Early gender diversity in reading and writing: Research and didactical consequences

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Learning languages is strongly influenced by an existing, but in institutionalised settings of language learning, still widely disregarded diversity. In many respects, boys and girls, men and women obviously learn and use languages in a completely different way. This initially hypothetical claim, based on pedagogical and educational as well as linguistic and psychological observations, can currently be newly restated using neuro-scientific research. Extraordinary progress in functional brain imaging now allows scientists to broadly understand the neural systems serving language skills, and how these systems differ in gender. So, they can prove evidence of developmental differences between males and females in language acquisition related brain structure during childhood as well as adolescence. A cross-science, non-statistical synopsis of these studies, focusing on early reading and writing competences, is absolutely necessary to prepare, identify and select evidence-based implications. In some specific aspects, the results indicate a paradigm shift in early reading and writing skills development to the explicit advantage of females, mainly in the pre-primary and primary language classroom. These, however, may not lead to discrimination or injustice of any kind – not even through school didactics or pedagogy for example – but have to be considered an asset.

KEYWORDS: *language acquisition, early language learning, gender diversity, neuro-didactics, differentiation, reading and writing skills*

1. INTRODUCTION

Differences between boys and girls, men and women, are numerous: from body height and muscle growth to endocrine functions. Finding differences in the brain, however, is not an easy task. The dimorphisms are small, few, and mostly have quite unknown functions. There have been many scientific attempts to locate gender differences. The first functional magnetic resonance tomography (fMRI) studies particularly referred to the differences in size between the male and female brain, in addition to cognitive skills in cortical and subcortical areas (Kaiser et al., 2009).

With the exception of two potentially ground-breaking distinctions, there are hardly any differences between girls and boys discernible within the early childhood and childhood years – in the framework of either neurosciences, or

educational or linguistic sciences. Yet, on closer inspection, i.e., with analytical comparisons and cross analyses of the related results, the interfaces between all research landscapes lead to vital implications and a potential for change in the field of early language didactics and methodology. This includes a look from the outside into learning behaviour with observations from pedagogical and educational, as well as linguistic sciences, and a look into the brain. In this context, it is not primarily a matter of what and how much there is to be learned, but more importantly, how languages can be acquired. The answer is much more refined than has been assumed so far, which may come as no surprise for those involved in teaching/learning processes.

These seemingly marginal, gender-specific differences in neuronal organisation simply mean that boys and girls, women and men, learn and use languages in an entirely different way. Differences in functional activation between boys and girls for various elements of language processing have been discussed, for example, in (Schmithorst et al., 2008; Plante et al., 2006). Methods of differentiation, however, are still in short supply and are definite desiderata for the future.

This article provides a starting-point and basis for further comprehensive interdisciplinary research projects. The goal is to provide a comprehensive summary of the current state of scientific knowledge on gender differences in language learning, particularly in the development of early reading and writing skills, as well as to establish an initial, language-didactic framework for future implementations of the findings in early teaching and learning contexts.

2. INTERDISCIPLINARY METHODS OF GENDER RESEARCH

Gender-specific research designs are progressively difficult to define; aspects of language learning can only be separated from social influence with difficulty. Gender studies claim that a clear-cut distinction between a biological sex and a social gender does not exist (Butler, 1990; Fausto-Sterling, 2000). The latter is not a purely physical or material state, but is deeply linked with social and cultural structures of gender (Kaiser et al., 2009). The terms ‘gender’ and ‘sex’ are thus often used synonymously. Gender defines the social gender, the gender role, and has cultural and, typically, behavioural implications. From a medical viewpoint, gender is defined by biological differences, from chromosomes to sex organs, which also characterises the term sex, the biological gender.

According to neuroscientific findings, the development of children’s and teenagers’ brains is paralleled by constant neuronal plasticity, well into old age (Kaiser et al., 2009). Experiences of

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every description are biochemically entered into neural networks, or rather, are newly formed. Therefore, it is likely that prenatal and pre-linguistic interdependencies between gender and sex can be expected. Caregivers and relevant situations change and characterise early on. They result in barely alterable gender markers, in addition to biological markers.

Increasing gender-specific imaging research methods (Kaiser et al., 2009) in medicine, psychology and biology via functional magnetic resonance tomography fMRI, and recently also magneto encephalography (MEG), are able to determine and describe the structural differences in male and female brains. Differences, however, can also be identified through fMRI research focusing on cognitive language processing (Burman et al., 2008). Language acquisition is thus considered a highly gender-specific phenomenon, particularly because of the observation that girls and women seem to learn and speak new languages more easily and faster than boys and men.

Questions concerning the influence of social indicators and experiences (Leonard et al., 2008), as well as on the irreversibility of gender-specific attitudes (Jordan et al., 2002), need to remain excluded from purely neuroscientific structural analyses. Nevertheless, as Kaiser et al. (2009) establish in their meta-analysis, gender differences

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do not remain invariable in terms of higher cognitive skills within the neuronal organisation, but are subject to the lifelong influence of (learning) experiences (Jäncke et al., 2001; Draganski et al., 2004). Thus gender-specific differences during a person's biological development also become part of brain biology, such that sex and gender are linked in a way which means they cannot be easily isolated (Fausto-Sterling, 2000).

3. RELEVANT FINDINGS

3.1 General observations

Kaiser et al. (2009) summarise general gender-specific research findings related to early reading and writing. In psycholinguistic studies, there is a consensus that a female advantage can be discerned in terms of language production and fluency (Halpern, 1992), while males show an advantage in the understanding of word analogies (Hyde & Linn, 1988). The connection between anatomic preconditions, as well as linguistic skills, and potential male advantages regarding, among other things, absolute brain size, could not be determined in a meta-analytical study either with

healthy or with ailing participants. In comparison, research into language behaviour identified an accumulation of pre-linguistic skills (Rome-Flanders & Cronk, 1995), as well as a spontaneous willingness to speak among girls (Craig et al., 2005; Jackson & Roberts, 2001). Further gender-specific differences with slight and early female advantages have been documented for such abilities as the speed of identifying and reading words (Majeres, 1999).

3.2 Lateralisation – different use of hemispheres

The link between the two cerebral hemispheres, the corpus callosum, or bridge, influences the symmetry of brain functions in both sexes. With more than 200 million nerve fibres, it transfers signals to both hemispheres, but can also inhibit signal currents. In a particular part of the corpus callosum, the splenum, the cross-linking of the speech centres takes place. The male counterpart is one fifth smaller (Hoyenga, 1979). Mutual inhibition of both hemispheres determines the so-called lateralisation during productive, as well as receptive, language activity. The left hemisphere usually takes the lead when the brain has to process linguistic stimuli and inhibits the activity of the right hemisphere. Girls and women have special sex hormones which reduce the process of inhibition.

Lateralisation can already be observed prenatally using a special imaging method, the diffusion tensor imaging, DTI (Schmithorst et al., 2008). With the aid of fMRI, the diffusion movement of water molecules in body tissue can be measured. Spatially resolved, it can be displayed three-dimensionally (Le Bihan et al., 2001). Weiss et al. (2003) carried out functional connectivity analyses via fMRI during language activities. Results showed that girls use both cerebral hemispheres in a stronger and functionally more symmetrically organised way in order to solve linguistic tasks more efficiently (Schmithorst et al., 2008; Sommer et al., 2008; Shaywitz & Shaywitz, 2008).

Boys master linguistic tasks better with the hemisphere best specialised for the task, which means the left. Clinical trials (McGlone, 1977; Kimura, 1983; Hier et al., 1994; Hoyenga, 1979) confirm this. According to the findings, girls apparently tend towards multi-tasking, although it cannot be confirmed that mental capacities are divided during this process. Boys work more efficiently with only one task. Despite being approximately 13% smaller, the female brain devotes about 20 to 30% more brain areas to language, probably through lateralisation (Harasty et al., 2000).

Another clear gender distinction can be noted in early metaphoric reading skills: girls are usually able to empathise with others slightly sooner. Areas in the right hemisphere, which are most responsible for emotions, were activated during

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girls' attempt to read, but not among boys. Boys, on the other hand, only use half of the brain areas girls use for emotional verbalisations. Likewise, during the phonological processing of words in the course of reading, activities among boys could be measured in the left gyrus frontalis only; girls, on the other hand, additionally used the right side. All differences regarding lateralisation have less to do with a gender-specific gradient in intelligence, however, than with skills even though girls' and women's performance on the linguistic part of IQ-tests in intelligence surveys on partial aptitudes is superior.

3.3 Myelination – disparities on cellular level

The neuron, or the nerve cell, is the basic functional unit of the brain system, although it is by no means the only cell type in the body. Axons transmit electrical nerve stimuli, wherein the conduction and communication velocity between the cells is determined by the thickness of the myelin sheaths (Barkovich, 2000). These nerve fibres are gradually coated with myelin (Konrad et al., 2013; Carmody et al., 2004; Reiss et al., 1996) when the brain develops and matures, approximately until the age of 30. Myelinated axons make up the so-called white substance. In the first three years of life (Carmody et al., 2004; Paus et al., 1999), the 'critical step' (Pujol et al., 2006), as well as between the ages 10 and 20, developmental progress in this regard seems to be the steepest (Giedd et al., 1999).

Later, it is no longer as easy to form connections among nerve cells; their flexibility and thus their ability to learn decreases. Existing connections are optimised, however.

Human intelligence – genetically determined – depends qualitatively strongly on the condition of the axons, in particular on the thickness and corresponding capacity of the isolating myelin shaft for speed, *'... which may account for differences in reaction times, processing speed, and intellectual performance across subjects'* (Chiang et al., 2009). Velocities of 100m/sec can be measured. Myelination in the areas responsible for language takes place precisely when the first decline in learning ability can be observed. It is assumed that this happens very early (Hyltenstam & Abrahamsson, 2003).

There are indicators for the development of reading skills. The fibres that cross over in the posterior mid-body region of corpus callosum interconnect the parietotemporal regions and undergo extensive myelination during the typical years of reading acquisition, i.e. 6–10 years of age (Thompson et al., 2000). One may therefore speculate that acquiring reading and writing skills at the appropriate age shapes not only the morphology of the corpus callosum and the corresponding interhemispheric connectivity but also the pattern of interaction between the interconnected inferior parietal regions.

Thus, according to Petersson et al. (2007), there might be a causal connection between reading and writing acquisition, the development of the corpus callosum, and the hemispheric differences' (p. 797). This is where gender differences become apparent. They can be identified for language development in general: it is well known that the acquisition of certain language skills is delayed in boys relative to girls (Schmithorst et al., 2008). It is also true for anatomic details: 'The language centre in boys is myelinated later than in girls and this means generally they develop language skills slightly later' (Macintyre, 2009). Additionally, the differences can be proven even for development processes: *'The process of maturation is completed faster in girls than it is in boys, both with respect to progressive myelination and volumetric increases'* (Seeman, 2013, p. 1504).

There is a strong link between reading skills and level of myelination: *'... myelination is suspiciously coincident with the timing of early language/ cognitive development'* (Bates et al., 2003; Nagy et al., 2004).

Long nerve pathways, clearly identified as responsible for reading and writing, are strengthened by myelin coating until the age of 30. Between the ages of 4 and 8, this process is gender-differentially strong for hormonal reasons. At the age of 8, these processes reach a relatively stable plateau. During this period, girls are far more hormonally developed (Benes et al., 2004), up to approximately three years ahead of boys (Zambo & Brozo, 2009; Morisset et al., 1995).

And what is more, until puberty, brain areas responsible for fine motor skills, such as handwriting, develop up to six years sooner with girls (Denckla et al., 2014; Anokhin et al., 2000). At the same time, within clinical studies, a preponderance of dyslexia occurs in boys. Only around the age of 18 does this imbalance level off. Nevertheless, it is important that the role of myelination not be overgeneralised (Aslin & Schlaggar, 2006; Chiang et al., 2009).

3.4 Further distinctions in cortex and speech centres

The cerebral cortex is an accumulation of nerve cells located as a thin layer of cortex on the outer rim of the cerebrum and cerebellum. Generally speaking, neuronal cross-linking can be measured sooner and more strongly among girls, which points to an early maturing of their cortex. The fact that this has implications for potential early learning skills can be seen in the parietal/temporal lobe. Girls are able to 'habituate' as early as from the third month of pregnancy, i.e. they react less and less to the same constant auditory stimuli until they stop reacting to them altogether. This indicates a memory for detailed sensory inputs, as well as an ability to attentively follow aural

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content, especially different voices. Even female frontal lobes develop earlier. The prefrontal cortex is the brain's C.E.O. It helps organise, analyse, and strategise. Spatial thinking and problem-solving strategies are connected with this area. Sooner than boys, girls are already able to do conscious, intentional activities in their early school years. Their attention span is longer, and they master transitions between lessons and subjects more promptly (Havers, 1995). Such early cognitive control can be explained by the hormone serotonin, which is generated in the frontal lobes. Among other things, it is the basis for recognising cause and effect, as well as for lessening impulsivity. Boys use the prefrontal areas for spatial and mechanic functions (Moir & Jessel, 1989).

Two important and decisive speech centres in the left hemisphere are located in the temporal lobe: Broca's area, mainly responsible for language production, and Wernicke's area, responsible for language comprehension. Statistically speaking, they are larger in women by 20%, or even close to 30%, than they are in men, have better blood circulation, and show a higher density of neurons. Both areas develop earlier among girls. While language is formulated and acquired, even written, many other areas of the cerebral cortex are being activated.

Taken together, all fMRI studies indicate that girls are generally superior to boys with regard to language production (Schlösser et al., 1998; Weiss et al., 2003; Kaiser et al., 2007) and language awareness (Pugh et al., 1996; Kansaku et al., 2000; Phillips et al., 2001; Baxter et al., 2003), as well as in verbal communication and their overall communication skills, i.e. they use more words (vocabulary size), start speaking and thinking about language earlier. When school starts, there are already measurable differences. Girls are also slightly better at memorising new lists of vocabulary items and at reproducing them later on. The early advantage regarding vocabulary size will even out during adulthood.

4. DISCUSSION

4.1 Didactic consequences

Drawing didactic consequences regarding early reading and writing from each single neurological result is unrealistic and also disingenuous. The image of a brain-appropriate and thus truly learner-oriented pedagogy becomes sharper and more vivid, however, if, like a puzzle, it forms and expands with increasing information on details, which then turn into increasingly large didactic

action fields. In each case, however, structural, gender-specific differences in neuronal organisation demands equally differentiated language teaching methods (Fine, 2010).

4.2 Changing attitudes

A crucial first step in this direction is a change in attitude among teachers, as well as learners. Discrimination, stigmatisation, degradation and ignorance of existing or still developing reading or/ and writing skills and competences exist because of common social stereotypes concerning sex and gender, or rather the social expectations they transport. Overcoming them means gaining sufficient knowledge about biological gender differences, as well as about the learning needs of girls and boys, particularly in regard to language learning. Only then can a clear presence of gender-specific diversity lead to a conscious enrichment of learning contexts. What is still needed is a gender-balance-systematic that makes it possible for boys and girls to have equal chances when developing their reading and writing skills, and at the same time does both justice – in the true sense of the word.

4.3 Approaching early literacy

In the area of receptive language skills, such as reading comprehension, current research indicates that findings disparity in terms of attention span needs to be considered. In doing so, individual and well-prepared approaches to text comprehension should be allowed. Audio, video, or print versions of a text are ideally emotionally connected to the children's and teenagers' environment; they are challenging, authentic and, in the best sense, meaningful. Unlike receptive skills, speaking and writing need to be considered as gender-specifically different on many levels from the very beginning. Evident disparities between boys and girls in terms of the development of spoken language skills and literacy are considerable.

Dealing with the acquisition of purely linguistic reading and writing skills (functional literacy), first a narrow understanding of the term 'literacy' can help. Skills that go beyond this, such as text comprehension, familiarity with media and literature and reading experiences, are not directly neuro-didactically relatable to existing pedagogic or linguistic findings. *'It should be emphasised that reading and writing skills are learned cognitive capacities of a different kind than natural language per se, the latter being a human universal, acquired by all normal humans in a largely spontaneous unsupervised fashion'* (Petersson et al., 2007, p. 797).

If there is evidence that the female brain at preschool age develops quicker in terms of verbal-emotional functions and that most girls have an early ability to sit still and stay focused on given tasks without any cognitive effort, there are

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bound to be ramifications. Not only are learning successes in foreign language learning greater; developing written competences, in particular, is more successful and intense (Whitmire, 2010). Many educational failures derived from failures in reading and writing at the very beginning of school, especially when learning tasks and learning materials progressively initiate the shift from *'learning to read'* (Shaywitz & Shaywitz, 2008, p. 1330) to *'reading to learn'*. A long-term study demonstrates that early intervention is necessary: *'Over the last 20 years, the reading skills of 17-year-old boys have been in a steady decline. Each year since 1988 the gap between boys' and girls' reading skills has widened a bit more'* (Whitmire, 2010, p. 31).

Reading and writing courses in the mother tongue, as well as in foreign languages, if they exist at all, therefore need to be reconsidered and re-structured gender-specifically. Additionally, because a boy's prefrontal cortex develops more slowly than a girl's, there is a need to encourage higher-level thinking skills, in this case especially, reading and writing strategies. The varying early rate of myelination among girls and boys showing a difference in development of up to four years renders affirmative differentiation in the development of literacy absolutely necessary. That involves didactic intervention:

1. The playful, experimental and individual contact

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with spelling in the sense of an 'interlanguage': spelling mistakes are hereby viewed as intelligent adjustment to writing standards; models and self-corrections lead from the children's own reading and writing hypothesis to the target form. This requires a time-independent learning process. Restrictions such as negative corrections lead to neuronal counter-reactions and are distinctly counter-productive.

2. A varying range of texts, the so-called 'boy books,' e.g., placed omnipresent in reading corners and with individualised learning materials, contain topics such as competition, adventure, sports, science fiction, and how-to-do-things, but also war stories and fictional violence, and stuff about slime, bacteria and bugs, to make it more specific. It is necessary to create motivational access to biologically difficult brain functions at elementary school level, especially for boys.

3. From the lower secondary level onwards, special foreign-language literacy courses are appropriate measures for boys and girls in all

school types to differentiate the upper and lower level of their corresponding competences. More concrete implementations at the methodical level, including pedagogic processes, choice of material and media, as well as topic-related organisation, are tasks for future work.

4.4 Preparing early productive reading and writing

Productive language skills differ significantly between boys and girls with a clear and early advantage for females. Their larger vocabulary allows for more elaborate, differentiated means of expression which, in turn, develop verbal communication skills, particularly the readiness to speak spontaneously. This is also why, early on, boys and girls develop different linguistic narrative skills (Gilligan, 1982). The fact that these circumstances additionally go hand in hand with cognitive advantages, which in parallel also seem to develop quicker, and thus have significant consequences for further foreign language learning, widens the performance gap between boys and girls in early language learning. Three aspects of differentiation can be identified:

1. Productive vocabulary size, with early advantages for girls, correlates strongly with established differences in the corresponding memory capacity for connected and random word lists. Strong visualisation with word webs, objects, pictures, symbols, etc., specify the vocabulary for boys and prepare its availability. Specific memorisation strategies, e.g., playful 'photographing' with their eyes, encourage this.

2. Only literacy skills make it possible to develop passive vocabulary. Passive availability leads to productive availability via practice and verbalisation. The previously mentioned affirmative action for literacy is therefore also absolutely vital for the verbal use of foreign languages.

3. The higher emotional connection girls have with a language leads to their verbalising their feelings more easily. Boys evidently develop this skill later. However, they are able to describe exactly what they have done, are doing at the moment, or will do.

Since the brain puts things that are done actively in a higher hierarchy than passively received ones, there is much to suggest that, besides offering specifically active, personal phrases (chunks, idioms), language- and speaking-oriented task formats are also gender-differentiating in every respect (Eliot, 2000).

5. CONCLUSION

Almost all suggested areas of differentiation initially focus on affirmative action with regard to development-specific, albeit short-term, disadvantages among boys when it comes to

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language use. This is necessary, however, in order not to leave boys behind early on – either consciously, subconsciously or against better judgment – when it comes to the existing learning progressions in foreign languages, which follow a more linear than progressive curriculum. At the same time, there cannot be any 'ceiling effect' caused by limited challenges, task formats, extent of language use, or lack of individual linguistic tutoring for gifted children so as not to inhibit the language development of girls. This would result in an unnecessary delay and protraction of the high potential that girls have in language learning, specifically in reading and writing. Gender-specific differences must not lead to discrimination of any kind, but must be seen as enrichment.

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