Review Article

Understanding functional illiteracy from a policy, adult education, and cognition point of view: Towards a joint referent framework

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Abstract: The article discusses the emergence of a functional literacy construct and the rediscovery of illiteracy in industrialized countries during the second half of the 20th century. It offers a short explanation of how the construct evolved over time. In addition, it explores how functional (il)literacy is conceived differently by research discourses of cognitive and neural studies, on the one hand, and by prescriptive and normative international policy documents and adult education, on the other hand. Furthermore, it analyses how literacy skills surveys such as the Level One Study (leo.) or the PIAAC may help to bridge the gap between cognitive and more practical and educational approaches to literacy, the goal being to place the functional illiteracy (FI) construct within its existing scale levels. It also sheds more light on the way in which FI can be perceived in terms of different cognitive processes and underlying components of reading. By building on the previous work of other authors and previous definitions, the article brings together different views of FI and offers a perspective for a needed operational definition of the concept, which would be an appropriate reference point for future educational, political, and scientific utilization.

Keywords: functional illiteracy, large-scale studies, reading, policy, cognition

Verständnis des funktionalen Analphabetismus aus politischer, erwachsenenpädagogischer und kognitiver Sicht: Auf dem Weg zu einem gemeinsamen Referenzrahmen

Zusammenfassung: Der Artikel beschreibt die Entstehung des Konstrukts "Funktionaler Analphabetismus" und dessen wachsende Bedeutung in den Industrieländern in der zweiten Hälfte des 20. Jahrhunderts. Dabei wird insbesondere auf unterschiedlichen Sichtweisen bei der Entwicklung des Konstrukts eingegangen: der kognitiven und Neurowissenschaften einerseits und den beschreibenden und eher normative orientierten Bildungswissenschaften sowie der Politik andererseits. Es wird eine Übersicht über Large Scale Surveys, wie Level One oder PIACC gegeben, deren Ergebnisse eine umfassendere Sicht auf die Verteilung von Lesefertigkeiten in der Bevölkerung in Form von Levels bietet und eine Brückenfunktion zwischen verschiedenen Sichtweisen auf das Konstrukt "Funktionaler Analphabetismus" erfüllt. Kognitive Modelle des Lesens werden diskutiert. Aufbauend auf früheren Arbeiten und Definitionen anderer Autoren wird versucht, verschiedene Ansichten zum funktionalen Analphabetismus zusammenzubringen und eine integrative Perspektive für eine notwendige zukünftige operationale Definition des Konzepts zu bieten. Diese wäre ein geeigneter Bezugspunkt für die zukünftige Erwachsenenbildung sowie für bildungspolitische Richtlinien und für weitere Forschung.

Schlüsselwörter: funktionaler Analphabetismus, Großstudien, Lesen, Politik, Kognition

Literacy can best be understood by distinguishing biologically primary from biologically secondary knowledge (Geary, 2007; Geary, 2008; Paas & Sweller, 2012; Sweller, Aryes, & Kalyuga, 2011). While the former consists of information that humans were specialized to adopt during evolution, including language acquisition, like literacy biologically secondary knowledge is considered a sort of cultural "expertise" for which evolution provides no corresponding specialized neural substrate (Lachmann, 2018a; Lachmann, 2018b). In other words, literacy results from ontogenesis rather than from phylogenesis, having developed only about 6,000 years ago (Carreiras et al., 2009) and still not a universal human phenomenon (Ward, 2015). This ontogenesis, however, does not imply that the "functional architecture" of the brain of illiterate and literate people is the same. For example, during the

phonological processing of words and pseudowords, different neural structures (right middle frontal-frontopolar region) are activated in illiterate than in literate adults (Castro-Caldas, Petersson, Reis, Stone-Elander, & Ingvar, 1998). This implies that mastering literacy competencies affects the functional organization of brain tissue (see Huettig, Kolinsky, & Lachman, 2018, for a review).

Behavioral studies have found differences in many aspects of cognitive functioning between literate and illiterate individuals. For example, it was found that literate individuals recognize simple two-dimensional shapes using a holistic processing strategy, while they prefer analytical processing for letters. In contrast, illiterate participants showed no processing difference between letters and nonletter shapes (see Lachmann, Khera, Srinivasan, & van Leeuwen, 2012). Undoubtedly, though, illiterate and literate adults possess the same cognitive components. What distinguishes the literate population is a fully developed, automatized, literacy-specific, functional coordination of preexisting cognitive functions (Lachmann & van Leeuwen, 2014), achieved through years of intensive, routinized daily literacy training (Froyen, Bonte, van Atteveldt, & Blomert, 2009; Lachmann & van Leeuwen, 2014).

The concepts of functional literacy and functional illiteracy (FI) were developed in the second half of the 20th century, spurred by the growing need of advancing industrial progress and in recognition of the inadequacy of compulsory basic education to provide a sufficient level of literacy skills needed for future socioeconomic development. This article discusses the various comprehensions of FI from the following perspectives: policy and adult education, large-scale literacy assessment surveys, and cognitive and neuroscientific sciences. In order to find a common reference determination of FI, this article develops a perspective toward a common minimum intersection of diverse disciplinary and practical understandings of the notion. Thus, rather than trying to resolve the issue by providing a final definition, we offer insights to further close the disciplinary gap inasmuch as it pertains to FI. Because FI is a socially and cognitively valid concept, we advocate for a more interdisciplinary synchronized definition in the future.

Adult Education, Policy and Functional Illiteracy

The conceptualization of FI and the development of modern adult basic education (ABE) and adult literacy (AL) occurred interdependently during the second half of the 20th century (Bulajić & Despotović, 2018). Once the need for the improvement of basic literacy skills for further socioeconomic development became recognized, different ABE and AL programs began to emerge, in conjunction with large-scale national and international literacy skills assessments. A strong impetus for the development of the ABE programs and the further development of the concept of functional literacy came from the paradigm of lifelong learning as well as from national and international large-scale studies on literacy skills. These studies, widely introduced in the second half of the 20th century, "rediscovered" the topic of illiteracy in industrialized countries (Goffinet & Damme, 1990, p. 4) and led to the need for "appropriate provision for learning arrangements in a non-conventional and innovative manner," based on "the principles of lifelong education on the one hand and the development of suitable practices in the field of functional literacy and basic education in developed countries on the other" (Fuchs-Brüninghoff, Kreft, & Kropp, 1986, p. IX). However, after World War II there was also a reluctance and strong opposition to recognizing the full scope of the problem in industrialized countries. For example, only at the end of 1970s did the debate begin on the inadequate level of literacy skills in the population of Western Germany, though this had occurred somewhat earlier in the United Kingdom during the BBC's National Adult Literacy Campaign (Fuchs-Brüninghoff et al., 1986). By this time, it had become apparent that the notion of illiteracy, often defined as the inability to recognize words and even identify individual letters, needed to be broadened. Moreover, it was discovered that free and compulsory elementary education was not as a strong guarantee as previously believed for the acquisition of an adequate level of literacy skills to ensure further socioeconomic development. As a result of these insights, the notion of functional literacy was born.

At the end of the 20th century, the results of the International Literacy Survey (IALS) showed that at least 25% of the adult population in 13 industrialized countries was not functionally literate, i.e., did not possess "the minimum level of competence needed to cope adequately with the complex demands of everyday life and work" (OECD, 1997, p. 3). This dramatic insight was followed up by the innovation and intensification of the ABE and AL programs in many industrialized countries. However, in addition to education policy and practice, large-scale assessment studies and life-long learning philosophy, functional literacy was also influenced by an increasing interest in the topic by cognitive science. The latter became highly focused on analyzing cognitive-cerebral patterns of written language processing, i.e., the perception and reproduction of a written language, and especially on comparing differences between literate and illiterate individuals in that respect.

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Functional Literacy – Defining Its Conceptual Boundaries

Up until then, the concept of FI and of functional literacy had been rather resistant to attempts to be defined in a more operationalized manner. One of the main reasons for determining functional (il)literacy definitions only as a broad descriptive narrative is that functional literacy represents a dynamic concept shaped by current cultural events. Thus, the concept was primarily defined normatively, according to the needs of the respective time and the cultural context, social development, or specific demands of the labor market and further education (Bulajić & Despotović, 2018). Our understanding of the term "literacy" can thus be historically divided into the period before 1950, when literacy was understood solely as alphabetical literacy (word and letter recognition) and the period after 1950, when literacy slowly began to be considered as a wider concept and process, i.e., functional literacy (Dijanošić, 2009). Although functional (il)literacy has become one of the priorities of educational policies and scientific research in the last decades, there is still no coherent image nor sufficiently empirically based conclusions on what the cognitive profile is for a functionally illiterate person. This deficiency also includes operational definitions, estimates, and/or differential diagnostic patterns of FI (Vágvölgyi, Coldea, Dresler, Schrader, & Nuerk, 2016).

The 20th session of UNESCO General Assembly in 1978 served as a cornerstone for further research and the implementation of intervention programs regarding FI, as functional literacy then became fully acknowledged on an international level for the first time. A functionally literate person was defined as a person "who can engage in all those activities in which literacy is required for effective functioning of his group and community and also for enabling him to continue to use reading, writing and calculation for his own and the community's development," while someone who is functionally illiterate was defined as the negation of the previous statement (UNESCO, 1979, Annex I, p. 18). A literate person who does not possess literacy skills at the level of appropriate functionality, i.e., an individual who is functionally illiterate, would only be able to read, write, and comprehend "a short simple statement on his everyday life" (Annex I, p. 18). Therefore, FI should be distinguished from (primary) illiteracy, which is defined as the inability to read and write a short simple statement concerning one's own everyday life.

Based on this formal recognition of FI within UNESCO, and reflecting a transformation in the understanding of literacy as more than simple reading and writing skills, new literacy programs started to emerge. These took the form of modern and functional ABE and AL, and there was a tendency to widen the content and outcomes of the programs to address different aspects of adult life. For example, the 1991 National Literacy Act (USA) significantly expanded the scope of literacy programs that had previously treated low literacy levels in adults as a "short-term crisis that could be quickly addressed and eliminated" (Belzer, 2017, p. 12). After 1991, the US Federal Government began building the infrastructure for more long-term and wider actions leading to the evolution of traditional AL programs into more functional ABE. Considered to be more than an instrumental activity of acquiring basic literacy skills, these new programs began to be perceived as a first step in introducing wider logistical and psychological changes into the lives of often marginalized illiterate adults (Bedder & Valentine, 1990). Consequently, ABE evolved into the "symbolic activity in which student's internalized or perhaps socially imposed feelings of inadequacy are formally deleted" (p. 79). As such, ABE was almost seen as an intervention in which a dose of modernity is to be injected into the reference frame of illiterate or uneducated people, representing a sort of modern formalized and institutionalized normative rite of passage into the world of modernity.

This broadening of the ambitions of ABE programs inevitably led to an expansion of the concept of functional literacy in adult education policy and practice. In the numerous attempts to comprehensively approach functional literacy, some of them went so far as to violate the limits of representing the phenomenon. Various skills that went beyond the literacy concept started being included in functional literacy. For instance, the Dutch law on Adult Basic Education from 1987 connects functional literacy with additional components/outcomes encompassing different social skills in addition to linguistic and numerical literacy skills. The law also defined an upper limit of previous education allowed for inclusion in ABE as completed 2nd year of high school (Hamminock, 1990). What we consider problematic for this comprehension of functional literacy is the inclusion of additional concepts of social skills in it. The law and program goals prescribed the effective use of basic skills in 14 different areas such as "education and training, education of children, work, hobby, household and environment, family life and home care, social security, social participation, communications and media, consumer culture, health care, politics and culture, transport, personal interests" (p. 16).

Although this and similar descriptive definitions emphasize the importance of different contexts and individual and social development, we believe that they do not represent functional literacy, but rather a considerably wider concept. Such a "holistic" approach is not helpful for conducting empirical research or for creating specific instruments for FI assessment. Ultimately, it forces researchers to create their own definitions of FI in a broad manner. Thus, not uncom-

monly in adult education literature, one finds a high number of similar reflections on functional (il)literacy, for instance: "Literacy is much more than reading and writing; it is a way of communication, the acquisition of knowledge, the learning of language, the development of culture" (Dijanošić, 2009, p. 28). Similarly, many other European authors consider functional literacy in the 21st century not to be only a set of basic skills, but rather a complex corpus of knowledge and skills, the strategy of personal development in the context of lifelong learning, as well as the basis for the development of an integrated and educated European community (see Mukan & Fuchyla, 2016). Moreover, these broad definitions emerging from adult education seem to equate functional literacy with the wider concept of *lifelong learning competences*, such are those defined in the European reference framework for such key competences (European Parliament and the Council of Europe, 2006).

Functional Illiteracy and Primary Illiteracy, Cognitive and Neuroscientific Research

So far, most studies on the cognitive and brain aspects of illiteracy have dealt with primary illiteracy or full illiteracy. Possessing absolutely no reading and writing skills in any language, possibly because of not having received any organized and systematic literacy training, may be referred to as primary illiteracy (Boltzmann, Rüsseler, Ye, & Münte, 2013). Some inferences relevant for FI can be drawn from studies conducted on individuals who are primary illiterates, which showed that illiterate adults achieve poor scores on a wide range of cognitive abilities tests, especially those concerned with reading-related cognitive domains and tasks such as verbal fluency, verbal memory, visual and numerical abilities (Ardila, Ostrosky-Solis, & Mendoza, 2000). The exception was the naming and identification of real objects or orientation ability (see Ardila & Rosselli, 2007). It was found that education level explains variance in cognitive skills much better than age. For example, in the domain of verbal abilities, there is no decline as the function of age, when differences in the educational level are controlled for (Albert & Heaton, 1988). Similar inferences apply to FI individuals as well. They also achieve low scores on the wide spectrum of cognitive tasks, including those targeting skills unrelated to reading and writing specifically, such as visual organization, mental spatial orientation, vigilance, divided attention, visual memory, and visual organization (van Linden & Cremers, 2008).

Several studies and meta-analyses (Petersson, Reis, Èf, et al., 2000; Petersson, Reis, & Ingvar, 2001; Petersson & Reis, 2006; Reis & Castro-Caldas, 1997; Reis, Petersson, Castro-Caldas, & Ingvar, 2001; Rosselli, 1993) provide a more general overview of the effects of education, i.e., literacy skill mastering on cognitive abilities:

a. Functional and anatomical cortical and neural differences between literate and illiterate individuals
b. General cognitive functioning
c. Cognitive abilities associated with natural language (verbal fluency, semantic and phonological coding of visual representations, phonological awareness, capacity of verbal working memory)
d. Numerical abilities (counting, number processing, basic calculus, and estimation of quantity)
e. Visual and spatial abilities (visual reproduction of simple two-dimensional objects, identification of objects in superposition, e.g., modified, extended, masked objects, and other abilities)
f. Different domains of memory

When it comes to language processing and literacy, many studies (e.g., Reis & Castro-Caldas, 1997) showed that illiterate individuals are limited to a semantic system of oral-language processing, while literate persons use all three pathways (lexical, semantic, phonological) in a general strategy for solving language-related tasks. Mastering literacy skills seems to create new and qualitatively different strategies of oral-language processing, e.g., "conscious phonological processing, visual formal lexical representation, and all the associations that these strategies allow" (p. 445). Other studies (Kosmidis, Tsapkini, Folia, Vlahou, & Kiosseoglou, 2004) confirmed that there is no qualitative difference in semantic processing strategies between literate and illiterate individuals, only quantitative ones, such that education (i.e., literacy training) enhances the effectiveness of semantic processing strategies. However, literacy does indeed affect phonological aspects of language processing (phonological awareness, phoneme-grapheme correspondence) in a qualitative manner. This was confirmed by neuroscientific studies that showed a lower ability of illiterate persons to separately process phonological aspects of the language. Hence, although they can rhyme or manipulate syllables, they lack the ability to add/remove consonants from word beginnings, memorize phonologically related pairs of words, and repeat pseudowords. Regarding the final skill/task, individuals who are illiterate tend to make the specific mistake of transforming pseudowords into meaningful concepts (Landgraf et al., 2012; Reis & Castro-Caldas, 1997). In pseudowords repetition, noticeable differences occur that are related to the phonological loop, i.e., interactions between the Broca's area and the inferior parietal region. Differences were also found regarding the posterior-midinsular bridge between Wernicke's and Broca's area (Petersson, Reis, Askelöf, Castro-Caldas, & Ingvar, 2000,

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p. 364). Furthermore, the fact that differences in phonological processing are culturally universal was also shown by a silent word and picture-naming task study in literate and illiterate Chinese adults (Li et al., 2006) which concluded that literacy strongly influences patterns of neuronal activity leading to "increased efficiency of cognitive processing of tasks related with the language" (p. 144).

Besides the aforementioned phonological differences, important disparities in neural functioning also appear to underlie orthographical processing related to different illiteracy levels. The left ventral occipito-temporal cortex, called the "visual word form area" (VWFA; Dehaene, Poline, Le Clec'H, Le Bihan, & Cohen, 2002) is found to be closely related to reading acquisition. It seems that, as the reading skill is being mastered, the responsivity of the region starts shifting more toward script rather than to nonletter objects. After reading acquisition, the VWFA is still responsive to nonscript visual stimuli, though it responds more actively to script than other visual objects. ERP data showed that the left-lateralized, VWFA-associated N170 component is greatly enhanced in individuals who are literate and formerly illiterate compared to illiterate ones, following visual presentation of a letter string (Dehaene, Cohen, Morais, & Kolinsky, 2015, p. 2).

These findings may serve as valid markers of neural differences, not only between illiterate and literate individuals, but also between different levels of illiteracy, such as between individuals who are primary illiterate and those who are functionally illiterate. Several studies conducted with individuals who had completed 9 months of intensive literacy training for functionally illiterate adults in Germany (Alpha Plus) and various controls (functionally illiterate individuals who had attended less intensive literacy training and average readers) provided several new insights. In response to word presentation, there was an increase in the VWFA related N170 amplitude observed in formerly functionally illiterate individuals after completion of intensive Alpha Plus training, compared to before the training, whereas no differences were found in controls (Boltzmann & Rüsseler, 2013). A parallel fMRI study showed differences in activation of the fusiform gyrus, often regarded as a key neuronal component of word recognition (Boltzmann et al., 2013). There was larger activity found in fusiform gyrus (including VWFA) in formerly functionally illiterate adults immediately after the training completion compared to pretraining baseline. While some benefit can almost always be related to various ABE/AL programs, both studies provide strong evidence that only intensive interventions yield efficient (functional) reading skills. The above-mentioned studies validate the benefits of literacy training intervention in several different ways. They show that there is (1) a diminution/disappearance of the neural functional differences between literate and formerly functional illiterate individuals after training intervention, (2) a positive correlation between the N170 enhancement and reading skills before and after training, and (3) that N170 can be modulated even in adulthood.

It seems that FI adults have linguistic deficits in numerous domains such as phonological, orthographic and lexical processing, oral and reading comprehension, and verbal fluency (Vágvölgyi et al., 2016). Apart from the neural differences mentioned, the use of oral language in illiterate adults is also observed to be characterized by lower fluency, simpler grammar, and lower symbolic representability of language i.e., greater attachment to a concrete and direct context, or more action-obvious direction of verbal reasoning (see Ardila et al., 2010). A recent study on the impact of years of schooling on a range of language skills and abilities showed differences in the variation of the following abilities and skills in relation to the time spent in the education: oral-language comprehension, reading, graphical comprehension, naming, lexical availability, dictation, graphical naming of actions, and number reading (Soares & Ortiz, 2009).

The above-mentioned studies show that education and literacy training primarily affect the coherence and development of semantic (quantitative differences), phonological, and syntactic processing. The nature of the stimulus used in cognitive tasks also appears to affect performance differences between literate and illiterate individuals. For example, it was shown that literate and illiterate adults showed no difference in naming usual everyday real objects, whereas there differences did appear if the stimuli were photographs or drawings of given objects (Reis, Guerreiro, & Castro-Caldas, 1994; Reis et al., 2001). Thus, it was found that the further the stimulus is from concrete objects, the greater the performance differences. Hence, as in many other examples, the ability of illiterate individuals decreases with the level of abstraction of the task on the continuum of concrete-iconic-symbolic. This applies for visual-orthographic as well as semantic aspects. Reis et al. (2001) pointed out that literacy strongly influences the visual system or mediates the relationship between the visual and the language system. This general conclusion agrees with the behavioral research on differences between literate and illiterate persons' recognition of letters and simple two-dimensional shapes. It suggests that, unlike literate persons, illiterate ones visually perceive letters (perceptive strategy) similarly to how they perceive two-dimensional shapes (Lachmann et al., 2012).

The "Literate and Illiterate Brain"

Results from imaging studies indicate that literacy and education influence the functional architecture of the adult

brain (Ardila et al., 2010). Up until the 1990s, it was believed that differences in the general abilities (intelligence) test achievements of literate and illiterate persons were the consequence of (1) the lack of sensibility to test situation, (2) the inadequacy of existing tests for illiterate individuals, or (3) simply "lower" intellectual abilities of illiterate individuals. More recent research, however, showed that acquisition of literacy significantly transforms the organization of cognitive skills by adapting them to the modern industrial and postindustrial cultural framework. Culture, education, and literacy seem to change the way human cognition is organized, affecting all or nearly all cognitive abilities (Rosselli, 1993). This conclusion points out to the existence of a historical modulation of the human cognitive abilities.

An increasing number of studies are focusing on anatomical brain differences between illiterate and late literate adults (i.e., those who acquired literacy skills in adulthood), showing cerebral differences occurring due to literacy mastering and without the influence of brain maturation. One of the studies showed greater interhemispheric connectivity in late literates who expressed "more white matter in the splenium of the corpus callosum and more grey matter in bilateral angular, dorsal occipital, middle temporal, left supramarginal and superior temporal gyri" (Carreiras et al., 2009, p. 983). The corpus callosum seems to be the bridge that one has to cross over in order to get phonological and visual linguistic information connected. Similarly, one of the studies, which experimentally examined the intensive 9-month literacy Alpha Plus training of FI adults, showed that they possess smaller gray matter volume in various reading-related brain areas (e.g., lateral occipital cortex, superior temporal gyrus, angular gyrus, supramarginal gyrus, and precuneus) than literate ones at the baseline condition. After completion of the program, however, there was no longer any observed mass differences in gray matter between the two groups (Boltzmann, Mohammadi, Samii, Münte, & Rüsseler, 2017). According to Dehaene et al. (2010), acquiring literacy (even in adulthood) enhances brain responses in at least three ways: It boosts the organization of visual cortices, it allows activation of the entire left-hemispheric oral-language network by means of written sentences, and it "refines spoken language processing by enhancing a phonological region, the planum temporale, and by making an orthographic code available in a top-down manner" (p. 1364).

The influence of literacy on the anatomical and functional brain organization and corresponding cognitive functioning is perhaps most noticeable in tasks in which literate and illiterate adults achieve equivalent behavioral results. In particular, where there are no *quantitative* differences between the two populations or where the effect size of the observed differences is negligible, but where cognitive processing is *qualitatively* different. For example, in quantity evaluation tasks (Deloche, Souza, Braga, & Dellatolas, 1999), there was a very small effect size for achievement differences between the sample of illiterate persons and university students. The differences were significant, however, in task strategy as well as in patterns of brain activation. Unlike most of the students who relied on abstract reasoning on a given task, illiterate adults relied strongly on the ability to visualize. While illiterate adults activated parts of both hemispheres, i.e., they solved the task bilaterally, in students only the left hemisphere was activated.

Large-Scale Literacy Surveys and the Concept of Functional Illiteracy

Large-scale international adult literacy surveys have traditionally been carried out by global international organizations such as the OECD and UNESCO. The most commonly known ones were carried out by the OECD, such as the International Adult Literacy Survey (IALS) administered between 1994 and 1998, the Adult Literacy and Life Skills Survey (ALL) applied between 2003 and 2007 (OECD, 2000), and their successor, the Survey of Adult Skills a product of PIAAC (The Programme for the International Assessment of Adult Competencies). The latter has been in place since 2012 to the present day (OECD, 2013a; OECD, 2013b; OECD, 2016). It may be important to also mention the UNESCO's Education for All (EFA) global program, launched in 2000 by the Dakar Framework for Action initiatives (UNESCO, 2000), which relies on national reports to evaluate and monitor the progress of member states toward the defined program goals. One of the goals was to reduce the illiteracy of adults by 50 % by 2015, which, unfortunately, has not been achieved. Starting from the estimate that in 2000 about 18 % of all adults in the world were illiterate, the situation in 2015 reveals that 14 % of the adults in the world population were illiterate. Two major national literacy skills surveys are also well-known: the National Assessment of Adult Literacy (Baer, Kutner, Sabatini, & White, 2009) in the United States and the German Level One Study (leo.; Grotlüschen, Riekmann, & Buddeberg, 2015; Grotlüschen & Buddeberg, 2017). In addition to these, there are also several standardized and commercially available literacy tests presently in use for literacy assessment, mainly in English, such as a specially designed ABE learning impact assessment tests (e.g., Test of Adult Basic Education, consisting of subtests of reading, mathematical skills, language skills, vocabulary, and spelling at five levels of difficulty; CTB/McGraw-Hill, 2008).

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For the further operationalization of FI and an understanding of which skills and what levels it encompasses, it would be beneficial to define FI within the leo. and PIAAC scale levels, which would help to bridge different FI comprehensions, including those of policy and adult education on the one hand and cognition on the other, as these studies are constituted by both.

Contributions of the Level One Study for Understanding Functional Illiteracy

Launched as part of the National Strategy of Literacy and Basic Skills 2012–2016, the leo. study focused on assessing the lower levels of literacy in Germany, which are ranked on the scales or "Alpha levels" 1-4. The Alpha levels 5 and 6, in turn, represent levels of literacy. Alpha levels 1 and 2 represent illiteracy in the narrow sense, i.e., a person can read, understand, and write individual words, but not whole sentences. At these levels of literacy, individuals read letter by letter. Alpha level 3 represents FI in a stricter sense, i.e., individuals who can read and write individual sentences, but not a whole continuous (prose) text, which creates a barrier in their everyday life activities. Alpha level 4 refers to people who can read and write at the level of the entire text, but do it slowly and/or with more errors. They often tend to avoid reading and writing in everyday life. Levels above Alpha level 4 depict medium and proficient level of literacy skills (Grotlüschen & Riekmann, 2011).

One of the most important contributions of leo. study for the purpose of FI operationalization and utilization in cognitive science is that it offers a clear division of skills separating FI from primary literacy. Functional illiteracy implies letter recognition, word and sentence comprehension, but also major difficulties with comprehension of continuous texts. Literacy, therefore, can be measured on a hierarchical scale when applying the proposed definition of the leo. study (Grotlüschen, Riekmann, & Buddeberg, 2014). The ecological validity of this literacy hierarchy is represented by the study results, which reflect clear literacy level distinction in the population.

The Level One Study results indicate that typical prejudices in the population about FI persons are incorrect. It was found that 57% of the FI population is in fact employed, 80% have a school diploma, 58% had German as their first acquired language, and there were more males (60%) than females (40%). It is important to note that, according to leo.'s broader concept of FI, there are 14.5% FI people in Germany. This percent includes persons with literacy skills at Alpha levels 1 and 2 (levels more close to primary illiteracy), as well as individuals whose native language in not German.

In the strictest sense of the term, there are at most 10% FI individuals in Germany, based on our objective of defining FI in cognitive terms. This means that, from a cognitive perspective, a person cannot be treated as functionally illiterate in L2, where L2 is understood to be the language not acquired first or not their native language. Therefore, FI can be applied only to one's native language, first acquired language(s), or to language spoken on a native-like level. Literacy in L2 depends on one's knowledge and skills of the oral component of the L2 language. Therefore, in terms of cognitive skills, one can be completely literate in a native language but illiterate in the L2. However, from the policy and adult education perspective, which aims to increase functional socioeconomic integration, it may be necessary and justified to include those instances, whereby members of the population are functionally literate in their native language but not in the L2. For example, where the L2 is the official language of the country used in schooling and/or daily life.

Contribution of PIAAC for Understanding Functional Illiteracy

The Survey of Adult Skills, popularly named PIAAC, was developed largely under the conceptual and methodological influence of the previous IALS. The first round of research was carried out in 2012 (OECD, 2013a; OECD, 2013b), the second in 2014 and 2015 (OECD, 2016), when nine additional countries (33 in total) joined the study. The main focus of PIAAC was information-processing skills, consisting of language literacy (only reading), numerical literacy, and problem solving in technology-rich environments, the latter mostly representing ICT (information communication technology) or digital skills.

PIAAC's definition of language literacy is a based on more specific and experiential cognitive skills of literacy – seeing that literacy envelops "a range of skills from the decoding of written words and sentences to the comprehension, interpretation, and evaluation of complex texts" (OECD, 2013b, p. 20). Although PIAAC does not use the term functional illiteracy, we suggest that FI can be placed within the PIAAC language literacy scale levels. PIAAC differentiates the following three cognitive strategies of written text decoding and processing: access and identification (locating the relevant information within the text), integration and interpretation (linking different information located in the text into the meaningful unity, enabling the making of relevant conclusions), and evaluation and reflection (relating text information to other information, knowledge and experiences).

In PIAAC, the language literacy scale consists of six levels. The scores of each level represent the level of profici-

ency, i.e., they reflect characteristic literacy features that are quantitatively and qualitatively different. On this basis, we hereinafter place FI at the following PIAAC levels of proficiency: level below 1 and level 1 (see OECD, 2016).

In the last round of the PIAAC survey, 4.5% of participating countries' population achieved average scores corresponding to *Literacy level below 1* (0-175 score range). Tasks at this level require locating one brief bit of information on a commonly known topic in a short text which is identical or synonymous with the information given in the task request. Rarely is information included that is mutually competitive, i.e., seemingly similar to but different from the point of view of the task requirement. Furthermore, only basic vocabulary is required but not an understanding of the structure of a sentence or paragraph. As for *Literacy level 1*, it was found that 14.4% of the participating countries' population on average achieved score points corresponding to this level (176-225 score range). As with the previous level, tasks at this level require locating only one bit of information identical to or synonymous with the information in the task request. Once more, only basic vocabulary is required, but unlike the previous level, the content format can be continuous and noncontinuous text – and it may be necessary to compare or take into account more information, though seldom mutually competitive information (OECD, 2013b; OECD, 2016). These two levels can be determined lying below functional literacy, that is, as levels of FI, taking into account FI criteria by the leo. study (Grotlüschen & Riekmann, 2011, as well as Vágvölgyi et al., 2016). However, both levels do not require a more complete and thorough comprehension of the text.

When comparing results on the PIAAC literacy scale levels of below 1 and 1 with educational attainment levels, the average achieved score for OECD countries is 231 and for Germany 219.5, for educational attainment up to the completed, lower level of secondary education (OECD, 2016, p. 70; OECD, n.d.). These values roughly lie near the maximum PIAAC-defined score points for levels below 1 and 1 of (0-225). It further justifies the insight that, according to education normative criterion, FI adults are most probably individuals who have not completed basic education (Vágvölgyi et al., 2016) or completed basic education but have attended only 1 or 2 years of schooling at the secondary-education level (Dutch Law on Basic Adult Education, 1987; Hamminock, 1990).

Functional Illiteracy and the Development of Reading Skills

The behaviorally manifested differentia specifica of FI compared to primary illiteracy means having a fair ability in letter and word recognition and comprehension as well as comprehension of single sentences. The FI-specific feature compared to full literacy is a low effectiveness in text comprehension. This may then beg the question of what the status of the cognitive components and processes underlying FI individuals' reading skill would be. We expound on this in the following paragraphs.

From the criteria given above, we presume that FI implies having completed processes for the development of phonological awareness. Yet, there are studies that claim literacy in general is not required for solid phonological awareness, but rather one's knowledge of the alphabet that distinguishes or at least largely contributes to good phonological awareness skills (Falk Huettig, Lachmann, Reis, & Petersson, 2018; Read, Yun-Fei, Hong-Yin, & Bao-Qing, 1986). However, because FI is a broad category, FI adults may share some of the same difficulties as illiterates with respect to phonological awareness. These include issues concerning onset (but not rhyme) phonological awareness as well distinguishing phonologically similar words (Landgraf et al., 2012).

We may also presume the existence of the developed phoneme-to-grapheme conversion relative to level of orthographical depth/transparency of the language in FI individuals. Because FI requires the recognition and comprehension of words, one may expect to find the word superiority effect (Cattell, 1886; Reicher, 1969; Wheeler, 1970) in FI individuals. Thus, both routes, the alphabetic and the lexical semantic route (Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001), should be developed to some extent. Deficiencies in FI individuals relative to literate persons may also be expected in terms of richness of mental lexicon (stemming from less frequent exposure of prose texts), in addition to difficulties operating with words of increased level of abstractness and related verbal-logical aspects of language and text (Bulajić & Despotović, 2018). A lower capacity not only of verbal, but also of visual short-term and working memory is also well established (van Linden & Cremers, 2008). Lower scores on verbal intelligence tests are also likely to be expected as a consequence of all the aforementioned verbal deficiencies in association with other additional causes.

In a more general outlook on reading and FI, we refer to the functional coordination framework, which describes the cognitive processes involved in reading (Lachmann & van Leeuwen, 2014; Lachmann, 2018b). The framework contains four stages: recruitment, modification, coordination, and automatization. When learning to read, the individual first reverts to already existing components and skills, that is, primarily auditory and visual ones. These skills are then modified to be optimized for the reading context. Stated in Piagetian terms, the existing visual-au-

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ditory perception schemes accommodate and broaden up to enable the assimilation of the written material. During the third stage, phonological skills (grapheme-to-phoneme conversion) and analytical strategies for letter perception (Lachmann et al., 2012) achieved in the second stage are coordinated. This coordination is automatized (Nicolson & Fawcett, 2018) over several years during the final stage (Froyen et al., 2009).

Based on the framework of the model, we can hypothesize that FI adults did not fully achieve complete coordination of the processes from the modification phase and, most importantly, did not properly or fully automatize the whole process. This can be inferred based on their ability to read individual words and sentences, yet their lack of capacity to understand longer text in its entirety. Indeed, our main hypothesis is that FI adults perform with low effectiveness and efficiency at the text level because they invest more cognitive load to reading individual words and sentences due to a lack of automatized reading. Consequently, they have less residual cognitive capacity for comprehension on the test level. Alternatively, the reading process in some FI individuals may be automatized, but the modification or coordination of skills underlying reading is inadequately developed.

Toward a Definition of Functional Illiteracy

Recently, Vágvölgyi et al. (2016) suggested an operational definition of FI as "the incapability to understand complex texts despite adequate schooling, age, language skills, elementary reading skills, and IQ. These inabilities must also not be fully explained by sensory, domain-general cognitive, neurological or psychiatric deficits" (p. 9). In addition, the authors offer inclusion criteria for FI such as older than 16 years of age, minimum of 6-8 years of schooling, native-like oral language skills, as well as exclusion criteria for "pure FI": IQ below 70, neurological or mental disorder, uncorrected speech, hearing, or vision problems, dyslexia, dyscalculia, and hyperactivity.

Based on this definition and in light of the aspects we discussed earlier in this article, we recommend the following criteria for a future operational definition of FI:

General Literacy Skills Criteria

- FI is characterized by the ability to identify and comprehend single letters, words, and sentences, albeit with low levels of comprehension when it comes to reading continuous texts (Grotlüschen & Riekmann, 2011; Rüsseler, Gerth, & Boltzmann, 2011; Vágvölgyi et al., 2016).

Normative Criteria

- It is presumed that FI is not a result of the total absence of education and training, but is most probably the result of such individuals possessing a poor education. This is considered mainly in terms of low educational level (measured in years of schooling). Thus, if poor reading skills were still observed in individuals who have completed secondary or tertiary education, it would reflect a case of developmental dyslexia or another developmental disability. Because educational systems (both national and regional) differ in terms of the number of years and grade outcomes for basic (primary, elementary) and secondary education, we propose a more general categorization that is also more internationally comparable, based on the International Standard Classification of Education (ISCED; UNESCO Institute for Statistics, 2012). The lower boundary of educational level for FI is uncompleted upper half of the basic education, which according to ISCED would correspond to level 03 (minimum 5-8 years of primary education; UNESCO Institute for Statistics, 2012, p. 32). The upper boundary (maximum education level corresponding to FI) is having completed the lower half of the secondary education, or the ISCED level 2, sublevel 244/254 (total of 8-11 years of schooling, mostly referring to pupils up to 15/16 years age, pp. 34-36). So, this criterion would include persons who have completed only basic education, basic education plus 1 or 2 years of secondary education, as well as those with uncompleted basic education.
- FI can be applied only to the adult population or youth (16 years of age and older) legally defined as capable of working. Any younger members of the population cannot be considered functionally illiterate because of the social aspect of the FI definition (UNESCO, 1979). They are still not mature enough to be responsible for their own well-being or the social and economic development of the community. Elderly adults who suffer from degenerative processes such as poor and/or uncorrected hearing and/or vision, dementia, brain damage, etc., should be excluded from the characterization of FI. Accordingly, there is an issue regarding the upper age limit as an exclusion factor for FI. For instance, the PIAAC study was not applied to individuals above 65 years of age, albeit only for practical reasons. We believe that there is no rational reason to exclude this age group from the FI concept if there are no relevant medical/neurological reasons for doing so.

Language Skills Criteria:

- Individuals cannot be regarded as FI in a language they are not proficient in on a native-like level (Vágvölgyi et al., 2016).

- If someone is functionally literate in one language, for example, in their native language, this person cannot be considered FI by possessing poor literacy skills in some other language. That individual would be literate in cognitive terms, having fully recruited, modified, and coordinated the reading relevant cognitive processes, and fully automatized the resulting reading specific procedure (Lachmann & van Leeuwen, 2014).

Other Causes of Reading Inability:

- Neurological or mental disorders such as uncorrected speech, hearing, or vision problems, dyscalculia, and hyperactivity (Vágvölgyi et al., 2016) are additional exclusion factors for FI. In particular, FI needs to be differentiated from developmental dyslexia. As a result of a literacy training deficiency, FI can be overcome by appropriate training itself, leading to the full development of functional coordination of all underlying cognitive components (Lachmann & van Leeuwen, 2014). On the other hand, while various deficiencies underlying developmental dyslexia might be compensated for in one's overall reading ability by alternative enhancements, coping strategies or brain plasticity (Frith, 2001), the deficiency of certain underlying skills and processes involved in reading, such as phonological awareness, cannot be fully corrected by training.

Cognitive Processes, Specific Reading Skills in FI:

- Letter recognition (grapheme-to-phoneme conversion) is established, whereas emerging analytical strategy of letter perception may not yet be fully automatized.
- There is whole-word recognition for high-frequency words and more concrete everyday words.
- A limited vocabulary in comparison to skilled readers.
- Adequate word and sentence comprehension.
- Difficulties in phonological processing, especially in onset phonological awareness and in distinguishing phonologically similar words.
- From the perspective of the functional coordination model, not fully achieved coordination of reading relevant subskills, and, most importantly, incomplete automatization. Because of the latter, difficulties in comprehension of complete text emerge, since most of the cognitive load is allocated to decoding the text content.

General Intellectual Ability and FI:

- General cognitive ability measured by intelligence quotient (IQ) of FI individuals should not be below 70 (Vágvölgyi et al., 2016). However, our current ongoing research suggests that FI individuals, especially those from the marginalized parts of society, are not well habituated to current intelligence tests, or vice versa. For example, even nonverbal, relatively culturally neutral tests like the Ravens Matrices pose the risk that marginalized FI adults may perform below their intellectual capabilities and thus be unfairly characterized as individuals with an intellectual disability. According to the analyses of the Flynn effect, there has been an increase in the average scores on intelligence tests since the first mass testing occurred, especially within the last several decades. For example, from 1947/1948 to 2002, there was an increase of 0.5 scores per year on the Ravens Progressive Matrices in the general population (Flynn, 2009). A similar progression is also found for most of the well-known tests and subtests highly loaded with factor *g* (general intelligence factor; Spearman, 1927). Furthermore, the closer the task is to measuring relatively purer crystalized abilities (G_c), the smaller gain associated with Flynn's effect becomes (Blair, 2006). Analyses of these findings reveal a paradox: Projecting contemporary intellectual gains as described by the Flynn effect onto the population at the beginning of 20th century would reveal that our ancestors living at that time were intellectually disabled, possessing an average IQ in the range between 50 and 70 (Flynn, 2009). As Flynn suggests, current mental gains result from post-scientific abstract reasoning, imposed by contemporary education. Because a large portion of the FI adults have not completed basic education, it can be expected that their test performance would be invalidly poor and thus not validly reflect their actual intellectual skills. Many authors raised similar concerns, explaining the education variable impact on intelligence test scores (Ceci & Williams, 1997). Ravens Matrices, often used for assessing illiterates, are tests of abstract analogies or tests of reasoning on abstract materials, and therefore may not be appropriate tests for many FI individuals. Moreover, some studies show the effects of educational intervention that lead to increases in performance on the Ravens Standard Matrices (Skuy et al., 2002). Therefore, it is suggested using in the future tests more adapted to low-educated persons, or alternatively that adapted norms be utilized for this group of adults.

Conclusion

Literacy acquisition is a long-term process of conceptual and procedural learning that must combine many preexisting cognitive functions to attain full proficiency. As a cultural imperative, literacy has been increasingly imposed on individual cognitive systems since the establishment of compulsory basic education. In the process of mastering literacy, individuals go through several stages of an intensive learning process, starting with gaining conceptual know-

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ledge about letters and then the manner in which words are composed, which in turn form sentences and texts. This is followed by the acquisition of a procedural knowledge of automatizing the cultural practices of reading and writing on, more or less, an everyday basis. The assimilation of this behavioral aspect forces an individual to accommodate and reorganize cognitive structures in order to create/incorporate the novel system underlying written language. Stated differently, existing cognitive and neuronal systems supporting biologically primary knowledge become "recycled" (neuronal recycling hypothesis; Dehaene, 2005); the old functions are weakened in order to respecialize the processing of secondary knowledge such as reading (e.g., literacy-induced changes in left VOT region). According to an alternative explanation, these preexisting cognitive systems are not recycled per se, but rather "synthesised in a novel manner" (Lachmann & van Leeuwen, 2014): They preserve their original functions, but become reorganized and recoordinated on a new, higher level by building up an automatized higher order system for supporting evolutionary novel behavior, i.e., literacy.

In this paper, we offered a perspective and several recommendations for criteria to develop a more operationalized definition of FI, to serve as a basis for future multidisciplinary utilization. We argued that there are four different approaches to FI, that highlight different aspects of what functionality is in the notion of functional (il)literacy, as they all tend to explain different categorical levels of functionality. However, these all reference the same unitary but complex skill of literacy. From the perspective of policy and ABE, functionality refers to a literacy level sufficient for integration in a (post)modern industrial society as well as for personal well-being and lifelong learning, communal and economic development (social inclusion/development level). Large-scale literacy studies understand functionality to be a level of efficient and fluent reading/writing, sufficient for manipulating and understanding prose and document texts that are ecologically important for everyday functioning (behavioral level). The cognitive science approach emphasizes functionality pertaining to established and developed cognitive processes underlying reading skill, such as phonological awareness, orthographical processing, and lexical route-based reading strategy (cognitive level). The neuroscientific approach focuses on functionality in terms of accommodation, recycling, and/or reorganization of neural structures that emerge along with literacy learning and that, in return, enable literacy on an average reading level (neural level). The future operational definition of functional (il)literacy should incorporate all four aspects in a more coherent and cohesive manner. In the current areas of research, a vast plurality of definitions is utilized, making these studies often mutually incomparable. In order to accomplish a more multidisciplinary synchronized approach, it is necessary that each of the approaches outlined further explore and explain what defines the functionality threshold in each of the four categories/domains in a mutually aligned manner. The possible outcome of this endeavor would answer the important questions implied at the beginning of the text, such as: What is the cause of functional illiteracy that distinguishes it from primary literacy or learning difficulties such as dyslexia? Also, what is the cognitive profile of an individual whose literacy is (not) functional enough to allow that person to participate in a (post)modern society without encountering reading/writing-related obstacles? In closing, we would make a suggestion that, as the research field(s) of functional illiteracy consider FI to be literacy that is underdeveloped, inefficient or not functional enough, a more precise term that may be used to describe the phenomenon is "dysfunctional literacy".

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