Chapter 1
Introduction to Reading and Dyslexia

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Abstract The objective of this chapter is to introduce the topic of Reading and Dyslexia. A more complete understanding of the processes behind literacy acquisition, of skilled reading and of the underlying neural mechanisms, is required to fully understand dyslexia. The process of literacy acquisition is described as a form of procedural learning. During this learning process, pre-existing functions from different domains are recruited and coordinated, which are relevant but not specific for literacy acquisition. Further, it is argued that there is not merely one cause for dyslexia. Instead, everything that disturbs the fine-tuned coordination between the functions involved in learning to read and write is a potential cause, which is not restricted to a certain domain.

Keywords Literacy acquisition · Definition of dyslexia · Diagnosis · Brain development · Automatization · Learning disability · Phonological processing · Visual processing · Temporal processing · Procedural learning · Functional coordination · Training and remediation

1.1 Literacy Acquisition and Skilled Reading in Different Orthographies

To most of us reading and writing are everyday activities, secondary to spoken language. Usually, we do not estimate these activities as something extraordinary. However, reading and writing are in fact extremely complex skills, involving reams of cognitive functions, none of which is specific for literacy. Reading and writing are

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human cultural inventions. Therefore, reading and writing skills have to be taught and learned, and thus, successful literacy acquisition depends on the interaction of both the learning environment and individual factors. The learning environment encompasses macro- and meso-level factors of the society, such as teaching methods in institutions and families, orthographic systems, culture, and politics (Hung, Frost, & Pugh 2018; Joshi 2018; Morais 2018; Wimmer & Ludersdorfer 2018). The individual factors include general learning ability and motivation, individual brain development, possible specific processing deficits, etc. (Hung et al. 2018; Wimmer & Ludersdorfer 2018, see Part II). Yet, literacy functions to change both the society and the individual's mind in a feedback process (Morais 2018).

After several years of schooling, preexisting functions (including basic visual and auditory abilities, phonological processing and speech perception, oculomotor control, attentional and executive functions, short- and long-term memory, higher order language processing, and many others) become coordinated to create literacy specific cognitive procedures. These become automatized after intensive training (Lachmann 2018; Nicolson & Fawcett 2018). The process of automatization is accompanied by structural and functional changes in the brain when neural reading networks become functionally specialized (Hung et al. 2018; Wimmer & Ludersdorfer 2018). Thus, reading and writing are undoubtedly, truly extraordinary achievements of the human brain.

Part I of the present book addresses different aspects of literacy acquisition and skilled reading. Chapter 2 focuses on the impact of socio-cultural-political factors on literacy development and the feedback process of literacy on the individual and society (Morais 2018). Chapters 3 and 4 focus on brain structures and functions involved in literacy acquisition (such as the Visual Word Form area; Hung et al. 2018; Wimmer & Ludersdorfer 2018), and Chap. 5 outlines the relationship between linguistic comprehension and reading comprehension, reviewing evidence from monolinguals, second-language learners, and various orthographies (Joshi 2018).

1.2 Developmental Dyslexia: From Basic Functions to Higher Order Cognition

Even though literacy acquisition is quite a challenge for the brain, with the appropriate learning conditions and instructions almost all individuals will eventually become fluent in reading and writing, no matter which orthographic system is involved. However, some individuals have serious problems to acquire these skills adequately. If these problems are restricted to literacy development (i.e., no general cognitive deficit) and are not justified by insufficient learning conditions, then this specific learning disability is defined as developmental dyslexia. In Part II of the present book, a number of renowned theories on developmental dyslexia are introduced and discussed.

After more than a century of intensive research on this topic, there is still a debate about the cause of dyslexia (see Nicolson & Fawcett 2018, for a review). For this reason, most definitions (including the clinical definition from the World Health Organization) are still descriptive. These definitions require that for the diagnosis of dyslexia, there should be a significant discrepancy between individual performance scores from standardized reading and spelling tests when compared to (a) those of a reference population, and (b) indicators of the individual's general cognitive development (usually IQ). In other words, although there is common consensus that dyslexia is a neurodevelopmental disorder, when it comes to the diagnostic criteria in practice, it is currently still all about statistics rather than etiology. It means that the prevalence rate is preassigned and whether or not a person will be diagnosed as dyslexic depends on the distribution of certain test scores in a specified reference population. Since such statistical data can only be considered meaningful when some proficiency has been acquired, a diagnosis cannot be given before the middle or end of Grade 2. As a result, intervention usually starts later than it should (Lachmann 2018).

Is it really the case that we have that little knowledge about the cause of dyslexia? At the outset of systematic research on dyslexia, the focus was primarily on visual deficits. However, since the late 1970s overwhelming evidence was collected on the essential role of phonological processing for literacy development (see Nicolson & Fawcett 2018, for a short review). Specifically, phonological awareness was identified as a strong early predictor for subsequent reading and spelling performance. Yet, phonological awareness deficits do not always lead to problems in performance and not all dyslexics display such deficits before literacy acquisition. Nonetheless, the majority of children with developmental dyslexia show deficits in overall phonological processing. Hence, deficit in phonological processing was used to generalize the universal cause for dyslexia. However, phonological processing abilities do not only function as an important prerequisite for learning to read and spell, but are also enhanced and further developed when these skills are acquired. This means that the quality and quantity of reading experience has an impact on phonological processing abilities. Consequently, it cannot be said to what extent phonological processing deficits are the cause for or the effect of dyslexia. Nevertheless, the importance of phonological processing abilities for successful literacy acquisition is irrefutable even if the impact is considered as bidirectional. If phonological processing deficits are considered to be causal, then they still reflect symptoms at the cognitive level, which are secondary to information processing deficits at a more basic level (Calcus, Hoonhorst, Colin, Deltenre, & Kolinsky 2018; Galaburda 2018; Jaffe-Dax, Daikhin, & Ahissar 2018; Lallier et al. 2018; Nicolson & Fawcett 2018; Witton & Talcott 2018). These basic deficits may be the result of anomalies in brain development (Galaburda 2018; Jaffe-Dax et al. 2018; Lallier et al. 2018; Stein 2018; Witton & Talcott 2018). Importantly, anomalies in brain development may not only cause problems in basic auditory processing but also in the visual domain (Lachmann 2018; Stein 2018), in cross-modal integration (Lachmann 2018), in general temporal processing (Galaburda 2018; Jaffe-Dax et al. 2018; Stein 2018), or in automatization (Nicolson & Fawcett 2018). These may then

lead to secondary symptoms at the cognitive level (e.g., speech perception deficits; see Calcus et al. 2018), which are not restricted to phonological processing (see Nicolson & Fawcett 2018, for a review).

If anything can be concluded from the immense body of research findings collected over the past decades, it would be that there is not merely one cause of dyslexia (see Burgess, Witton, Shapiro, & Talcott 2018). In fact everything that disturbs the fine-tuned coordination between the functions involved in learning to read and write is a potential cause (Lachmann 2018), which is not limited to a certain domain. Therefore, understanding dyslexia requires a better understanding of the processes behind learning to read and write (Lachmann 2018; Nicolson & Fawcett 2018), of skilled reading, and of the underlying neural mechanisms (see chapters of Part I).

The Functional Coordination approach (Lachmann 2018) describes literacy acquisition as a form of procedural learning (Nicolson & Fawcett 2018). During this learning process, preexisting functions from different domains are recruited, which are relevant but not specifically designed for the task of literacy acquisition. By guided instruction, these functions are then optimized for the task and subsequently coordinated to create specific procedures for reading and writing. The coordination requires fine-tuning of complex functions to warrant cross-modal integration. This leads to a novel synthesis of functions that finally become automatized, as a package, over several years of intensive practice (Nicolson & Fawcett 2018). Consequently, developmental dyslexia is described as a Functional Coordination Deficit (Lachmann 2018), since a failure in coordination is most liable to manifest deficiencies in alphabetic and orthographic coding and decoding. This means, developmental dyslexia is actually not a consequence of a deficient automatization per se but of the automatization of suboptimal functional coordination. Various anomalies in brain development and the ensuing basic and secondary cognitive deficits can hamper this functional coordination. Part II of the present book delves into this subject.

1.3 Training and Remediation for Children with Dyslexia

A remediation program must be based on theoretical and causal assumptions and empirical findings. It was argued that developmental dyslexia can be caused by different anomalies in brain development (Galaburda 2018; Nicolson & Fawcett 2018; Stein 2018) that result in basic and secondary cognitive deficits. However, these deficits are not restricted to a certain domain (auditory, visual, cross-modal, executive, etc.; see chapters of Part II). At the behavioral level, these deficits all have the potential to disturb the process of learning to read and write. Therefore, it is impractical to create a training program that is restricted to solely one isolated function on the basic or cognitive level. Instead, it is more useful to train the coordination of functions (Lachmann 2018). This would involve implementing a multifunctional, cross-modal, hierarchical, adaptive program that is individualized

for each participant (Klatte, Bergström, Steinbrink, Konerding, & Lachmann 2018). Such a training program should be administered at the earliest opportunity with respect to the process of literacy acquisition and not necessarily the age of the participant. However, the design implemented should be age specific, taking into consideration motivation, feedback and cognitive development.

Furthermore, any remediation program implemented should be evaluated using a longitudinal control group design (see Klatte et al. 2018; Tallal & Jenkins 2018). This evaluation should not simply test the effect on the functions and sub-skill(s) that were trained in the program (e.g., phonological awareness) but rather on how it transfers to reading and writing performance in the long run.

However, it cannot be expected that any established program would impact all dyslexic individuals to the same extent, given the multi-causality assumption of dyslexia. On the other hand, the differential effects of a training program, i.e., the response to intervention of an individual or a group, do also provide insight to the causal factors of their reading and writing problems. If a substantial number of participants in a remediation program demonstrate no (or only a short-term) transfer to the behavioral level, then it is rather unlikely that the trained function(s) and sub-skills would play a major role for the learning process in the general population.

Hence, Part III of the book presents two remediation programs, which provide data from evaluation studies. These were developed for two different orthographies. *Fast ForWord*® was developed for nontransparent English (Tallal & Jenkins 2018) while *Lautarium* was developed for the German phonetic system and a transparent orthography (Klatte et al. 2018).

References

Burgess, A., Witton, C., Shapiro, L., & Talcott, J. B. (2018). From subtypes to taxons: Identifying distinctive profiles of reading development in children. In T. Lachmann & T. Weis (Eds.), *Reading and dyslexia.* Cham: Springer.

Calcus, A., Hoonhorst, I., Colin, C., Deltenre, P., & Kolinsky, R. (2018). The "rowdy classroom problem" in children with dyslexia: A review. In T. Lachmann & T. Weis (Eds.), *Reading and dyslexia.* Cham: Springer.

Galaburda, A. M. (2018). The role of rodent models in dyslexia research: Understanding the brain, sex differences, lateralization, and behavior. In T. Lachmann & T. Weis (Eds.), *Reading and dyslexia.* Cham: Springer.

Hung, Y.-H., Frost, S. J., & Pugh, K. R. (2018). Domain generality and specificity of statistical learning and its relation with reading ability. In T. Lachmann & T. Weis (Eds.), *Reading and dyslexia.* Cham: Springer.

Jaffe-Dax, S., Daikhin, L., & Ahissar, M. (2018). Dyslexia: A failure in attaining expert-level reading due to poor formation of auditory predictions. In T. Lachmann & T. Weis (Eds.), *Reading and dyslexia.* Cham: Springer.

Joshi, R. M. (2018). Simple view of reading (SVR) in different orthographies: Seeing the forest with the trees. In T. Lachmann & T. Weis (Eds.), *Reading and dyslexia.* Cham: Springer.

Klatte, M., Bergström, K., Steinbrink, C., Konerding, M., & Lachmann, T. (2018). Effects of the computer-based training program Lautarium on phonological awareness and reading and spelling abilities in German second-graders. In T. Lachmann & T. Weis (Eds.), *Reading and dyslexia.* Cham: Springer.

Lachmann, T. (2018). Reading and dyslexia: The functional coordination framework. In T. Lachmann & T. Weis (Eds.), *Reading and dyslexia.* Cham: Springer.

Lallier, M., Lizarazu, M., Molinaro, N., Bourguignon, M., Rios-Lopez, P., & Carreiras, M. (2018). From auditory rhythm processing to grapheme-to-phoneme conversion: How neural oscillations can shed light on developmental dyslexia. In T. Lachmann & T. Weis (Eds.), *Reading and dyslexia.* Cham: Springer.

Morais, J. (2018). The methods issue revisted: From a developmental and a socio-cultural-political perspective. In T. Lachmann & T. Weis (Eds.), *Reading and dyslexia.* Cham: Springer.

Nicolson, R. I., & Fawcett, A. (2018). Procedural learning, dyslexia and delayed neural commitment. In T. Lachmann & T. Weis (Eds.), *Reading and dyslexia.* Cham: Springer.

Stein, J. F. (2018). The magnocellular theory of developmental dyslexia. In T. Lachmann & T. Weis (Eds.), *Reading and dyslexia.* Cham: Springer.

Tallal, P., & Jenkins, W. (2018). The birth of neuroplasticity: A twenty year perspective. In T. Lachmann & T. Weis (Eds.), *Reading and dyslexia.* Cham: Springer.

Wimmer, H., & Ludersdorfer, P. (2018). Searching for the orthographic lexicon in the visual word form area. In T. Lachmann & T. Weis (Eds.), *Reading and dyslexia.* Cham: Springer.

Witton, C., & Talcott, J. B. (2018). Auditory processing in developmental dyslexia: Some considerations and challenges. In T. Lachmann & T. Weis (Eds.), *Reading and dyslexia.* Cham: Springer.