The effect of illiteracy on the human brain - A systematic review

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BACKGROUND AND OBJECTIVES

Illiteracy persists as a significant global challenge [1]. The global illiteracy rate for both men and women is 13.7%, with men having a lower illiteracy rate (10%) than women (17.3%) [2]. Significant disparities are also found between the illiteracy rates of developed nations (4%) and least developed nations (35%) [2]. Illiteracy is regarded as the inability to read or write [3, 4, 5] and pure or real illiterates are individuals that have never been exposed to or experienced a written symbolic representation or learned a grapheme-phoneme correspondence operation because they have never attended school for social reasons (e.g., because of family dynamics) [6, 7, 3, 8]. Literacy appears to alter the human brain at a morphological and functional level, impacting both linguistic and non-linguistic functions [8, 9]. These phenomena can be observed through the usage of assessment tools such as neuropsychological tests and tasks [6, 10, 11, 13, 5, 15] and imaging techniques [16, 17, 13]. Illiteracy appears to constitute a risk factor associated with the onset of dementia, particularly Alzheimer's disease [6, 12], which may be associated with increased vulnerability to cognitive deterioration [9].

AIM - to identify and analyse literature to further understand the effect of illiteracy on the human brain, exploring existing patterns.

METHODS

Materials

Preferred Reporting Items for Systematic Reviews and Meta-Analyses 2020 protocol and software tools.

Selection Process

Three phases: (1) identification; (2) screening and eligibility; and (3) inclusion.

Search Equation

'illiteracy OR illiterate' AND 'neuropsychology OR neuropsychological OR neuroscience OR brain' NOT 'test OR testing OR assessment'.

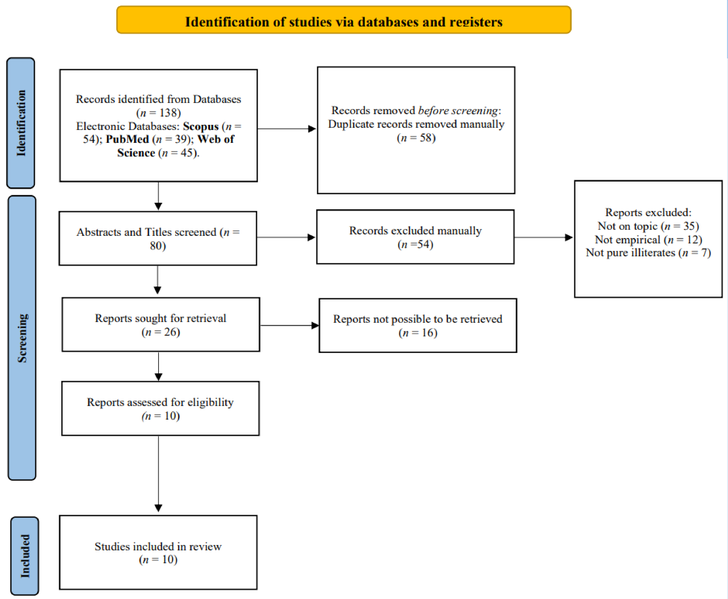
The initial set of terms was restricted to the title, the subsequent set to the abstract, and the final set of terms was confined to the title.

Inclusion Criteria

- Empirical articles;
- Target population of pure illiterates;
- Published in peer-reviewed academic journals;
- Written in English, Portuguese, Spanish, or Italian;
- Full-text and published.

Exclusion Criteria

- Evaluated the translation, standardization, or development of neuropsychological and psychological assessment instruments tailored for the illiterate population;
- With samples that contained functional illiterates or ex-illiterates;
- Systematic reviews, meta-analyses, meta-synthesis;
- Books and conference proceedings.



RESULTS

STUDIES' SAMPLES

- The samples were composed of adults (*n*=9) and children (*n*=1).
- They ranged from 12 to 983 participants, although 8 studies had less than 43 individuals.
- Most studies (*n*=7) had two groups, one experimental and one control, two only had an experimental group, and one had four groups, one of illiterates and three other groups with different literacy levels.
- Their nationality were Portuguese (*n*=2), Indian (*n*=1), Uruguayan (*n*=1), Mexican (*n*=1), Korean (*n*=3), Turkish (*n*=1), and Latin American (several countries such as Puerto Rico or Dominican Republic) (*n*=1).
- The samples of the three first studies spoke Portuguese, Hindi, and Spanish (in the case of the Uruguayan and Mexican samples). Only one of the studies whose samples were Korean specified the language which was fluent Chinese in the Cantonese dialect. The samples from the last two studies were immigrants living in the United States of America and Denmark, respectively, and whose languages were not specified.

RESULTS

STUDIES' RESEARCH DESIGN AND METHOD

- The research design of the articles analyzed was mostly cross-sectional (*n*=9) with one of the studies having a quasi-experimental design with a community intervention (*n*=1).
- The method of nine of the studies (*n*=9) was composed by at least two phases, a screening phase and an experimental or observational phase. One study (*n*=1) did not provide information on its method.
- In the **screening phase**, standardized neuropsychological tests, batteries, or tasks (*n*=7), questionnaires, scales or inventories (n=4), and socio-cultural and clinical semi-structured interviews (*n*=2), were used. Two studies did not specify the screening or participant selection process. In the **experimental phase**, performance of standardized tasks (*n*=5), tests and batteries (*n*=4), and imaging techniques (*n*=4), were used.

STUDIES' INSTRUMENTS

Structural and functional imaging techniques (*n*=4)	**Other laboratory testing and medical techniques** (*n*=1)	**Standardized neuropsychological tests, batteries and tasks** (specified in 9 studies)	**Scales to measure dementia and cognitive deterioration** (specified in 4 studies)	**Interviews** (specified in 4 studies)	**Acculturation scale** (n=1)	**Handedness inventory** (*n*=1)
MRI fMRI resting-state fMRI PET	ECG, X-Ray, CT, Clinical Analysis	E.g., Mini-Mental State Examination, Boston Naming Test, Rey-Osterrieth Complex Figure, The Stroop Test, Controlled Oral Word Association Test, Picture-Naming Task, Word and Non-Word Recognition Task.	E.g., Clinical Dementia Rating Scale, Global Deterioration Scale, The Identities and Oddities subtest of the Mattis Dementia Rating Scale.	Medical or clinical, and socio-cultural or personal interviews.	Turkish adaption of the Short Acculturation Scale for Hispanics (Nielsen & Jørgensen, 2013)	Handedness Inventory (Snyder & Harris, 1993)

STUDIES' RESULTS

All studies showed differences in the results of illiterate participants, being that they scored lower and made more errors on tasks, tests, and batteries. However, in one study, the illiterate group performed higher on the "counting test". Other studies concluded that illiterate adults were more likely to develop prevalent and incident dementia, despite not exhibiting a faster rate of cognitive decline (*n*=1), differences in brain activation patterns when doing specific tasks (e.g., picture-naming task) (*n*=2), differences in their regional brain metabolism (*n*=1), and differences in brain resting state and BOLD activity of illiterate and newly literate people (*n*=1).

CONCLUSIONS

- The disparities observed in the illiterate population, coupled with the high illiteracy rates in less developed countries such as India and Angola, underscore the critical importance of investigating this issue.
- In this study, it was found that individuals who are illiterate, including children, adults, and older adults, face challenges in acquiring cognitive skills beyond reading and writing.
- It was observed that imaging, although not the most used technique, added interesting findings to the perception of differences between the illiterate and literate population such as functional and anatomical changes that greatly enrich the knowledge of reading and writing acquisition.
- Differences in brain activation patterns among native speakers of Mandarin Chinese discerned in one of the studies, who use a logographic writing system rather than an alphabetic one, may reveal further distinctions in this population.
- Future studies should further analyze the child population because of their unique brain characteristics (e.g., elevated brain plasticity) as well as processes (e.g.: pruning). The development and analysis of intervention programs aimed at promoting literacy are important.

Limitations: The sample size is small, and it was not possible to correct for some biases (e.g.: publication biases).

Future Studies: Future research should aim to increase the sample size, correct for biases, and analyze grey literature.

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* Reviewed studies