currency symbols (€). Graphic transcription "can be defined as the programming and the execution of necessary motor movements to produce a letter, a word or a text" (Alamargot & Chanquoy, 2001a, p. 86) either through handwriting or through typing.

Transcribing has been investigated from different perspectives. Van den Plaats and van Galen (1990) and van Galen (1991) proposed a theory about the management of graphic transcription by hand as a parallel multi-component task. In their model, a processing unit receives its input from the next higher operational unit in the hierarchy, for instance graphemic representation, transforms this information, buffers it if necessary, and passes it on to the next lower process level with the activation of a motor program, initially selecting the suitable allographs that are then as a final step realized as strokes. The units of processing can operate in parallel on different features of the information. Although these processes are modeled in parallel, one can easily think of learners or novices handling these processes in serial mode, which can be demanding and attention consuming. However, research findings are somewhat poor in this respect. There is evidence, that transcribing can become a bottleneck not only for novice writers (Berninger et al., 1994; Berninger et al., 1992) but also for expert writers, depending on the task. Studies of Hayes and Chenoweth (2006) show that adult writers' transcription was slowed down when verbal working memory capacity was reduced by means of articulatory suppression. In a within-subjects design, twenty participants transcribed six texts from one computer window to another, three of these texts with articulatory suppression and three without. In the articulatory-suppression-condition participants transcribed significantly slower and made significantly more errors than in the control condition. Hayes (2012a, p. 371) concluded "that transcription does compete with other writing processes for cognitive sources." Olive and Kellogg (2002) found, that if the motor execution is relatively automatic, writers can attend more to the high-level processes required in the text composition, leading to a higher quality text. Younger children or writing novices often fail to engage in high-level processes. One reason why children do not perform well at higher-level processes is that motor processes, i.e., transcription, consume available attention (see also Bourdin & Fayol, 1994). Wicki et al. (2014) found that the automaticity of handwriting (measured as the number of inversions in velocity of strokes and stroke frequency) was systematically related to handwriting speed as well as orthographic skills. The authors concluded that the automaticity of handwriting is associated with saving cognitive resources.

Transcription and translating both fall back on working memory, in particular if transcription is not automatized completely (Berninger, 1999). A good interlacing of these processes may boost writing fluency and reduce the risk of getting stuck during the writing process. The interaction of these two processes is described in the following section.

3.3 Interaction between Translating and Transcribing

For the discussion of writing fluency, the processes of translating and transcribing are of high relevance. In summary, based on the outlined results of the research on the translator and transcriber, it can be stated that the lack in writing fluency can occur at both process levels: Firstly, hesitation can occur during translation, when retrieved ideas cannot be translated into language sufficiently fast due to the limitation of the capacity of the translator (Chenoweth & Hayes, 2001; Hayes & Chenoweth, 2006; Hayes, 2007). Secondly, the writing process can become faltered if the already linearized language cannot be produced on paper or screen due to the limiting factor of transcribing, especially due to a low level of automatization. Both processes, translating and transcribing, may present bottlenecks for fluent production of texts (Hayes, 2012a).

Hayes and Flower (1980) and Flower and Hayes (1980) call the management of these processes and resources "juggling with constraints." The writing process is subjected to the limited capacity of working memory; so, there is a necessity to focus on the most relevant aspect of the writing process at a specific moment: „[D]uring a given timespan, attention to aspects of the text on one level will be reduced because the attention is focused on another level" (Broekkamp & van den Bergh, 1996, p. 71). Depending on the strategy and expertise, a writer can shift between the processes. If it is necessary for a writer to produce a text in a short period, either he or she can neglect to trigger the transcriber properly, which can result in a non-legible typeface or the omission of letters, or he or she might place little to no value on correct spelling. This phenomenon is in line with Hayes' latest model (2012a, p. 23) and "consistent with the notion that the translator can use up cognitive resources, which in turn can slow transcription." Limpo and Alves (2013) and Alves and Limpo (2015) investigated the development of transcription, writing fluency and written composition in Portuguese students from grade 2 to 7. The authors found that the automaticity of transcription allowed for more efficient composition processes. Regardless of grade and genre, more automatic transcription contributed to higher writing fluency, which was measured in written words per minute, and higher text quality.

An explanation of the results of the studies described is provided by the approach of Olive (2014). Taking numerous proposals into account, Olive (2014) assumes a parallel and cascading concept of writing (see also Fayol & Lété, 2012). This parallel and cascading architecture corresponds to the notion of incremental production in Levelt's model (1989). In Olive's (2014) conception, each piece of information is sequentially processed, depending on the stage, either at a conceptualizing level, at a formulation level, or at an execution level. These different levels of processing operate simultaneously on different segments. Because information cascades between levels of processing, operations at a particular level may interact with a subsequent level of processing. The levels of processing are organized hierarchically, from conceptual to execution processes, and operate in parallel. The main feature of this model is that "levels of processing can overlap to a greater or lesser degree, depending on the demands they place on working memory" (p. 187). This implies that if transcribing is sufficiently automatized, working memory capacity is available for higher levels of the writing process, such as formulating or conceptualizing. Furthermore, "low-levels of processing may affect higher levels" (p. 187). It is also relevant that processes do not have to be fully completed before the resulting mental representation is passed to the next level. Finally, cascading systems enable top-down effects: "operations at a level of processing may affect lower levels" (p. 187). With reference to Caramazza et al. (1987), Olive (2014) adopts a graphemic buffer that stores content until it can be transcribed. The assumption of buffers, which can already be found in Levelt's Model (1989), is nevertheless problematic, as it raises the question of why buffers are not present at all levels and store and provide information whenever a process is capable of handling this piece of information. A conception of a potentially insufficient working memory would thus be obsolete.

Overall, it can be stated that writing fluency is highly affected when processes are not automatized and therefore draws heavily on specific resources such as the working memory capacity (e.g. Berninger, 1999; Bourdin & Fayol, 1994, 2000; Fayol, 1999; Olive & Kellogg, 2002; Kellogg, 1999; Torrance & Galbraith, 2008; Torrance & Jeffery, 1999). As a result, a 'chain reaction' begins the following: translating is affected by a non-automatized transcribing process. Transcribing cannot work efficiently if the working memory is loaded with controlled and attention-demanding tasks such as translating.

3.4 A Definition of Writing Fluency

In the second section, we described cognitive and language fluency as interdependent automatized and controlled processes. In the process model of writing, some processes, such as the retrieval of letters, can be seen as automatized (or at least automatable). Other processes, such as choosing the right word out of a pool of synonyms, can be seen as controlled processes. This means, two dimensions of writing fluency must be integrated to become a fluent writer (McCutchen, 2011):

(a) *Text generating fluency (TGF)* is the process of translating thoughts into language, relying on controlled but quick linguistic decisions. Text generating fluency depends on parts of a writing plan and contains the elaboration of the text content based on the writing plan, linearization of the preverbal message and the formulation of locally coherent sentences (cf. Hayes & Flower, 1980; van Wijk, 1999).

(b) *Transcription fluency (TF)* is the process consisting of the automatized linguistic retrieval and legible transcription of letters, of letters as parts of words, or of an isolated phrase/sentence including the grammar that rules the form of the used lexemes. Even if spelling is insurmountably intertwined with the transcription of words, it is not the same. Even wrong spelling can be automatized when a word, e.g., a sight word, is encoded incorrectly, which may consume fewer resources of the working memory.

Based on these theoretical considerations, we define writing fluency as follows:

> **Writing fluency** comprises the automatized ability to produce legible letters, correct words and, on the basis of information in lemmas, syntactically correct phrases/sentences (= Transcription fluency) as well as locally coherent text (= Text generation fluency) at a reasonable pace with sustained attention.

Writing fluency is, therefore, the interaction between automatized transcription fluency and controlled but quick text generation fluency.

3.5 Relationship Between Writing Fluency and Text Quality

Writing fluency is a necessary, but not sufficient condition to produce a functional text. Strategic planning, setting and pursuing goals (Graham & Harris, 2012; Hayes, 2012b), following specific genres (Donovan & Smolkin, 2006), anticipating the addressee (Linnemann, 2014), taking different perspectives into account (Schmitt, 2022), establishing coherence (Weinzierl, 2022), accessing referential information (Dansac & Alamargot, 1999) and reviewing the text are some variables that must be taken into account when it comes to text composition. Due to the limitations of working memory and the limitation of retrieval from long-term memory, writing fluency must be acquired to free up memory in order to process the mentioned 'ingredients' for text production. Automatization of transcription abilities is an important factor, yet there also has to be a tight interaction between translation and transcription.

Several studies have demonstrated a relationship between aspects of writing fluency and text quality or writing competence. Jones and Christensen (1999) showed that handwriting practice improved the quality of children's handwritten texts. Christensen (2004) found that typing practice improved the quality of the eighth and ninth graders' typed texts; nevertheless, this did not enhance the text quality of their handwritten texts. Connelly, Gee, and Walsh (2007) compared 300 fifth and sixth graders' handwritten essays to essays written on a keyboard. Students wrote significantly faster by hand than by keyboard, and handwritten essays were significantly better than their typed counterparts. Limpo and Alves (2013) showed a direct contribution of low-level skills to writing quality in younger students due to the lack of automaticity in transcription. Writers who struggled with the orthographic-motor and orthographic-linguistic components of writing also produced lower quality written texts. In older students, transcription fluency indirectly contributed through planning and self-efficacy to text quality. Alves and Limpo (2015, p. 387) found that differences in burst length and pause duration accounted for a significant but small proportion of the variance in students' text quality. Students who composed texts using longer bursts and shorter pauses wrote better texts than those who showed shorter bursts interrupted by longer pauses (see also Limpo & Alves, 2017).

Hurschler et al. (2018) investigated the impact of a handwriting training on fluency, spelling and text quality among third graders. As handwriting automaticity was already high at the beginning of the training, the intervention could not improve it further. An intervention effect on the quality of composed texts was not observed, still text quality was related to working memory, fluency, spelling, and gender.

4. Reading Fluency

Reading fluency (cf. Kuhn et al., 2010; Kuhn & Stahl, 2003; Rasinski, 2004) is the second type of language fluency we address in this paper. It is much more in focus and better understood than writing fluency. In reading research, fluency is considered a bridge between decoding and comprehension. "[Reading] fluency combines accuracy, automaticity […]. It is demonstrated during oral reading through ease of word recognition, appropriate pacing, phrasing, and intonation" (Kuhn et. al. 2010, p. 240). In the following, we describe briefly what is understood by the term "reading fluency" to re-define the term, and to show parallel traits to writing fluency.

4.1 Accuracy and Automatization of Decoding

During reading either, grapheme-phoneme correspondence is being used, or whole words are used to find an entry in the mental lexicon (Coltheart et al., 2001). Only if these processes are accurate, is the reader able to retrieve and subsequently understand the written word. In oral reading, accuracy is typically measured by the number of correctly decoded/pronounced words related to the overall number of words in a text (Rasinski, 2004).

By automating the basic decoding processes, cognitive resources are freed for higher comprehension processes (LaBerge & Samuels, 1974; Perfetti, 1985; Perfetti & Hart, 2002; Samuels, 1994). Accuracy and automatization are two distinct factors but can also be seen as an equivalent to reading rate (Carver, 1990) or reading speed.

4.2 Prosodic reading

In addition to accuracy and automation, prosodic reading plays a vital role as a dimension of reading fluency (Godde et al., 2020; Kuhn & Stahl, 2003; Rasinski, 2004; Rasinski et al., 2005; Sappok et al., 2020). It shifts the focus from word reading to sentence and text reading by aiming at larger units such as phrases and sentences. The reader should be able to divide a text into meaningful sections and to read it prosodically and rhythmically adequate and with a meaningful intonation contour (Chafe, 1988) both in oral and silent reading. According to Fodor's (2002) *Implicit Prosody Hypothesis*, a "default" standard contour of intonation is projected onto the stimulus, which influences, for example, the way syntactic ambiguities are handled (cf. also Kentner; 2012). Which prosodic aspects play a relevant role in reading and influencing text comprehension (or vice versa), has not yet been clarified for the German language. For example, are certain intonation contours and accents in the text more important than others for comprehending? Is the absence of emphasis more prominent in a new piece of information than in one that is relevant but already established? (Stephany et al., 2021). Kuhn, Schwanenflugel and Meisinger (2010) define prosodic reading as "appropriate expression or intonation coupled with phrasing that allows for the maintenance of meaning" (p. 233). Groen et al. (2019) go even further by assigning prosodic reading a more important contribution to text comprehension than the decoding aspect: "The construction of meaning seems more closely tied to text reading prosody than to decoding efficiency, at least, when children have mastered automaticity in reading" (p. 16). This is an indication that prosodic aspects are only partially automatized since they are closely linked to text comprehension and these variables presumably strongly influence each other.

4.3 A Definition of Reading Fluency

To become a fluent reader, both automatized reading speed (comprised by decoding accuracy and automatization) and the more attention-consuming prosodic reading must be integrated:

(a) *Reading speed* is the process of accurate and fast decoding of words, word compounds and word combinations such as idioms. This aspect is the automatized component of reading fluency.

(b) Applying the adequate *reading prosody* during reading is the controlled and attention-consuming process within the construct of reading fluency. It is closely tied to the construction of meaning, at least at the level of sentences. Prosody becomes obvious during oral reading through appropriate pacing, phrasing, and intonation.

Parallel to the definition of writing fluency, in reading fluency there is a distinction between lower and higher-level processing being defined as follows:

> **Reading fluency** comprises the automatized ability to decode words, compounds and word combinations (= reading speed) as well as the adequate application of prosody (= reading prosody).

4.4 Relationship between Reading Fluency and Reading Comprehension

Reading is a complex cognitive process in which numerous sub-processes, such as the decoding of words and the development of local and global coherence, must be integrated (cf. Groeben & Christmann, 1996; Kintsch, 1998; Müller & Richter, 2014; Schnotz & Dutke, 2004). Perfetti's *Verbal Efficiency Theory* (Perfetti, 1985; Perfetti & Hart, 2002) shows the relevance of accurate and rapid word recognition for reading comprehension. Fast, automatic, yet accurate word recognition requires few cognitive resources, which makes cognitive capacities available for comprehension processes (cf. also Wolf & Katzir-Cohen, 2001). LaBerge and Samuel's Automaticity Theory (1974) also assumes that a limited cognitive capacity of memory makes it difficult for words to be recognized and text to be understood at the same time. In contrast to processes of comprehension that demand attention, processes at the word level, such as decoding, can be automatized (cf. Fuchs et al., 2001), which relieves the cognitive capacity. A positive influence of fast and automated reading on text comprehension (especially in case of words, but partly also at the level of sentences, text passages and full texts,) is generally well documented (cf. e.g.

Adams, 1990; Cutting et al., 2009; Jenkins et al., 2003; Schwanenflugel et al., 2006). The identification of this relationship led to the rise of the *Simple View of Reading* approach (Gough & Tunmer, 1986; Hoover & Gough, 1990), which attempts to explain reading comprehension solely through decoding and language comprehension.

Nevertheless, in addition to reading speed, Klauda and Guthrie (2008) found a significant effect of prosodic reading on reading comprehension. Further studies indicate that prosodic reading plays an important role as a predictor of reading competence. For example, prosodic reading proved to be a predictor of text comprehension: prosodic reading of simple texts in first grade predicts understanding of more demanding texts in the second grade (Kuhn et al., 2010). A study by Veenendaal et al. (2015) showed that reading speed and prosodic reading can predict reading comprehension beyond decoding and language comprehension proclaimed by the *Simple View of Reading*. Furthermore, a study of 84 third, fourth, and fifth graders (Groen et al., 2019), demonstrated that students with low reading comprehension scores but age-appropriate decoding performance ('poor comprehenders') had lower prosodic reading scores than students having their reading comprehension and decoding competence at the same level. These findings show a connection between prosody and text comprehension, even if decoding skills are kept constant. Paige et al. (2017) found correlations between reading comprehension and accuracy and prosodic aspects, but none with reading speed. In a meta-analysis, Wolters and colleagues (2020) examined the relationship between reading prosody and reading comprehension. A total of 35 studies were included in the analysis. Overall, a moderate relation of .51 was found between reading prosody and reading comprehension (Wolters et al., 2020). The above-mentioned studies showed that prosody is indeed a factor in its own right.

5. The Relationship Between Writing and Reading

Reading and writing are based on comparable cognitive skills and common knowledge resources (Berninger & Abbott, 2010; Shanahan, 2006) including prior knowledge of content, knowledge of meta-language (Fitzgerald & Shanahan, 2000) and knowledge of aspects of written language such as spelling, vocabulary and coherence (Abbott & Berninger, 1993; Berninger et al., 2002; Cox et al., 1990; Parodi, 2007; Shanahan, 1984). Additionally, basic processes must be automated for reading and writing so that resources are available for higher level processes. Factors that improve these skills may influence the development of both writing and reading skills (Shanahan, 2006). The small number of available studies on this subject indicates a positive effect of promoting reading on writing competence and vice versa (Stephany et al., 2020; Tierney & Shanahan, 1996). Furthermore, research findings indicate that reading comprehension is a good predictor of later writing skills of primary school children (Berninger et al., 2002).

6. The Present Study

The study at hand has two aims. Our first aim is to (re-)define writing fluency and reading fluency and to split these skills into theoretically based measurable subskills. The second aim is to locate fluency in a common model of writing competence and reading comprehension. The research on the components of writing and reading fluency and their relationship with components of writing competence and reading proficiency is relevant to establish a focused and precise training program to tackle the before mentioned problems of students while writing or comprehending texts. Only if the assumed mechanisms are clarified and have been proven to be robust, can a training program of writing and reading fluency be established.

Language fluency has been defined as the interaction between automatized and controlled processing, (1) writing fluency can be modeled as the interaction between transcription fluency and text generating fluency. (2) Reading fluency can be seen as an interaction between automatized processes of word decoding and the (more) controlled processes involved in prosodic reading.

We addressed the following research questions:
(1) Does writing fluency consist of the two factors that are considered to influence writing competence? How are the underlying latent constructs related?
If transcription fluency is not sufficiently automatized, text generation fluency cannot unfold, i.e., there should be a connection between transcription fluency and text generating fluency as transcription fluency is considered a prerequisite for text generating fluency. Therefore, a unidirectional relationship is being assumed. High transcription fluency offers the possibility of a high text generating fluency but not vice versa. If transcription fluency is not automatized, the writing gets stuck. We expect that transcription processes may affect translating processes in writing novices due to a loaded working memory.

(2) Does reading fluency consist of two factors that are assumed to influence reading competence: Is there a distinction between correct and automatized decoding and prosodic reading? How are the latent constructs related?
Both reading speed (correct and automatized reading) and prosodic reading contribute to reading fluency. A directional relationship between reading speed and reading with expression is assumed because a high speed of decoding provides the opportunity to capture the prosodic cues of a sentence or text quickly. The enhanced automatization frees the working memory, resulting in additional

resources that can be used for computing prosodic cues and for comprehending the text.

(3) How are writing and reading fluency connected with reading and writing competence? What are the contributions of these components?
Writers with a high transcription and text generating fluency have freed working memory capacity from overload. They thus can manage processes such as addressee anticipation, perspective taking, elaborate choice of words and establishing coherence or inference making. A substantial relationship can be expected.

Similarities can be drawn when it comes to reading: Anyone who can read a text accurately and automatically, taking the prosodic aspects also into account, has resources available for higher processes of constructing a mental model and interpreting a text. Since text comprehension includes other components for constructing a mental model in addition to fluency, such as prior knowledge, the ability to generate inferences, and the use of reading strategies, a considerable yet imperfect correlation is expected.

(4) What is the influence of resource variables on reading and writing fluency?
The underlying resources of writing and reading fluency, such as memory, motor skills and vocabulary, can contribute to the variance of writing and reading fluency. Handwriting is a physical issue, hand and eye movements must be coordinated; text production and reading depend on the proper functioning of the working memory and quick retrieval from-long term memory. Although not the focus of this study, these resource variables are integrated into the structural equation model.

7. Method

7.1 Design

The design of the study is correlational. Nevertheless, some hypotheses about the direction of relations were developed and tested by using a structural equation model. This model is based on theoretical findings and assumptions. The goodness of fit of the parameters was decisive in evaluating the model.

Since the total number of subjects was just sufficient for a structural equation model, it was impossible to create models for subgroups. However, correlations showed that there were no differences in the relationships of the above variables between students who stated that they spoke only German at home and students with a multilingual background, the same result was found for gender. Since analyses across age groups always involve general maturation and learning processes (and thus may produce correlations as artifacts), the variable age is considered in more detail.

7.2 Participants and Procedure

The study is part of a research project to specify, diagnose and promote reading and writing fluency. The following sections refer to the first stage of the project, which was primarily concerned with the testing of instruments, the operationalization of variables and the relationships between these variables and hierarchically higher competencies.

Data collection took place in six schools after the summer break in single-, group- and classroom assessments depending on the test material (see table 1). The total assessment time per student was 120 min. 160 students participated in the study. The students attended grades 4, 6 and 9 from primary and secondary schools. Students with too many missing values due to illness were excluded. Furthermore, students with reading disorders and mentally disabled students were excluded from further analyses. 145 students were finally included, 46% of these were L1-speakers of German, 54% L2-speakers; 50% were female. Participants were distributed over class levels as follows: 46 students attended grade 4, 48 students grade 6 and 51 students attended grade 9. All schools were located in urban areas.

7.3 Materials

The materials included in this study represented language-related and nonverbal cognitive measures. Table 1 shows the constructs and the associated measurements and whether the tests were assessed either within a classroom setting, in a group setting, or individually. In addition to the commonly used measures for assessing reading fluency and to the newly developed measurements for assessing writing fluency, materials and tests for reading comprehension and for composition competence, motor skills, working memory, rapid automatized naming, vocabulary and spelling were included. Multiple measures of each construct were administered to examine the relations among latent abilities independently of task-specific factors and measurement error (Kline, 2005). In the next section, we describe each task or assessment according to the latent construct it indexed.

7.3.1 Writing Fluency and Writing Competence

Transcription fluency. In an alphabet task (cf. Berninger, Cartwright, Yates, Swanson & Abbott, 1994) used for assessing fluency at the level of letters, students were asked to write the lowercase alphabet as quickly as possible and legibly. When they had reached the end of the alphabet, they were requested to start from the beginning. The result was the number of letters written correctly during a one-minute interval. One point was awarded for each legible letter in the right sequence; any other instance was counted as an error and awarded zero points. The interrater reliability was .98 (intraclass correlation).

Table 1. Assessment battery

#	Construct	Materials	Assessed
1	Writing Fluency	a) Alphabet task b) Developed and validated test material I: writing words c) Developed and validated test material II: writing sentences d) Writing of two texts (school day, picture story task) with digital pens	class class class group
2	Reading Fluency	a) Oral reading of a text about toads (grade 4 only) b) Oral reading of a text about elephants (grades 6 and 9)	indiv. indiv.
3	Writing Composition/text quality	a) Writing of a letter about a dream zoo/dream indoor hall b) Writing of a detailed route description	class class
4	Reading Comprehension	a) Standardized reading comprehension test ELFE (grades 4 and 6) a) Standardized reading comprehension test LGVT (grades 6 and 9) a) Questionnaire with questions according to the orally read texts used for the assessment of reading fluency (see #2)	class class indiv.
5	Motorical Skills	German version of the Developmental Test of Visual Perception (Frostig)	group
6	Working Memory	a) Digit span forwards b) Digit span backwards	indiv. indiv.
7	Naming Speed (Rapid Automatized Naming)	a) Naming of colours (30 seconds) b) Naming of letters (30 seconds)	indiv. indiv.
8	Vocabulary	Peabody picture vocabulary test-revised (PPVT-R)	indiv.
9	Spelling	Number of spelling errors in written texts	class
10	Language Biography	Questionaire: Language Background	-

Note. class = classroom testing, group = small group testing, indiv. = individual testing

In addition to the proficiency to recall and write down single letters, words had to be recalled and transcribed. In several studies, these skills were measured as the number of syllables or words in a produced text (cf. Alves & Limpo, 2015). In our opinion, this measure is invalid because the amount of text in a specific interval depends on the genre; genre-specific planning and revision processes can cause a bias. In contrast, we developed test items that aim to write words matching pictures as quickly as possible. This writing task requires the same motor program and semantic structure from all students. The selected words were derived from the basic vocabulary of children and should be known by students of grade 4. A point is awarded as long as the test taker could identify the specific word; spelling was not taken into account. This is because even a wrong entry in the mental lexicon can be automatized and can thus be retrieved quickly.

Transcription fluency also covers the automatized retrieval of simple phrases or very short sentences. A second tool was developed for the measurement on this level: Students had to write down sentences of the form subject-verb-object matching given pictures, for instance, "The dog is on the table" or "The man is reading a book." We did not consider assessing more complex sentences because this may lead to too large variability between students, challenging the reliability of the measurement. Moreover, syntactically complex sentences require a high level of attention and go way beyond automatized processing.

The materials showed good reliability (word production = .88; split half = .98; sentence production = .75; split half = .84).

Text generation fluency. In addition to the automatized transcription fluency, writing fluency comprises the writing of (at least locally) coherent text. Language constantly must be adapted to new ideas and to the content and therefore it cannot fully be automatized. This leads to the translating process (Hayes, 2012b) that transforms thought into a stream of language. To make this stream visible during writing, pauses and bursts (phases in which writers produce the actual text) can be observed during the writing process. Hayes and Chenoweth (2001; see also Chenoweth & Hayes, 2001; Chenoweth & Hayes, 2003; Hayes & Chenoweth, 2006; Kaufer et al., 1986), concluded that an increase in burst size and length is strong evidence of writers' more efficient translating processes: "An increase in burst size reflects an increase in the capacity of the translator to handle complex language structures" (Chenoweth & Hayes, 2001, p. 94).

Alves and Limpo (2015) found that individual differences in burst length (and pause duration) accounted for a significant proportion of the variance in students' fluency, measured in words per minute, and text quality. Longer bursts and shorter pauses were associated with more words per minute and better texts. The authors concluded that longer bursts and shorter pauses are likely to reflect greater abilities in converting ideas into language and in externalizing it in writing. The association of bursts and pauses was more sizeable to writing fluency than to text quality.

To measure text generation fluency, two writing tasks were administered: (1) a description of a common school day and (2) a simple picture story. To eliminate planning processes as far as possible, the students were given one minute to plan before the writing task. Writing time was 5 min each. The writing process was recorded with a digital smart pen to provide the opportunity to analyze writing bursts with the help of the software 'handspy' (Monteiro & Leal, 2013). The bursts-criterion was set at 2 seconds so that the number of words per interval between pauses of more than two seconds was counted.

Writing competence. Writing competence was measured by means of two writing tasks: (1) Writing a letter to a director of a zoo, one would like to visit. The quality of this text was rated by using comparative judgment (Pollitt, 2012a; Pollitt, 2012b). In this procedure, two texts are being compared by the software Comproved (https://comproved.com/en/), and a logit value for the 'winner' is being computed on the basis of a set of comparisons (Coertjens et al., 2018). One advantage of comparative judgement is that the raters do not have to be intensively trained. The assessment was done by students studying German as a teaching qualification, each of the 290 students rated 15 texts. Every text was judged for at least 30 times until reliability was above .80. To validate the resulting ranking ten percent of the texts were rated using an analytical rating, judging grammar, coherence, vocabulary, idea, topic development and venture based on a catalog of criteria from Becker-Mrotzek and Böttcher (2006, p. 184). The scoring was done by the authors on a three-point Likert scale. The correlation between the rank and the sum of the analytical rating was r = .90. (2) The second writing task was to write a detailed route description, so that a reader can find a treasure on an island without using a map. These texts were graded by analytical ratings of the formal and content criteria. In both cases, the interrater reliability was very high (ICC (using the two-way mixed model and an absolute agreement definition) = .93 and .82 respectively).

7.3.2 Reading Fluency and Reading Comprehension

For measuring the dimensions of reading fluency, two expository texts were developed. Students had to read these texts aloud (prima vista). This session was audio-taped.

Reading fluency. For the analysis of accuracy, the proportion of correctly read words to the total number was calculated. To measure the amount of automatization, the number of correctly read words per minute, was used. The multi-dimensional fluency scale (Rasinski, 2004) was used to assess prosodic reading, measuring four subscales, stress, phrasing, rhythm, and pace. The data of 30 participants were rated by a second rater, and inter-rater reliability was calculated using intraclass correlation coefficients (ICC). The ICC's for the four subscales were very good to excellent and ranged between ICC = .88 and ICC = .92, significant at the .05-level.

Reading comprehension. Reading comprehension was measured by the reading comprehension test for first to sixth graders (ELFE 1–6; Lenhard & Schneider, 2006) and by the reading speed and comprehension test for grades 6–12 (LGVT 6–12; Schneider et al., 2007) which have been combined. Additionally, questions were asked about the content of the texts that were used for assessing reading fluency. The ELFE 1–6 consisted of the subtests *word comprehension*, *sentence comprehension* and *text comprehension*, from which an overall value can be calculated. The test was designed as a speed test. The internal consistency ranged, according to the manual, between = .92 and = .97. In the LGVT 6–12, the children were presented with a text that should be read as fast as possible. During reading, the test takers were asked at various locations to select the correct word for this position from three different words. The number of correctly marked words and the total number of words that a child read within the time limit was scored. Re-test reliability of the comprehension component was .87.

7.3.3 Resources

Visuo-motorical ability. The FEW scales, a current German test for developing visual perception based on the Developmental Test of Visual Perception (Frostig, 1961), were used to measure visuo-motorical ability. The FEW-JE is standardized for the age range from 9 to 90 years. Three of the six subtests were administered: copying figures, figure-ground perception, and shape consistency. These subtests are highly dependent on motor skills.

Working memory and rapid automatized naming. In this study, the digit span was measured forward and backward to assess working memory capacity. Additionally, two unstandardized measures of rapid automatized naming were used. They asked participants to name symbols and colors, respectively, as quickly and as accurately as possible in 30 seconds.

Vocabulary. The Peabody Picture Vocabulary Test-revised (PPVT-R; Dunn & Dunn, 1987) was used to assess participants' receptive vocabulary skill. The split half reliability of the PPVT-R is .96.

Spelling. Spelling was assessed by the number of spelling errors made in the written text "zoo" and by the proportion of correct words in the total number of written words in the transcription fluency test.

8. Results

In this section, we will provide a descriptive data analysis and a structural equation model. Table 2 shows the descriptive values of all measured variables grouped by grade.

Table 2. Descriptive statistics for all measures by grade

	Grade							
	4		6		9		Total	
Measure	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*
Reading Comprehension								
Standardized Reading Test Scores	12.74^{bc}	4.21	20.91^{ac}	4.01	23.08^{ab}	1.61	18.78	5.68
Reading Comprehension (Questionnaire Reading Fluency Texts, Questions 1,3 and 7)	1.86	0.88	1.80	0.91	2.06	0.74	1.90	0.85
Reading Fluency								
Accuracy (proportion of uncorrected error)	5.12	3.54	5.74	4.89	3.93	2.12	4.95	3.79
Automation (read words/min)	89.78^{c}	28.93	87.09^{c}	15.02	116.59^{ab}	20.38	97.54	25.51
Stress (Rasinski scale)	2.08	1.00	2.04	0.90	2.32	0.91	2.14	0.94
Phrasing (Rasinski scale)	2.13	0.97	2.36	0.83	2.59	0.87	2.36	0.90
Rhythm (Rasinski scale)	2.48^{c}	1.06	2.51^{c}	0.99	3.07^{ab}	0.85	2.68	1.00
Speed (Rasinski scale)	2.45^{c}	1.06	2.80^{c}	0.99	3.34^{ab}	0.79	2.87	1.01
Writing Competence								
Text Quality in logits (“Zoo Texts”)	-0.58^{c}	1.30	-0.03^{c}	1.14	1.02^{ab}	1.37	0.11	1.42
Text Quality - content criteria (“Description of a route”)	2.30^{c}	2.02	2.99^{c}	1.77	4.63^{ab}	1.90	3.32	2.13
Text Quality – formal criteria (“Description of a route”)	12.37^{c}	2.03	12.70	1.56	13.36^{a}	1.33	12.81	1.70
Writing Fluency								
Letter level (“alphabet task”)	33.16^{bc}	12.71	54.58^{ac}	16.86	72.55^{ab}	17.53	53.71	22.56
Word level	12.37^{bc}	3.15	14.72^{ac}	3.20	19.31^{ab}	2.93	15.52	4.23
Sentence level	2.98^{bc}	1.11	5.50^{ac}	1.96	7.29^{ab}	2.46	5.29	2.62
Median Burst Length	3.39^{c}	2.14	4.87^{c}	2.16	8.78^{ab}	7.43	5.15	4.43
Maximum Burst Length	10.72^{c}	8.02	14.00^{c}	6.07	24.80^{ab}	15.95	15.08	11.08
Working Memory								
WISC Digit Span, forward	8.84^{b}	2.07	7.52^{ac}	1.62	8.93^{b}	1.98	8.42	1.99
WISC Digit span, backward	6.84	1.93	6.61	1.45	7.45	1.70	6.96	1.73
Rapid automatized naming of colors in sec	55.11^{bc}	13.82	49.11^{ac}	7.18	39.36^{ab}	9.62	47.93	12.31
Rapid automatized naming of symbols in sec	49.96^{bc}	10.05	44.60^{ac}	7.08	37.32^{ab}	6.04	44.01	9.40

Spelling								
Spelling, number of errors ("Zoo texts")	10.89	6.68	14.14	10.01	13.25	8.84	13.62	9.28
Spelling, Proportion of correct words in the total number of written words ("Picture task").	0.90 [c]	0.13	0.95	0.07	0.96 [a]	0.07	0.94	0.10
Vocabulary								
PPVT raw score	164.84 [c]	17.82	173.49 [c]	14.83	192.55 [ab]	17.81	176.93	20.35
Visuo-motorical skills								
FEW Copying figures	21.93 [bc]	3.45	20.45 [a c]	5.86	26.52 [ab]	3.36	22.98	5.04
FEW Visuo-motoric search	69.54 [c]	21.89	61.57 [c]	17.59	51.31 [ab]	17.42	60.87	20.41
FEW Visuo-motoric speed	39.85 [c]	7.56	41.80 [c]	6.82	49.77 [ab]	12.07	43.70	9.97

Notes. [a] = sig. Δ between respective grade and grade 4; [b] = sig. Δ between resp. grade and grade 6; [c] = sig. Δ between resp. grade and grade 9

Table 3. Correlations between all measures

	Measure	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
	Reading Comprehension																									
1	Standardized Reading Test Scores	.15	-.22	.57	.35	.50	.43	.59	.49	.43	.34	.58	.54	.59	.35	.39	.00	.08	-.37	-.45	-.19	.41	.55	.25	-.28	.23
2	Questionnaire Reading Fluency Texts		-.19	.22	.24	.23	.25	.23	.04	.28	.21	.02	.08	.06	-.07	.09	.06	.07	-.10	-.08	.14	0.3	.33	.13	-.13	.09
	Reading Fluency																									
3	Accuracy (proportion of uncorrected error)			-.45	-.43	-.46	-.41	-.44	-.24	-.26	-.38	-.02	-.11	-.05	-.12	-.21	-.19	-.20	.22	.23	.47	-.23	-.23	-.02	.01	.01
4	Automation (read words/min)				.64	.67	.72	.76	.48	.39	.35	.39	.45	.39	.31	.35	.26	.25	-.44	-.48	-.23	.41	.44	.21	-.18	.24
5	Stress (Rasinski)					.71	.72	.68	.33	.22	.30	.20	.28	.17	.12	.22	.13	.15	-.32	-.32	-.27	.31	.26	.05	.01	.08
6	Phrasing (Rasinski)						.78	.79	.46	.20	.29	.22	.29	.19	.06	.18	.11	.12	-.21	-.31	-.40	.42	.30	-.05	.03	.02
7	Rhythm (Rasinski)							.82	.40	.14	.20	.21	.37	.25	.14	.31	.08	.13	-.31	-.37	-.31	.32	.30	.02	-.05	.12
8	Speed (Rasinski)								.51	.26	.33	.30	.40	.29	.16	.34	.02	.16	-.34	-.45	-.35	.33	.39	.04	-.11	.16
	Writing Competence																									
9	Text Quality logits ("Zoo Texts")									.20	.25	.34	.40	.39	.27	.46	.04	.06	-.32	-.32	-.09	.36	.43	.21	-.08	.24
10	Text Quality - content criteria („ Description of a route")										.62	.43	.36	.44	.29	.32	.13	.12	-.39	-.34	-.08	.14	.42	.30	-.32	.36
11	Text Quality – formal criteria („ Description of a route")											.26	.24	.26	.06	.14	.11	.14	-.28	-.22	-.09	.27	.36	.16	-.21	.24
	Writing Fluency																									
12	Letter level („alphabet task")												.67	.66	.48	.45	.14	.17	-.54	-.53	-.22	.20	.41	.30	-.42	.48
13	Word level													.70	.39	.53	.10	.13	-.47	-.50	-.08	.13	.43	.27	-.33	.39

14	Sentence level	.45	.55	.06	.09	-.48	-.38	06	.21	.44	.32	-.32	.38
15	Median Burst Length		.69	.08	.08	-.34	-.37	.08	.15	.23	.22	-.24	.37
16	Maximum Burst Length			.07	.19	-.31	-.39	.00	.17	.30	.21	-.20	.26
	Working Memory												
17	WISC Digit Span, forward				.34	-.06	-.14	.11	-.01	.03	.06	-.01	.17
18	WISC Digit span, backward					-.17	-.15	-.05	.23	.17	.12	-.28	.10
19	Rapid automatized naming of colours in sec						.70	.05	-.11	-.32	-.30	0.29	-.42
20	Rapid automatized naming of symbols in sec							.16	-.14	-.39	-.17	0.33	-.44
	Spelling												
21	Spelling, number of errors („Zoo texts“)								-.49	.07	.09	-.03	.02
22	Spelling, Proportion of correct words in the total number of written words (“Picture task”).									.26	.11	-.06	.02
	Vocabulary												
23	Vocabulary PPVT Raw score										0.33	-0.31	.27
	Visual-motorical skills												
24	FEW Copying figures											-0.25	.25
25	FEW Visuo-motorical search												.45
26	FEW Visuo-motorical speed												

8.1 Writing Fluency

As expected, there were differences between the grades with increasing transcription fluency in terms of the number of written letters, words and sentences (see table 2), which is an indicator of high validity of the developed test materials (all comparisons between grades $p<.01$). As expected, the median length and maximal length of the bursts, indicating text generation fluency, also increased with grade level. Significant differences were found between grades 6 and 9 and grades 4 and 9. On a descriptive level 6th graders produce 1.5 words per burst more than 4th graders, and grade 9 students more than doubled this score. The high variability in scores is due to some students in grade 9 who managed to produce an extremely small number of bursts, which is somewhat due to the artificial setting of the pause time criterion. Students' pauses are often marginally below the 2 second criterion.

The correlation matrix (see table 3) shows that the tasks assigned to transcription fluency intercorrelate medium to high (r=.66 to .70), explaining up to 49% of the variance. The two variables concerning text generation fluency also intercorrelate in the upper middle range (r=.69). However, the correlation between the constructs is somewhat less (r=.39 to r=.55), explaining only 16%–30% of the variance. A principal component analysis (PCA) revealed a two-factor structure (visual inspection of the scree-plot and Eigenvalue > 1-criterion) and an explained variance of 81.3%. However, there were marginal differences in grade levels concerning fluency on the letter level, but these could not be further investigated because of the small number of students in each grade. In-grade correlations were almost the same across grades (see appendix A). This means that the correlations between the factors were not due to the large range of the student's age in the sample or to general development. In grade 4, a three-factorial structure (letters, words and sentences, bursts) could equally fit the data. Nevertheless, the results of the descriptive analysis and the PCA were a good starting point to test the theoretically predicted two-factor structure of automatized transcription fluency and controlled text generation fluency using a structural equation model.

8.2 Reading Fluency

Concerning reading fluency, there was a significant increase in automatization and partially in prosodic reading between 4th, 6th, and 9th grade students (see table 2). Accuracy, on the other hand, declined slightly. However, this could be attributed to the process of reading aloud, which is unnatural for 9th grade students in contrast to the usual quiet and highly automated reading. Words read out incorrectly were not necessarily repeated correctly, even if the mistake had been recognized. Automatization, on the other hand, measured as correctly read words per minute, was increasing considerably.

The intercorrelations between the variables (see table 3) were high throughout. The correlation between accuracy and automatization and prosodic reading was around .44, whereas the correlations between automatization and prosodic reading variables were between *r*=.64 and *r*=.82. The developmental trajectories and interrelationships suggest a three-factorial structure. The analyses conducted using a PCA rather indicate a one-dimensional structure. For theoretical reasons, however, we have combined accuracy and automation into a single factor (reading speed) because both refer to the process of decoding.

The relationships within grades 4, 6, and 9 were almost the same for correlations between the prosody subscales. Accuracy and automatization correlated slightly higher (see appendix A). These correlations do not indicate an effect of the students' age.

8.3 Connecting Writing and Reading: A Structural Equation Model

The hypothesized relationships among the variables were evaluated using structural equation modeling. Structural equation modeling is a statistical procedure that incorporates the relationship of latent variables and supports the validity of measurements. Our model summarized the components of writing fluency and reading fluency on the one hand and text production competence and reading comprehension on the other hand. In addition to these variables, variables on the resource level of reading and writing, such as working memory, were examined. Figure 1 depicts the complete model. The model's paths and path directions were derived from various studies and theoretical expectations. To evaluate the fit of the model, we used the root-mean-square error of approximation (RMSEA). The proposed model was at the threshold of fit, RMSEA=.075, (90%-confidence interval: $.066 < RMSEA < .085$), $p < .001$. This result points at the proposed model as the most parsimonious one. Most of the correlations do not differ substantially between grades (see Appendix A), so it can be assumed that the following correlations are not artificially caused by the high range of the students' age. However, this should be further investigated. In Figure 1, the path coefficients are also shown without the 9^{th} grade students in order to narrow down the age range. This will be discussed below.

8.3.1 Confirmatory part of the model

Before the model is evaluated, it is investigated whether the manifest variables make an actual contribution to the respective latent constructs.

Writing. The upper part of the model describes writing fluency. From the theoretical considerations we modeled writing fluency as transcription fluency and text generating fluency. Transcription fluency was measured using particularly developed test materials for transcription at the letter level, word level and text level. The confirmatory part of the structural equation model shows a good fit of these three variables to the latent construct transcription fluency. The loads of these variables were .78 or higher. The same applies to the two variables 'median burst length' and 'maximum burst length'. The confirmatory values showed a good fit to the construct. The manifest variables loaded .77 and .88 respectively on the latent construct 'text generating fluency'.

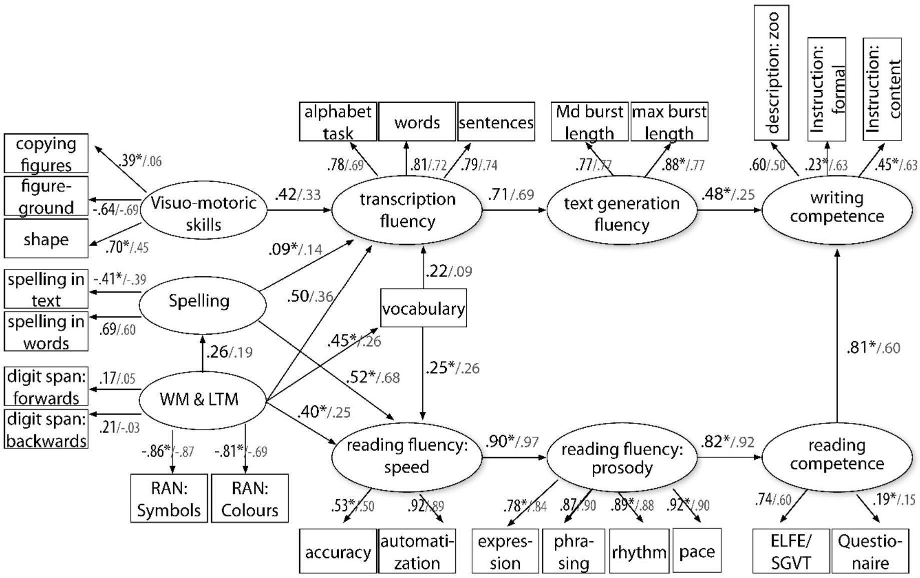

Figure 1. The structural equation model for writing and reading.

Note. Rectangles represent measured variables; circles represent latent factors; paths with single-headed arrows represent directional effects, measurement and structural errors were removed from the figure, * represent significant paths. Values represent path coefficients, large values that do not reach significance have a high SE. Values after the slash represent path coefficients for the sample without 9th grade students (no significant level was calculated due to the small sample).

Reading. The lower part of the model shows reading fluency. Theoretically, we modeled reading fluency as accuracy and automatization, and prosodic reading. Due to a high degree of accuracy, automatization and accuracy were taken together as reading speed. As accuracy is part of automatization by definition, this variable was connected somewhat weaker to the construct of reading speed. The variables measuring prosodic reading loaded between .78 and .92 and thus showed a good fit.

Resource variables. Memory was measured by two different types of tests, both contributing in a different size. Whereas rapid automatized naming loaded well on the latent construct memory (-.81 and -.86), the digital span did not (.17 and .21). For theoretical reasons, we have decided to leave these variables in the model. In fact, eliminating these variables did not make a difference in the overall fit. Since the vocabulary was measured using only one test, no latent variable could be calculated. The variable entered the model as a manifest variable. The loads of the spelling variables were medium sized (-.41 and .69 respectively).

8.3.2 Structural part of the model

Writing and Reading. Considering the structural part of the model, there was a moderate connection between transcription fluency and text generating fluency (β=.71), automatized transcription fluency is thus a moderate predictor (and prerequisite) of the ability to formulate (at least locally) coherent text fluently. The effect of text generating fluency on text quality (or text composition competence) was somewhat lower (β=.48). The model also showed a high connection between automatized reading fluency and prosodic reading fluency (β=.90), the connection between prosodic reading and text comprehension was slightly lower (β=.82).
Automatic processes are encapsulated, that is, 'immune' from interference with competing processes. Transcription fluency and automatized reading fluency depend on more basic resources such as working memory or word retrieval, but they are not dependent on the other fluency variables. For this reason, we did not assume a connection between these variables. Reading and writing are connected via basic skills such as memory, vocabulary and spelling, or via higher order skills such as addressee anticipation or coherence management. These higher order skills were unsystematically collected and therefore not included in the model. The model revealed an influence of reading comprehension on writing but not vice versa (β=.81).

Resource Variables. Memory had a substantial influence on transcription fluency (β=.50) and reading speed (β=.40) as expected. The influence of vocabulary was less than expected (β=.22 and β=.25 respectively). Spelling had only a small influence on writing fluency (β=.09) and a medium influence on reading fluency (β=.52). Visuo-motoric skills had a medium influence on transcription fluency. These results will be discussed in the next section.

9. Discussion

We have introduced writing and reading fluency as constructs embedded in a general theory of language fluency that incorporates automatized and attention-intensive processes. Writing fluency was conceptualized on the basis of Hayes' (2012) cognitive writing process model as a skill comprising two dimensions: automated transcription fluency (the ability to recall and write letters, words and simple sentences quickly) and attention-intensive text generation fluency (the ability to write content coherently and quickly). Reading fluency has been defined in accordance with current theory as automatized reading speed (the ability to read words and sentences accurately and automatically) and the attention-consuming processes of prosodic reading. For both writing fluency and reading fluency, it can be stated that a high level of proficiency releases cognitive resources. Increased writing fluency allows for greater focus on higher processes leading to higher quality texts. High reading fluency leads to better text comprehension.

Differentiation between transcription fluency and text generating fluency. Our first research question focuses on the dissociation of transcription fluency and text generating fluency. It was hypothesized that transcription fluency can be measured independently from text generation fluency. Therefore, new instruments have been developed for this purpose. Unlike Alves and Limpo (2015), our concept of writing fluency is not only about correct spelling and handwriting. In fact, *correct* spelling is not even part of our definition. It also involves the retrieval of letters in the context of words (at least in more frequent words) including the correct grapheme-phoneme correspondence and the retrieval of morpho-syntactically correct forms in the context of a sentence. This is because writing is not just a transcription into disconnected symbols; symbols must be displayed in relation to each other. This is only possible if a context is created for each symbol. The developed and adapted instruments were used to investigate the two dimensions. The confirmational part of the SEM showed high factor loadings on the corresponding latent factors. The model showed a high degree of explained variance for both latent factors and moderate correlations. The assumption that writing fluency can be explained by two factors is supported. These results are consistent with the cascading model of writing (Olive, 2014). According to this model, basic processes such as handwriting ("peripheral levels of processes," p. 179) can impede higher order processes. However, "levels of processing can overlap to a greater or lesser degree, depending on the demands they place on working memory" (p. 187). Parallel processing (Alamargot et al., 2007) is particularly evident in processes of expert writers. Data from this study were collected from writing novices. The processes described may not yet run in parallel. Nevertheless, some longer bursts occurred in grade 9. It can either be assumed that the text was formulated and written in parallel, which means that some students were probably able to write and think at the same time, at least in an easy writing task, or the bursts just did not reach the 2 s criterion.

In order to take this phenomenon into account in the data analysis, the SEM was additionally calculated only with the 4th and 6th grade. Even though the number of subjects is basically too small to obtain a stable SEM, it can be shown that the correlations are similar to the overall model even without the 9th grade. This shows that the correlations are not age-related artefacts.

Differentiation between automatized reading and prosodic reading. As stated in our second research question, results show that reading fluency can be seen as a multidimensional construct comprising an accurate and quick word decoding on the one side (reading speed) and prosodic reading on the other. However, the differentiation between the automatized reading speed and the attention-consuming prosody is not as distinct as that is in the writing process. The confirmational part of the SEM showed high beta weights for automatized reading on the latent factor reading speed; the loading of the manifest variable accuracy was somewhat lower, possibly due to a ceiling effect with accuracy. Factor loadings of the manifest prosodic variables were within an acceptable range. However, the correlation between the two latent factors reading speed and prosodic reading was very high at .91 (82% explained variance). The remaining 18% explained variance could be influenced by higher order processes such as comprehension or is due to measurement error. Nevertheless, it is necessary to discuss anew whether reading speed and prosodic reading are two distinct latent factors.

Relation of reading and writing fluency with comprehension and composition. Our third research question addressed the relationship between the fluency aspects and higher order competences. A low level of transcription skills, a low level of translation skills, or both have an indirect or direct negative effect on text quality due to the need for a large amount of cognitive resources or attention when translating or transcribing. Text generation fluency accounted for an essential part of the writing competence, 23% of the variance in text quality was assigned to text generating fluency. However, it is evident that writing fluency is a necessary but not sufficient component of writing competence. The anticipation of the addressee, perspective taking and the management of global coherence, for example, also play a vital role in the text production.

Similar associations as in writing were shown with respect to the relationship between reading fluency and text comprehension. The results revealed a high correlation between reading comprehension and prosodic aspects of reading fluency; slightly more than 60% of the variance in reading comprehension is explained by the differences in prosodic reading. Future studies should investigate this correlation in more detail, as it is still unclear in which direction the correlations lie. Here, an influence of prosodic reading on text comprehension was modeled on the basis of previous studies; prosody is used to predict the upcoming part of a sentence or text, but it is also used to correct afterwards if the interpretation has gone astray. However, an already understood text paragraph can also lead to a prosodically correct reading. Reading comprehension also serves as a prerequisite for a high level of writing competence. There is evidence that the influence of reading on writing is unidirectional, with over half of the differences in writing explained by the differences in reading while keeping the writing fluency constant. This is consistent with numerous studies; however, the reasons for this are not yet well investigated. A reverse unidirectional or bidirectional relationship led to a lower model fit.

Excluding the 9th grade from the sample showed a lower influence of reading comprehension on writing competence. It is possible that 9th grade reading plays a greater role in the revision of the written text. 4th and 6th graders revise their texts at a lower degree. This correlation has to be investigated further with a larger sample.

The theoretical explanations and empirical data presented here show the high relevance of the fluency aspects for the acquisition of writing and reading. It is therefore all the more surprising that writing fluency in particular has received little attention in German-speaking countries so far, both in educational research and in teaching practice. Training methods for writing and reading fluency based on the abovementioned theoretical concepts have hardly been available so to date.

Relationships with resources. Our fourth research question is less specific than the previous. It elaborates the influence of cognitive resources on writing and reading fluency. Memory turned out to be one substantial influence on transcription fluency (here in particular the retrieval from long-term memory) and reading speed. This is not surprising because these processes require memory capacity. The working memory capacity tests only slightly load the memory factor. This indicates the degree of automatization of transcription fluency and reading fluency, because high fluency relieves the working memory, so that differences in working memory performance have less effect. However, fast retrieval from long-term memory is a prerequisite for fluent writing and reading. In the SEM, this is demonstrated by the high load of the rapid automatized naming tasks and the high correlation with writing and reading fluency. Visuo-motoric skills are another influence on transcription fluency because these processes are particularly important in handwriting. The relationship between the vocabulary and the fluency aspects proved to be very low and not in line with theory. Therefore, the productive vocabulary in the produced texts is currently being investigated using databases on the frequency of words in (children's) texts in addition to the type-token ratio. The influence of spelling on transcription in our model was somewhat small. Former research has shown a high correlation between spelling and fluency. This difference may be due to the fact that no explicit spelling test was conducted. The effect of too good a spelling, i.e., a ceiling effect in the higher grades could also have led to a reduction in the effectiveness. Excluding the 9th grade students from the sample leads to a slightly higher correlation. Another reason for the weak correlation between correct spelling and transcription is the fact that also a wrong spelling can lead to high transcription fluency – as long as spelling is automatized (Lemke, 2021). However, this ceiling effect is contrasted by the positive correlation with reading fluency.

Limitations and conclusion. Although unidirectional paths can be modeled and give some evidence for causal relations, to test a causal relationship between two variables experimental research is necessary. Structural equation models are never "evidence" for a concrete structure, so that the structure given must be examined and validated in further studies. However, the acceptable fit of the structural equation model showed that the model fits satisfactorily and provides a solid basis for further studies.

The theoretical assumption behind the model is that processes that can be automatized affect those fluent processes that cannot be automatized and therefore require attention, but which nevertheless run quickly and interact with the automatized processes. It must be stated that the translation process in the writing process models is still very under-specified. Some parts of this process can presumably be automatized such as grammar, some cannot be automatized but differ in speed (lexical retrieval of common vs. uncommon words, use of connectors to manage local cohesion), while other subprocesses of the translating process cannot be automatized at all (e.g., linearization of propositions). The process of translating (better: formulating) requires closer examination to differentiate automatized and attention-consuming processes within translating. Additionally, although the model shows a close connection between translating and transcription, it does not yet make predictions about how these processes occupy working memory, i.e., how the "switching" from one process to another occurs, in particular in the case of writing novices who are beginning to automatize handwriting, typing, orthography and the like but are still in the "thinking-and-then-writing"-mode (Olive & Cislaru, 2015, p. 102).

The translating process was measured by using bursts. No distinction was made whether bursts were in a writing or a revision phase. P-bursts and R-bursts (Baaijen et al., 2012) were not distinguished. This was done on the assumption that writing fluency is the same no matter where it happens, in the ongoing writing process or while writing a revision. As this is an assumption, the impact needs to be verified.

It can be assumed, that the relationships between the variables shown are not the same across all grade levels. The presented model shows one potential connection between the dimensions of the writing and reading fluency on one side and their corresponding competences on the other side. In the model, however, all grades had to be combined in order to get enough participants. In future research, subgroups should be large enough to calculate differences between grade levels, as it is likely that relationships are not the same for all grades. In particular, in the case of processes that will be automatized with age (transcription fluency and reading speed), there should be less variance in the lower and higher grades due to floor- and ceiling effects, and a larger variance in the middle grade with some students displaying lower skills and others displaying higher skills. However, the data showed a different picture: While no difference in the variances could be observed in the reading speed, the variance of the transcription fluency rather increased between the grade levels. This could influence the relationship with more basic processes and with processes consuming more attention. In fact, the correlation between translation and writing quality was lower when grade 9 students were excluded from the sample.

An intervention related to writing fluency would focus on the differentiation into automatized and attention demanding processes. In case of an intervention on reading fluency it would be useful to focus on controlled prosodic aspects, as these were not considered thoroughly enough in previous research.

Writing fluency and reading fluency were placed in the context of models of language fluency in particular in Levelt's 1989 model of speech production. It would be interesting to extend the model by adding components of oral fluency and listening fluency to provide a unitary theory of speech production and reception of all four modes, reading, writing, speaking, and listening.

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Appendix A

Table A1: Correlations between all measures by grade.

	Measure	Grade	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
	Reading comprehension																										
1	Standardized Reading Test Scores	4	.24	**.62**	**.86**	**.60**	**.70**	**.72**	**.81**	**.56**	**.29**	**.38**	.13	.28	.08	**.36**	.29	.09	.23	.03	-.21	-.17	**.51**	**.41**	.18	.04	-.16
		6	.13	.08	**.50**	**.44**	**.57**	**.35**	**.48**	.09	**.32**	**.30**	.22	.23	.22	-.02	.08	.27	-.06	-.06	-.11	-.01	.00	**.35**	.13	-.12	-.08
		9	.16	.16	.31	.18	.29	.29	.31	.29	-.01	.04	-.17	-.23	.00	.05	.15	**-.32**	**-.37**	-.03	.11	-.22	**.37**	.31	.13	-.16	-.01
2	Questionnaire Reading Fluency	4		.31	.28	.38	.20	.26	.20	-.06	**.32**	.09	.01	.21	.16	.18	.31	.09	.01	-.01	.07	-.07	.11	.27	.28	.22	-.16
	Texts	6		.09	.19	.19	.28	.15	.24	.01	**.39**	**.34**	-.03	-.04	-.01	-.14	.05	.02	.13	-.05	-.06	-.02	.04	**.31**	.04	**-.35**	.22
		9		.15	-.01	.09	.15	.28	.14	.10	.05	.15	-.04	-.10	-.02	-.38	-.41	-.08	.00	-.12	-.12	.20	-.20	**.40**	-.03	**-.32**	.06
	Reading fluency																										
3	Accuracy	4			**.73**	**.64**	**.66**	**.66**	**.71**	**.47**	**.44**	.30	.08	.24	**.32**	**.44**	**.43**	.08	.14	-.31	**-.46**	-.23	**.32**	**.44**	**.33**	-.05	.14
		6			.19	.25	.32	.26	.27	.07	.10	**.56**	-.29	-.14	-.19	.00	-.09	.21	.21	-.08	.00	**-.52**	.03	.00	**-.32**	.24	-.24
		9			**.39**	**.56**	**.51**	.24	**.36**	.17	.12	.01	.28	.04	-.01	-.19	-.03	.17	.21	-.21	-.17	**-.47**	**.60**	.03	-.05	-.02	-.29
4	Automatization	4				**.81**	**.85**	**.87**	**.91**	**.59**	**.42**	**.44**	.29	**.44**	.26	**.48**	**.35**	.21	**.39**	-.22	**-.37**	-.18	**.47**	**.43**	.24	.04	-.02
		6				**.63**	**.73**	**.70**	**.69**	.20	.19	.31	.09	.04	.09	.17	.09	-.02	-.06	-.12	**-.30**	**-.39**	**.42**	.11	-.27	.02	.04
		9				**.56**	**.49**	**.52**	**.58**	.18	-.04	-.09	.20	.07	**.35**	.03	.03	.25	-.04	**-.46**	**-.31**	-.13	.22	.04	-.22	-.08	.04
5	Stress	4					**.76**	**.79**	**.77**	**.42**	**.44**	**.39**	.24	**.41**	.16	**.41**	.31	.21	**.33**	**-.36**	**-.35**	-.12	**.34**	**.49**	.28	.04	.07
		6					**.80**	**.76**	**.75**	**.32**	.21	**.34**	.00	.26	.10	.04	.18	.02	.07	-.21	-.23	-.23	.27	.11	-.16	.01	.18
		9					**.55**	**.59**	**.51**	.18	-.24	-.03	.32	.02	.13	-.04	.09	.06	-.06	**-.35**	**-.36**	-.22	**.32**	.09	-.04	.13	-.09
6	Phrasing	4						**.84**	**.84**	**.51**	.30	**.35**	.26	**.43**	**.35**	**.47**	.30	.19	**.38**	-.18	-.28	-.18	**.44**	**.41**	.19	.15	-.02
		6						**.74**	**.75**	.26	.25	**.32**	.07	.23	.11	-.06	.09	.10	.01	-.09	-.24	**-.37**	.35	.24	-.20	.00	.03
		9						**.72**	**.76**	**.52**	-.19	.01	.06	-.06	-.08	-.21	-.03	.02	-.20	-.08	-.21	-.31	**.41**	.05	**-.38**	.24	-.17
7	Rhythm	4							**.88**	**.45**	.31	.30	.20	**.51**	.28	**.51**	**.43**	.17	.24	-.27	**-.34**	-.18	**.37**	.29	.30	.03	.01
		6							**.75**	.16	.10	.17	.02	.27	.22	.06	.27	-.05	.08	-.15	-.26	**-.40**	.29	.16	-.24	.04	.06
		9							**.82**	**.45**	**-.47**	-.21	.10	.00	.01	-.13	.04	-.07	-.16	-.24	-.26	-.13	.14	.14	**-.39**	.13	-.02
8	Speed	4								**.55**	**.44**	**.45**	.20	**.48**	.28	**.50**	**.37**	.06	.23	-.30	**-.43**	-.24	**.31**	**.45**	.26	-.01	.00
		6								.28	.20	.29	.04	.20	.18	.11	.28	.02	.16	.00	-.28	-.29	.29	.17	-.24	.03	.16
		9								**.46**	**-.44**	-.16	.07	-.05	-.10	-.27	-.01	-.13	-.15	-.21	-.25	-.20	.26	.07	**-.37**	.18	-.08
	Writing competence																										
9	Text quality logits	4									.21	**.40**	.26	.19	.18	**.46**	**.32**	.05	.19	-.14	-.16	.09	**.33**	**.36**	.14	.10	.19
		6									.12	.22	.11	.02	.10	.16	**.42**	-.06	.02	-.08	-.01	-.04	.25	.06	.06	.06	**.31**
		9									**-.37**	-.22	-.16	.19	.14	-.07	.34	.00	-.24	-.09	-.12	.05	.30	.28	-.09	.10	-.20
10	Text quality - content criteria	4										**.60**	.15	.04	.23	.06	.23	.00	.15	**-.34**	-.23	.00	.13	**.53**	**.40**	.03	.11
		6										**.62**	**.30**	.22	**.29**	.16	.20	.23	-.02	-.22	-.19	.02	.11	.36	-.07	-.26	.12
		9										**.55**	.10	-.04	.20	.10	-.07	.12	.00	-.05	.05	-.12	-.17	-.14	.17	**-.44**	**.32**
11	Text quality – formal criteria	4											.26	**.31**	.20	.11	.19	.10	**.30**	-.26	-.25	-.06	**.34**	**.44**	**.45**	-.13	.23
		6											-.02	-.01	.09	.01	.10	.22	.04	-.10	-.02	-.24	.11	.27	-.18	.05	-.03
		9											.17	-.07	.19	-.21	-.16	.00	-.18	-.17	.04	-.08	.06	.10	-.02	**-.33**	.25
	Writing fluency																										
12	Letter level	4												.12	.08	.26	.06	.14	.27	**-.23**	-.14	.25	.00	.19	.24	-.23	.20
		6												**.59**	**.36**	.29	.29	.06	-.15	**-.31**	-.11	.19	-.01	-.01	.10	-.31	.26
		9												**.40**	**.34**	**.38**	.30	**.41**	.27	**-.41**	**-.55**	**-.34**	.11	.04	.02	-.27	**.38**
13	Word level	4													**.56**	**.37**	**.38**	-.04	.04	-.12	-.14	.02	-.05	-.02	.19	-.03	.01
		6													**.45**	.14	**.39**	.00	-.10	**-.35**	**-.31**	.10	-.12	.09	-.18	-.21	.19
		9													**.50**	.05	.32	.24	.09	-.16	-.24	-.12	.08	.21	-.13	-.15	.22
14	Sentence level	4														**.30**	**.38**	-.11	-.04	-.05	.08	.00	.00	.14	**.34**	.11	-.13

		6	.23	**.41**	-.14	-.21	-.11	.03	.03	.11	-.05	.15	-.05	.24
		9	.23	.38	**.38**	.22	**-.53**	-.22	.00	.08	.31	.08	-.30	.24
15	Median Burst Length	4		**.56**	-.12	.02	**-.37**	**-.31**	.02	.10	.10	.04	-.09	.14
		6		**.59**	.03	-.25	-.23	-.19	.20	.06	.01	-.15	-.15	.20
		9		**.64**	.36	.07	-.07	-.31	.15	.10	.00	.23	-.13	.30
16	Maximum Burst Length	4			-.01	.06	-.13	**-.32**	.04	.04	.09	.00	.01	.11
		6			-.02	.04	-.13	-.20	.18	.12	.04	-.08	-.27	.18
		9			.40	.26	-.03	-.01	.03	.21	.11	.08	.02	.03
	Working Memory													
17	WISC Digit Span, forward	4				**.48**	.01	-.21	-.06	.17	-.05	-.08	.15	.24
		6				.03	.12	.07	.13	**-.40**	.03	-.08	-.14	**-.35**
		9				**.33**	-.22	-.27	.15	.04	-.02	-.08	-.13	.26
18	WISC Digit span, backward	4					.09	-.15	-.05	**.32**	.28	-.06	-.21	**.36**
		6					-.13	.07	-.24	.13	-.15	.10	**-.38**	-.14
		9					**-.40**	-.09	.09	.12	.05	.10	-.21	-.13
19	Rapid automatized naming of colours in sec	4						**.65**	.15	.05	-.06	-.21	-.08	-.21
		6						**.39**	.10	-.14	.18	-.14	**.31**	**-.51**
		9						**.61**	.02	.00	-.13	-.03	**.37**	-.27
20	Rapid automatized naming of symbols in sec	4							.01	.03	-.19	.02	.13	**-.31**
		6							.29	-.20	-.23	.18	.14	**-.32**
		9							.03	.05	.12	-.07	.27	**-.33**
	Spelling													
21	Spelling, number of errors (“Zoo texts”)	4								**-.34**	-.02	-.09	.01	.10
		6								**-.45**	.04	**.34**	-.17	.14
		9								**-.46**	.14	-.06	-.01	.05
22	Spelling, Proportion of correct words in the total number of written words (“Picture task”).	4									**.33**	.18	.02	.01
		6									-.01	-.10	.08	-.10
		9									.12	.16	.04	-.26
	Vocabulary													
23	Vocabulary PPVT Raw score	4										**.42**	-.14	.14
		6										-.07	.02	.06
		9										.12	-.26	-.02
	Visuo-motorical skills													
24	FEW Copying figures	4											-.02	.04
		6											-.13	.08
		9											**-.30**	.08
25	FEW Visuo-motorical search	4												**-.41**
		6												-.13
		9												**-.48**
26	FEW Visuo-motorical speed	4												
		6												
		9												