Nutritional cognitive neuroscience: advances in brain aging

Shriya Som

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ABSTRACT

Nutritional cognitive neuroscience is a new multidisciplinary topic of study that tries to understand the influence of diet on cognition and brain health across the lifespan. Many components of nutrition, from whole meals to single nutrients, impact brain structure and function, and hence have substantial implications for understanding the nature of healthy brain ageing, according to research in this developing subject. The goal of this Focused Review is to look at current breakthroughs in nutritional cognitive neuroscience, with a focus on strategies for discovering food biom-arkers that predict healthy brain ageing. We propose an integrated approach that advocates for the integration of nutritional epidemiology and cognitive neuroscience research, including: (i) techniques for precisely characterizing nutritional health based on nutrient biomarker patterns (ii) contemporary measures of brain health obtained from high-resolution Magnetic Resonance Imaging (MRI). Nutritional cognitive neuroscience will continue to expand our understanding of the positive effects of diet on the ageing brain by merging cutting-edge methodologies from nutritional epidemiology and cognitive neuroscience.

Key Words: *Nutrient biomarker*

PERSPECTIVE

Observational studies show that antioxidant foods, calcium, fiber, folate, zinc, omega-3 polyunsaturated fats, and vitamins A, B12, C, D, and E are all favourable to brain ageing. However, these effects have not been repeated regularly in randomized controlled trials. The major source of disagreement among findings is assumed to be methodological constraints in the assessment of dietary patterns, which has given birth to new methodologies in nutritional epidemiology that investigate blood biomarkers linked with healthy brain ageing. Traditional nutritional epidemiology research has focused on self-reported dietary assessment tools such as food frequency surveys, 24-hour recall, and weighed food records. Although these strategies are very simple to deploy in large samples, they are linked with measurement inaccuracy. Primary sources of mistake include underreporting of energy expenditure, recollection difficulties, and difficulty determining portion sizes. Furthermore, cognitive decline (for example, memory loss) may decrease recall on self-reported dietary evaluations, biasing nutritional assessment in older persons. Furthermore, age, gender, socioeconomic level, and education are known to impact biases in self-reported dietary data. Finally, self-reported dietary evaluation approaches fail to account for nutrient absorption variations. Blood, urine, and tissue can all be tested for biochemical indicators. The concentration of a certain marker indicates dietary component consumption. Approximately 100 biomarkers that correlate with food consumption have been found in epidemiological investigations.

These biomarkers can be used to assess consumption of a variety of dietary components, including as total fruit and vegetable intake, citrus fruits, cruciferous vegetables, salmon, red meat, soy, whole grain cereals, coffee, tea, and wine, food additives, and food pollutants. Biochemical investigations of nutritional indicators can increase data validity by offering an objective and sensitive evaluation of a wide variety of dietary components as a supplement to self-reported approaches.

Scientific developments in the study of nutrient biomarkers and the characterization of dietary patterns have resulted in new methodologies in nutritional epidemiology for measuring Nutrient Biomarker Patterns (NBP). This method uses Principal Component Analysis to capture the effects of nutrients in combination, allowing for the identification of patterns of nutritional biomarkers. Because this approach identifies NBPs in plasma, it avoids the methodological issues that plague standard food frequency surveys, such as inaccurate recollection of dietary consumption and failure to account for nutrient absorption variability. Each NBP is a linear mixture of various plasma nutrients that are highly concentrated within each biomarker pattern. For each pattern, each participant obtains a standardized NBP score, which may then be used to examine the association between nutritional patterns, cognitive function, and brain health. Early applications of this method revealed a variety of nutrient patter ns that influence cognition and brain ageing, including an NBP composed of antioxidants C and E, B vitamins, and vitamin D associated with improved global cognitive function; and an NBP com-

Editorial office, Journal Of Neuropathology, United Kingdom

Correspondence: Shriya Som, Editorial office, Journal Of Neuropathology, United Kingdom , E-mail: neuropathology@pulsusinc.com

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-posed of omega-3 polyunsaturated fatty acids Eicosahexaenoic Acid (EPA) and Docosahexaenoic Acid (DHA) associated with white matter integrity.

Metabolomics can identify biomarkers of ageing and elucidate the mechanisms of health status by characterizing individual dietary phenotypes with unprecedented scope and precision in an effort to improve early diagnosis, facilitate accurate prognosis, and assist in monitoring patient response to therapy. Metabolomics has found possible biomarkers for a wide range of foods and dietary patterns, including raspberries, broccoli, citrus fruits, total fruit and vegetable consumption, heavy meat diets, and the Western diet. However, research using metabolomics to study the association between the food metabolome and brain ageing is still in its early stages, with no published studies to date. G is now underway, as are efforts to uncover particular patterns within the food metabolome related with healthy brain ageing.

Magnetic Resonance Imaging (MRI) allows researchers to investigate structural and functional brain changes linked with ageing, as well as forecast neuropathological events in the ageing brain. Neurodegenerative processes can be detected and assessed with MRI even in cognitively normal brains. Thus, MRI approaches lay the groundwork for exploring anatomical and functional changes in the ageing brain, as well as the influence of diet on healthy brain ageing. There has been little use of fMRI techniques to describe the link between nutrition and brain function, particularly in the setting of brain ageing.

A small number of researchers have found that omega-3 PUFA supplementation modifies brain activity during working memory and calculating tasks. These findings encourage further research into how additional nutrients and nutritional patterns may assist age-related changes in brain function. Although accumulating data shows that nutrition can impact age-related changes in brain function, the mechanisms by which nutrients regulate brain function remain largely unknown. Thus, using modern methodologies from nutritional epidemiology and neuroscience to investigate the impact of diet on healthy brain ageing remains an exciting field for future research. Recent advancements in nutritional cognitive neuroscience show promise in tackling the challenges created by a constantly changing demographic landscape. This Focused Review focuses on current breakthroughs in nutritional cognitive neuroscience, with a particular emphasis on strategies for investigating nutrient indicators that predict healthy ageing. The burgeoning field of nutritional cognitive neuroscience will continue to advance our understanding of the beneficial effects of nutrition on the ageing brain by combining cutting-edge techniques from nutritional epidemiology (nutrient biomarkers in a priori hypothesised dietary patterns and data-driven methods) and cognitive neuroscience (high resolution MRI measures of brain structure and function). Finally, the identification of predicted nutrient patterns for healthy brain ageing will offer an empirically valid framework for the development of nutritional treatments that assist the tailored treatment of cognitive and neurological disorders.