Modeling the Development of Reading Comprehension

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Chapter 13

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A skilled reader can derive the meaning from a printed text rapidly and effortlessly. Becoming a skilled reader takes time and practice and is one of the main goals of primary school education. Since the previous edition of this book in 2005, research in this area has flourished and there are now many longitudinal studies examining how reading comprehension develops. This chapter will focus on what we know about the development of reading comprehension in the early school years, with a particular emphasis on understanding causal processes.

1. Theoretical foundations for reading comprehension development

According to the simple view of reading, reading comprehension is the product of decoding and language comprehension. Decoding refers to the ability to read isolated words quickly and accurately. The second component, originally labeled linguistic comprehension, deals with how meaning is derived from text once it has been decoded (Gough & Tunmer, 1986). Linguistic comprehension is typically assessed using tests of listening comprehension in which a person answers questions about the meaning of a spoken passage (see Hoover & Gough, 1990). Linguistic comprehension can be thought of as global assessment of a person's linguistic abilities and taps many sub-skills including vocabulary, syntax and word knowledge (Lervåg, Hulme & Melby-Lervåg, 2018). Finally, the product term in the simple view of reading implies that if either component is zero, reading comprehension cannot occur, because the product will be zero (Gough & Tunmer, 1986).

Although the simple view of reading has been highly influential theoretically, especially in studies of early reading development (for a review, see Hjetland et al., 2020), several other models and frameworks have been developed that focus on older children and skilled readers (Cromley & Azevedo, 2007; Kim, 2017; McNamara & Kintsch, 1996; Perfetti Landi & Oakhill, 2005; Perfetti & Stafura, 2014). These tend to be more fine-grained, focusing on the interplay between a range of different cognitive and non-cognitive operations

and abilities. It can be argued that it is more useful to see them as frameworks than models, since they are not well-specified and their complexity renders them less falsifiable than the simple view. Nevertheless, they have been influential and are often used to argue for a "less simple" view of reading (e.g., Joshi & Aaron, 2000; Kirby & Savage, 2008).

2. Understanding the development of reading comprehension— methodological considerations

Most longitudinal studies seeking to explain the development of reading comprehension use either autoregressive or a growth curve models. In an autoregressive model, later reading comprehension is predicted from (regressed on) earlier reading comprehension (the autoregressor) along with measures of the theoretical constructs that are believed to be causally related to the growth of reading comprehension (e.g., decoding, linguistic comprehension, working memory, etc.). By regressing later reading comprehension on earlier reading comprehension, such studies assess whether particular predictors are related to *changes* in reading comprehension between the beginning and end of a study (i.e. whether the change in the rank order of children is predicted by these various theoretical constructs). For instance, Ricketts et al. (2020) examined the reading comprehension of adolescents in Grades 7, 8 and 9. Although reading comprehension scores increased over this period, the rank ordering of their performance remained almost completely unchanged and, hence, there was no room for other variables to predict change.

A different approach to measuring the development of reading comprehension over time is to use individual growth curve modelling. Growth curve models use raw data collected from each individual at several time points. The models estimate several parameters including the intercept (typically the starting value) and the slope (the rate of growth) as well as variations in these parameters between children. In addition, there may be estimates of the degree of curvature to such growth trajectories. Both the average rate of growth and

variations in the rate of growth are interesting parameters. To find out whether a predictor associated with the rate of growth in reading comprehension is independent of any association with how good a child's reading comprehension is when it is first assessed, the rate of growth across individuals can be regressed on the starting value (to avoid confounding any association between the predictors and rates of growth with their association with initial levels).

The measures postulated to be important in the simple view of reading can be used in growth curve models as predictors of the growth of reading comprehension. For instance, in the study by Hjetland et al. (2019) that traced children from 4 years to 4th grade, measures of linguistic comprehension and decoding explained 99.7% of the variance in the starting levels of reading comprehension in second grade and 30.7% of the variance in growth rates up to the 4th grade. Similarly, in a study by Lervåg et al. (2018) such measures explained 95% of the variance in initial levels of reading comprehension in the middle of second grade, 27% of the variance in early growth and 64% of the variance in later growth up to 6th grade.

Regardless of whether one uses autoregressive, or growth curve, models there may be problems when the aim is to estimate the relationship between several predictor variables and an outcome, such as reading comprehension. One difficult issue is measurement error. Measurement error is present in all simple measures to varying degrees and serves to weaken the relationship between variables. When we simply want to estimate the correlation between two variables, measurement error is not a problem. If we know the degree of measurement error in each variable it is easy to estimate what the strength of the relationship would have been if the variables had been measured without error (Cole & Preacher, 2014). However, with several predictor variables with varying amounts of measurement error, it becomes difficult to judge what the outcome of a multiple regression would have been without measurement error (Cole & Preacher, 2014). When predictor variables have differing degrees

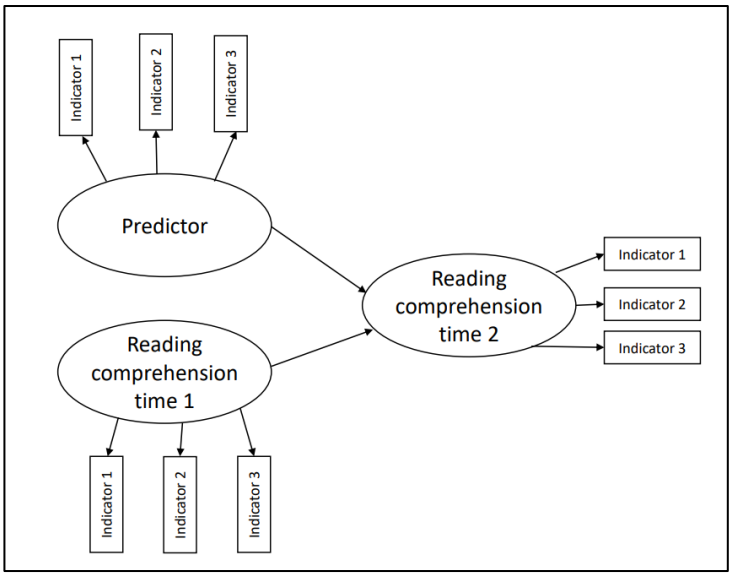
of measurement error, variables with lower measurement error will tend to appear more important predictors of an outcome (e.g., reading comprehension) than variables with higher measurement error. It is important therefore, to have measures with low measurement error (high reliability) and to report reliabilities for all measures from the sample being studied.

One way of avoiding the influence of measurement error is to use latent variables as predictors instead of observed variables. A latent variable is what is common (the factor) for a set of observed variables. Latent variables are typically considered to reflect a theoretical construct (e.g. using measures of vocabulary, syntactic, and morphological skills as indicators of linguistic comprehension). Using a single latent variable with multiple indicators to predict reading comprehension eliminates the effects of measurement error.

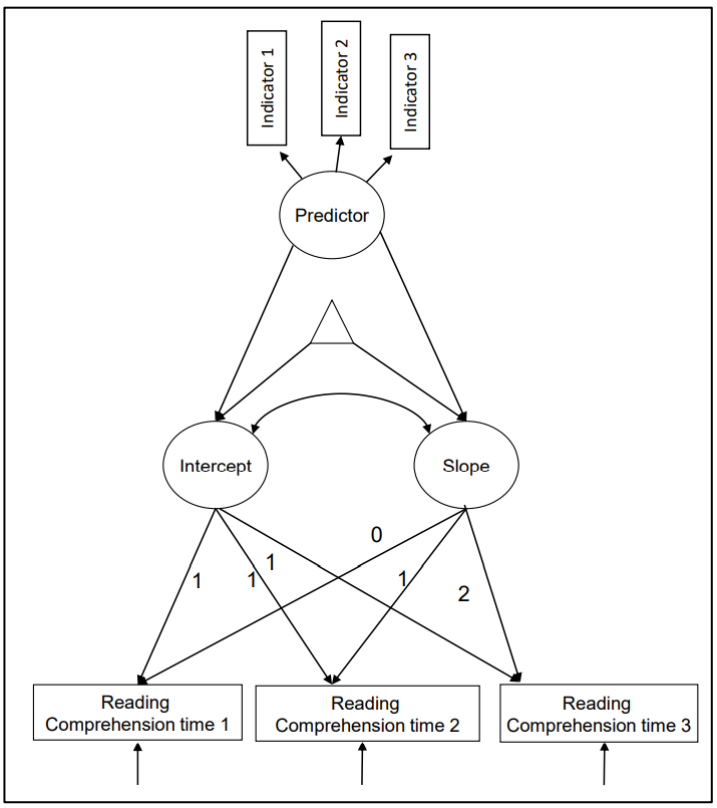
If it is not possible to form latent variables, two options can be used to control for the possible biases introduced by measurement error. One option is to divide the items of a test (e.g., a vocabulary test) into parcels and use them as indicators of a latent variable. A second option is to control for measurement error by estimating what the regression coefficients would have been without measurement error. Here, by estimating latent variables with single indicators, one can fix the error variance of the observed variables to be equal to an estimate of the error variance in the sample (e.g., alpha). Both these options will even out the differences between the predictor variables caused by the differences in measurement error, thereby producing more accurate estimates (Cole & Preacher, 2014).

Figure 1. Examples of models to investigate the development of reading comprehension

Panel A: Example of an autoregressive latent model



Panel B: Example of a growth model



3. Understanding the development of reading comprehension—what do we know?

The simple view of reading posits that reading comprehension is a function of two core skills: word decoding and linguistic comprehension. However, this tells us little about the development of these core skills or how they relate to the growth of reading comprehension.

In fact, word decoding and linguistic comprehension have different developmental trajectories: although linguistic comprehension gradually develops from birth, children only typically start to learn to decode words when they start school. It follows that children's reading comprehension in the early grades will depend heavily on the degree to which they have learned to decode words (Foorman et al., 2018; Language and Reading Research Consortium & Chiu, 2018). Two recent studies showing a curvilinear relationship between word decoding and reading comprehension in the early school years support this view (Hjetland et al., 2019; Lervåg et al., 2018). The curvilinear relationship implies that word decoding is more strongly related to reading comprehension in children with poor decoding skills than children with good decoding skills. To put this another way, the relative importance of word decoding and linguistic comprehension for reading comprehension changes as a function of decoding ability. In the early stages of learning to read, comprehension will be heavily influenced by the level of a child's decoding skill. If decoding skills are poor, there will be little influence of linguistic comprehension on reading comprehension. If a child is unable to decode a text, it follows that they will not be able to understand it even if they would understand the text perfectly if they listened to it. In line with this, some studies confirm that the relationship between linguistic comprehension and reading comprehension varies as a function of the level of word decoding (e.g., Lervåg et al., 2018), although findings are mixed (e.g., Hjetland et al., 2019).

According to the simple view of reading, linguistic comprehension becomes a more important influence on reading comprehension in older children because, by then, word decoding has become proficient. In support of this, several longitudinal studies show faster growth in reading comprehension during the early school years when children are rapidly improving their decoding abilities, in comparison to the later school years (e.g., Lervåg et al., 2018). In general, these studies also find that word decoding predicts early, but not later,

variations in reading comprehension even after the differences in initial reading comprehension have been controlled (e.g., Foorman et al., 2018; Language and Reading Research Consortium & Chiu, 2018; Lervåg et al., 2018). Linguistic comprehension, on the other hand, predicts variations in the development of reading comprehension over a longer time period. For instance, Lervåg et al. (2018) found that a listening comprehension latent variable predicted variations in the growth of reading comprehension both between Grades 1 and 3 and Grades 3 and 7.

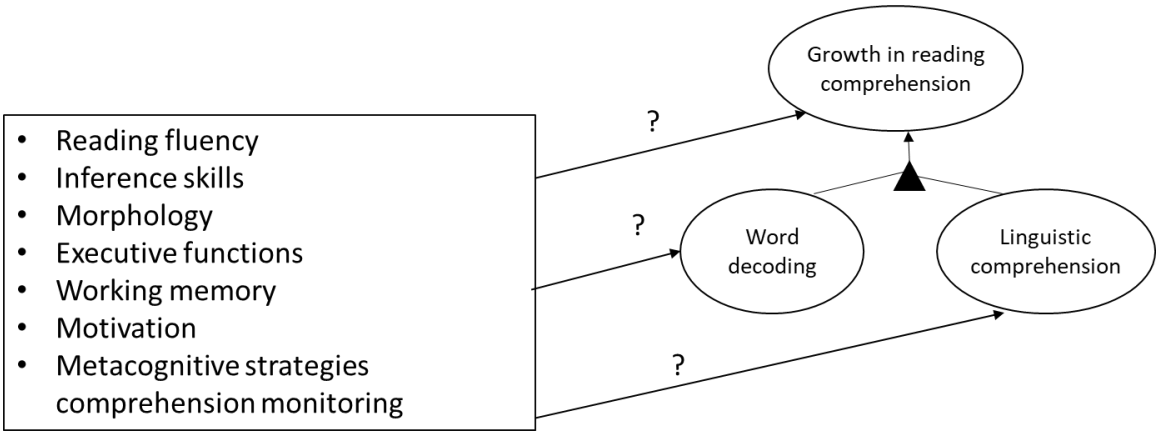
Later in development, individual differences in reading comprehension become highly stable and more or less isomorphic with individual differences in linguistic comprehension. Ricketts et al. (2020), in a study of adolescents assessed in Grades 7, 8, and 9, found that a latent vocabulary construct reflecting linguistic comprehension could not be differentiated from a latent reading comprehension construct .

Finally, despite differences in the regularity or transparency of different written languages, evidence for the simple view of reading has been found for several alphabetic orthographies. Caravolas et al (2019) showed that both a listening comprehension latent variable and a latent decoding variable predicted later reading comprehension in the middle of Grade 2 in Spanish, Czech and Slovak samples. However, in their English sample, only decoding predicted later reading comprehension. The strong influence of decoding and the lack of influence of linguistic comprehension on reading comprehension in the middle of Grade 2 in the English sample was interpreted as being due to the difficulties of learning to read the inconsistent English orthography in contrast to the relative ease of learning to decode in the more consistent Spanish, Czech and Slovak orthographies. Since it takes longer to learn to decode in the inconsistent English orthography, reading comprehension was still dominated by the ability to decode words in the middle of Grade 2.

4. Is the simple view of reading is too simple?

Although the simple view of reading has strong empirical support, it has been suggested that various components should be added to it (Geva & Farnia, 2012; Joshi & Aaron, 2000; Kirby & Savage, 2008). Here, we discuss some of the most common suggestions (see Figure 2) and evidence for them. Some, but not all, of the components in Figure 2 are thought to have both a direct and indirect relationship with reading comprehension.

Figure 2. Potential additional predictors of reading comprehension beyond the simple view of reading.



We place an emphasis here on evidence from longitudinal studies of typically developing children published between 2004 and 2020. However, if children with language and reading disorders are at the lower end of the distribution with no qualitative differences or nonlinear effects (Astle et al., 2020), the results should also generalize to these groups.

4.1 Reading fluency—a bridge between decoding and comprehension?

In English-speaking samples, word decoding is typically measured using tests of word reading accuracy though in recent years, word-list reading fluency measures have often been incorporated into assessment batteries. Beyond word reading accuracy, text reading fluency may place an additional constraint on reading comprehension because it draws on “higher

level" linguistic skills as well as the ability to recognize isolated words (Altani et al., 2020; Kim et al., 2014; Silverman et al., 2013; Tilstra et al., 2009). Thus, reading fluency could influence reading comprehension because if you are slow at decoding, this can draw on the resources that otherwise could be used to process meaning. Fluency might also be related to reading comprehension because linguistic comprehension underlies both of them. Indeed, as texts become more complex, readers need to be able to read them quickly and fluently and reading accuracy is unlikely to be sufficient for good reading comprehension (Adlof et al., 2006). Thus, at least in older children, it has been suggested that text reading fluency might make an independent contribution to reading comprehension.

Some cross-sectional studies provide support for the view that passage reading fluency is an additional predictor of reading comprehension. Silverman et al., (2013) found that although 88% of the variance in reading comprehension was explained in a model without reading fluency, this increased to 95% when fluency was added to the model. Similarly, Tilstra et al., (2009), found that there were unique contributions from reading fluency to the prediction of reading comprehension (5%, 8%, and 10% in fourth, seventh, and ninth grades, respectively, (N = 279)), although, another cross-sectional study found no unique contribution (Adlof et al., 2006, N = 604). There are few longitudinal studies relevant to this issue. However, Kim, Wagner and Lopez (2012) followed children learning to read from Grade 1 to Grade 2 (N = 270), and found that text reading fluency was uniquely related to reading comprehension in Grade 2 after controlling for list reading fluency (the speed of reading lists of unrelated words), but not in Grade 1 where only list reading fluency was important for reading comprehension (after accounting for listening comprehension). Kim et al.'s (2012) study uses latent variable models, but it did not control for the autoregressor and therefore cannot address the factors responsible for the *growth* in reading comprehension.

4.2 Inference skills

It has been suggested that the ability to draw inferences from text requires "reading between the lines", to a greater extent than when the same information is presented orally (Cain & Oakhill, 1999). Arguably, however, inferential skills are also critical for the development of listening comprehension, which, in turn, affects reading comprehension (Lepola et al., 2012). In addition, it has been proposed that they have a direct influence on reading comprehension (Cromley & Azevedo, 2007; Cain & Oakhill, 1999; see also Perfetti & Stafura, 2014).

The results from longitudinal studies of the relationship between inferencing skills and reading comprehension are mixed. One latent variable growth study examined inference skills together with other language skills, tracing 198 children from second grade through seventh grade (Lervåg et al., 2018). The results showed that inference skills did not predict reading comprehension, once the variance that it had in common with a latent language construct was accounted for. The latent language variable, on the other hand, predicted listening comprehension almost perfectly, and listening comprehension was strongly related to growth in reading comprehension. Another study by Oakhill and Cain (2012) traced children from 7–8 years to 10–11 years (N = 102). Verbal IQ, vocabulary, inference skills, comprehension monitoring, and knowledge of story structure were significant predictors of reading comprehension in 6th grade beyond the autoregressor (inference ability uniquely explained 6% of variance); the study used a path model with observed variables which means that its results may be biased by measurement error and so should be interpreted cautiously. Silva and Cain (2015) reported similar findings in younger children (a unique contribution of inference skills to the prediction of reading comprehension of 7%).

4.3 Morphology

Morphemes are the smallest meaning-bearing units in language. It is suggested that lexical and syntactic knowledge of morphology indirectly influences reading comprehension

(Perfetti, 2007). Moreover, morphology may also have a direct effect on reading comprehension because it is an integral component of the language comprehension system (Deacon et al., 2014).

Some longitudinal studies have found that morphological awareness is a predictor of reading comprehension even after the effects of other language skills have been controlled. Deacon et al. (2014) traced children from the third to fourth grade (N = 100); they found both an indirect and direct effect of morphological awareness on reading comprehension, after controlling for the autoregressor, nonverbal IQ, phonological awareness, and vocabulary (standardized regression coefficients = 0.24 in Grade 3, 0.30 in Grade 4). This study used path models with observed variables. Another study by Manolitis et al., 2017 (N = 215) traced children from kindergarten to second grade and found that morphological awareness in kindergarten and first grade accounted for 2–5% of unique variance in reading comprehension after controlling for the autoregressor and components in the simple view (i.e. decoding and linguistic comprehension). The study used observed variables, i.e. measurement errors were not controlled. A similar result was also found by Diamanti et al. (2018, N = 236).

Unfortunately, there are few longitudinal studies of morphological awareness and reading comprehension that use latent variables. In one such study, tracing children from third grade to fourth grade, morphological analysis and morphological awareness were latent variables, while the other constructs are observed (Levesque et al., 2019, (N = 197)). The results showed that morphological analysis, but not morphological awareness, predicted the development of reading comprehension after controlling for the autoregressor, phonological awareness, word reading, nonverbal ability, and vocabulary. However, in contrast, Lyster et al (2019) (N = 323) traced children from kindergarten to ninth grade and found that in kindergarten the best fitting model was one in which phonological, morphological, and semantic skills were conceptualized as a single language latent variable . This broad language

latent variable accounted for 69.2% of the variance in reading comprehension in ninth grade. Thus, the results concerning the specific role of morphology in the development of reading comprehension are mixed; several studies suggest that morphology plays a role but only insofar as it taps broader oral language construct.

4.4 Executive functioning

Executive functions refers to cognitive abilities involved in the control and monitoring of thoughts and behavior (Miyake et al., 2000). Executive functions are typically conceptualized as abilities such as shifting (cognitive flexibility), inhibition, planning, selective and sustained attention, and also some aspects of working memory (Karr et al., 2018; Miyake et al., 2000). Shifting is said to be important for reading comprehension because to understand the meaning of a text, readers have to switch between the different perspectives in a story (e.g. from one person to another). Also, shifting is considered to enhance the ability to create meanings by connecting new and old information or to be flexible in the use of strategies that facilitate comprehension, such as in re-reading or skimming (Kieffer et al., 2013). Inhibition, is thought to facilitate reading comprehension because it enables the reader to suppress irrelevant information (Borella et al., 2010; Kieffer et al., 2013). Planning is thought to contribute to reading comprehension by allowing the reader to create strategies used both before and during reading, including monitoring and revising the text (Cutting et al., 2009). Finally, it has been suggested that selective and sustained attention are involved in regulating the contents of working memory and keeping cognitive resources focused on tasks long enough to create a meaning-based representation of the text (Arrington et al., 2014).

Cross-sectional studies of the relationships between reading comprehension and measures of executive function show inconsistent findings. Some report a unique contribution from executive functions (Cirino et al., 2019, N = 846, unique contribution 1%; Christopher et

al., 2012, working memory p = .01 processing speed p =.08, N = 483). Others, however, show only indirect effects (Spencer et al., 2020, N = 271).

Longitudinal studies of these issues are scarce. Röthlisberger et al., (2015) found that kindergarten executive functions explained some variance in reading comprehension in second grade and third grade after controlling for vocabulary, socioeconomic background, and nonverbal IQ (N = 323). However, neither decoding nor the autoregressor were included in this model which used observed variables. Nouwens et al., (2020) in a one-year longitudinal study showed that both working memory and planning were unique predictors of reading comprehension, after controlling for decoding and linguistic comprehension (N = 113). Further, working memory and inhibition had an indirect effect on reading comprehension via decoding. However, the study did not control for the autoregressor (earlier reading comprehension) and used observed variables. Finally, in a recent longitudinal latent variable study tracing children from the beginning until the end of second grade, reading comprehension was related to executive functions (Dolean et al., 2021, N = 184). However, in this study, only linguistic comprehension independently predicted the development of reading comprehension over time. In summary, evidence that executive functions play a unique role in supporting the development of reading comprehension is sparse.

4.5 Working memory

As discussed earlier, there are theories of reading comprehension that consider working memory to be a part of executive functioning. However, there are also influential theories that consider working memory to be an independent construct. Such theories argue that working memory is an important component of reading comprehension because in order to comprehend text, a reader must be able to hold information in memory while processing new information (Daneman & Carpenter, 1980; Just & Carpenter, 1992). Indeed, it has been suggested that working memory plays both a direct and an indirect role as a predictor of

reading comprehension. Thus, verbal working memory ability is not only required to facilitate the process of reading comprehension but it has also been suggested to play an important indirect role as a predictor of reading comprehension via its effects on language comprehension (potentially because working memory is a driver of vocabulary development; Baddeley et al., 1998; but see Melby-Lervag, Lervag, Lyster, Klem, Hagvet & Hulme, 2012 for an alternative view).

Several longitudinal studies have examined the role of working memory in reading comprehension. Seigneuric and Ehrlich, 2005 (N = 74) found that vocabulary in first grade and working memory in second grade were unique predictors of third-grade reading comprehension beyond the autoregressor (unique contribution 4%). Further, tracing children from 8 to 11 years of age, Cain et al., (2004) showed that at each time point, working memory, inference making, comprehension monitoring, and story structure knowledge explained unique variance in reading comprehension after word reading ability and vocabulary were accounted for (Cain et al., 2004, unique contribution 5–7%, (N = 102)). However, the study by Cain et al., (2004) used regression analyses on observed variables and did not control for autoregressors. Studies with latent variables paint a different picture: Lervåg et al., (2018, (N = 198)) showed that a latent variable reflecting verbal working memory did not predict reading comprehension, once the variance that it had in common with a latent language construct was partitioned out. Only one concurrent study by Kim (2017) has examined whether working memory plays a role as an indirect predictor of reading comprehension via language comprehension (N = 350). This found a direct effect from working memory on vocabulary and listening comprehension and an indirect effect from working memory on reading comprehension. However, it remains to be seen whether such effects would hold up in a longitudinal study. Thus, so far there is very limited support for the

hypothesis that working memory plays an important independent role as a predictor of the growth of reading comprehension.

4.6 Metacognitive strategies and comprehension monitoring

Metacognitive strategies relevant to reading comprehension include knowledge about text characteristics and strategies for text comprehension, such as graphic organisers and identifying the main idea (van Gelderen et al., 2007). Metacognitive strategies are measured in different ways, typically with questionnaires. Comprehension monitoring is a related construct, referring to intentional activities by readers to monitor, control and integrate their own reading processes (Yang, 2006). Comprehension monitoring is typically measured with 'think-aloud protocols' describing the reader's reasoning during text reading.

Oakhill and Cain (2012) (N = 102) found that comprehension monitoring explained variations in the growth of reading comprehension beyond the components in the simple view and also beyond the autoregressor (unique contribution to reading comprehension 4%) This study used regression models with observed variables to analyze the results. Similarly, Lepola et al., (2016) (N = 90) tracing children from preschool to the third grade found that oral language comprehension, reading fluency, and task orientation (focus and ponder on solving a task) each contributed uniquely to concurrent reading comprehension. Together, they accounted for 76% of the variance in reading comprehension in the third grade. More importantly, however, task orientation at previous time points was not a predictor of reading comprehension beyond language comprehension and decoding; this study measured reading comprehension only once, so it cannot speak to the growth in reading comprehension.

4.7 Motivation

Reading motivation refers to factors that relate to a reader's experience of reading, such as mastery, joy of reading and increased social status (Stutz et al., 2016). Reading motivation is usually measured with questionnaires and it is common to distinguish between intrinsic

motivation (finding reading interesting and rewarding in itself) and extrinsic motivation (such as receiving positive feedback for reading and knowledge attainment; e.g., Wigfield & Guthrie, 1997; Stutz et al., 2016).

One longitudinal study found that motivation was a weak but unique predictor of the growth in reading comprehension (unique contribution 1%) from preschool to Grade 2 and onwards after accounting for earlier linguistic comprehension, decoding, and an autoregressor (Lepola et al., 2005, N = 139). Lepola et al. used observed variables and hierarchical multiple regression analyses. In contrast, a longitudinal latent variable study by Becker et al. (2010) (N= 740) failed to find any predictive relationship between measures of motivation and reading comprehension between the third and sixth grade when past achievement was taken into account (Becker et al., 2010, (N = 740)). In contrast, another study using latent variables tracing children from the fifth to eighth grade did find that motivation-related variables, such as reading enjoyment and reading self-concept, were unique predictors of the growth in reading comprehension (Retelsdorf et al., 2011 (N = 1508)). However, although this study controlled for reading comprehension at previous time points, and social background, nonverbal reasoning, and decoding there was no control for language comprehension. Thus, the extent to which motivation explains growth in reading comprehension beyond the predictors of decoding and linguistic comprehension as postulated by the simple view of reading remains unknown.

To summarize, when using observed variables, studies have reported unique relationships between several predictors that are not included in the simple view of reading, and the growth of reading comprehension. However, findings are mixed and some effects are small. Moreover, studies using latent variables reach different conclusions. In studies with latent variables measuring reading fluency, inference skills, morphological awareness, executive functions, working memory, motivation and metacognitive strategies no construct

explains growth in reading comprehension beyond the predictors in the simple view of reading.

5. The simple view of reading—simple but complex

Overall, our review shows that there is remarkably strong support for the simple view of reading. However, this does not imply that reading comprehension is in any way 'simple'. Gough and Tunmer (1986) emphasize that the simple view of reading separates the complexity of reading comprehension into two main parts: decoding and linguistic comprehension. The latter skill is itself immensely complex since it involves virtually all aspects of our language processing ability. It can be argued, therefore, that the simple view is useful in bringing into clear focus the critical importance of language skills for learning to read. It is also important to note that, while decoding is a constrained task that typically requires instruction, linguistic comprehension is an unconstrained skill that continues to develop over the life-span and is highly dependent on general knowledge. The multifaceted nature of language makes reading comprehension difficult to target with instruction (Catts, 2018). Although linguistic comprehension can be improved by intervention (Hulme et al. 2020; Rogde et al. 2019), only some studies have shown robust transfer effects from linguistic comprehension gains to reading comprehension performance (Brinchman et al. 2017; Clarke et al. 2010; Fricke et al., 2017; Wolff, 2011). Those that have done so typically have delivered rather intensive interventions to small groups of children (Brinchman et al. 2017; Clarke et al. 2010; Wolff 2011).

Reading comprehension is a highly complex skill which is undoubtedly heavily dependent on language comprehension ability. Evidence suggests (Hulme, Snowling, West, Lervåg & Melby-Lervåg, 2020) that oral language skills can be improved by high quality interventions delivered over significant periods of time. Thus, it seems likely that such

interventions might be an effective way of improving reading comprehension skills. Still, much more evidence is needed to understand both the long-term effects of such interventions as well as the transfer of effects from language comprehension to reading comprehension.

6. Relationships between longitudinal studies and theories of reading development

Most of the studies we have reviewed are motivated by theories about the causal mechanisms that underlie the development of reading comprehension. Finding reliable predictors of the development of reading comprehension is important, since such factors are likely candidates for effective interventions designed to improve reading comprehension.

Although longitudinal studies like the ones we have discussed are well suited to establishing both the existence and direction of associations between reading comprehension and other variables, they are limited as means of establishing causal influences on its development. The studies we have described are observational rather than experimental and, as discussed earlier, they may fail to assess confounders (common causes that affect both a predictor and the outcome (reading comprehension)). There are a set of complex statistical issues involved in testing causal theories using longitudinal studies of the sort we have discussed here (Lervåg, 2019). For example, the simple view of reading claims that if child at age 5 years has good linguistic comprehension skills, this will enable them to develop good reading comprehension skills (provided they also have sufficient decoding skill).

The longitudinal studies we have discussed involve both differences between individuals and changes within those individuals across time. However, the analyses which have typically been conducted in this area fail to separate between-person and within-person variance. Newer statistical models like the random intercept cross-lagged panel model (RI-CLPM; see Hamaker et al., 2015) allow the separation of within-person variance from the between-subject variance, hence allowing all unobserved trait-like confounders that are stable

across time to be controlled (i.e., the between-person differences; see Usami et al., 2019). Finding variables that can predict change in reading comprehension within a person is important because this might indicate which variables we could train to improve children's reading comprehension skills. However, while newer statistical models may bring us closer to understanding potential causal influences on the development of reading comprehension, ultimately only randomized trials can establish causal influences and demonstrate which interventions work to improve it (see Savage, this volume).

7. Future directions

There is very strong support for the simple view of reading: variations in reading comprehension are strongly predicted by variations in decoding and linguistic comprehension. However, evidence for other potential predictors of individual differences in reading comprehension, such as reading fluency, executive functions and metacognitive strategies, is distinctly weak. Indeed many putative influences do not consistently predict variations in reading comprehension beyond what they have in common with linguistic comprehension. Future studies should try to use reliable measures of both predictors and outcomes and, preferably, latent variables, ensuring construct validity by using a balanced number of indicators for each predictor construct. In the future, it will also be important to employ statistical models that can distinguish between within- and between-person variation (see Torppa et al., 2020).

Finally, multivariate observational studies give researchers many degrees of freedom (Wicherts et al., 2016). Arguably, the quest for unique predictors of reading comprehension beyond the simple view has rendered such studies prone to publication bias because journals typically prefer newsworthy findings (Tackett et al., 2019). Methods for improving reproducibility have become common in experimental studies, but it is also important that observational studies follow this lead (Tackett et al., 2019). Recent papers have suggested

procedures for pre-registration of large datasets; these can be useful in relation to observational studies, as can guidelines on how to make sound inferences from complex datasets and appropriate decisions regarding their analyses (van den Akker et al., 2019; Srivastava, 2018). Developing and employing these kinds of procedures will be important for helping this field produce more robust and consistent findings.

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