Industrial Dietary Patterns and Ultra-Processed Foods: Their implication for Attention and Memory in Children within the educational context– A Theoretical Analytical Study-

الأنماط الغذائية الصناعية والأغذية فائقة المعالجة: انعكاساتها على الانتباه والذاكرة لدى الأطفال في السياق التربوي - دراسة تحليلية نظرية

Maroua Ghediri*

Assistant "B", University of Djelfa

maroua.ghediri@univ-djelfa.dz

Received :05/03/2026 **Accepted :19/05/2026** **Published : 02/06/2026**

- **Abstract:** This study offers a theoretical and analytical exploration of the relationship between industrial dietary patterns, with particular reference to ultra-processed foods, and cognitive functioning in school-age children aged 6–12 years, focusing specifically on attention and memory. Childhood constitutes a neurologically sensitive period during which the developing brain remains highly responsive to environmental influences; accordingly, dietary quality merits serious scientific attention. Drawing on a narrative review of peer-reviewed international literature, the study suggests that ultra-processed foods, characterized by elevated levels of added sugars, industrially modified fats, and synthetic additives, are associated not only with adverse physical health outcomes, but also with functional and neurobiological changes that may affect attentional regulation and memory consolidation. These associations appear to operate through several proposed mechanisms, including disruptions in neurotransmitter activity, low-grade neuroinflammation, impaired cerebral energy metabolism, and diminished synaptic plasticity, particularly within neural structures implicated in executive control and memory formation. A further observation emerging from this review is that much of the existing literature approaches the issue from a fragmented perspective, emphasizing biological or nutritional dimensions while giving limited consideration to the psychological and educational contexts within which children's cognitive development unfolds. Accordingly, this study argues for an integrative analytical framework that brings together nutritional, neurodevelopmental, and educational perspectives. Thus, dietary quality should be regarded not only as a health-related variable, but also as a significant cognitive and educational determinant deserving greater attention in school policies, parental guidance, and future interdisciplinary research.

- **Keywords** Ultra-processed foods; industrial dietary patterns; cognitive functions; attention; memory; childhood; brain development

- **الملخص:** تتناول هذه الدراسة النظرية التحليلية العلاقة بين الأنماط الغذائية الصناعية، خاصة الأغذية فائقة المعالجة، وأداء بعض الوظائف المعرفية لدى أطفال المرحلة الابتدائية (6–12 سنة)، مع التركيز على الانتباه

*-Corresponding author

والذاكرة باعتبارهما من العمليات المعرفية الأساسية في عملية التعلم. وتنطلق الدراسة من اعتبار مرحلة الطفولة مرحلة نمائية حساسة يتأثر فيها نمو الدماغ بعوامل بيئية متعددة، من بينها نوعية الغذاء الذي يستهلكه الطفل بشكل يومي.

واعتمدت الدراسة على مراجعة تحليلية للأدبيات العلمية والدراسات السابقة التي تناولت تأثير الأغذية الصناعية على الأداء المعرفي للأطفال، بهدف بناء تصور نظري يفسر طبيعة هذه العلاقة. وأشارت نتائج التحليل إلى أن الاستهلاك المتكرر للأغذية فائقة المعالجة، بما تحتويه من سكريات مرتفعة ودهون مهدرجة ومواد مضافة، قد يؤثر في بعض الوظائف المعرفية، خاصة الانتباه والذاكرة. كما ترى بعض الدراسات أن هذه التأثيرات قد تعود إلى تغيرات في النشاط العصبي والكيميائي للدماغ، إضافة إلى تأثيرات الالتهاب العصبي وضعف كفاءة الاتصال العصبي في المناطق المرتبطة بالتعلم والتذكر.

في حين، بينت المراجعة أن أغلب الدراسات ركزت على الجوانب البيولوجية والصحية، في حين لم تحظَ الأبعاد النفسية والتربوية بالاهتمام الكافي، رغم أهميتها في تفسير تطور الوظائف المعرفية لدى الطفل داخل البيئة المدرسية والأسرية. ومن هذا المنطلق، تؤكد الدراسة أهمية تبني مقاربة تكاملية تجمع بين التغذية والصحة النفسية والنمو المعرفي والعوامل التربوية لفهم هذه الظاهرة بصورة أشمل.

وتخلص الدراسة إلى أن نوعية الغذاء لا ينبغي النظر إليها باعتبارها مسألة صحية فقط، بل باعتبارها عاملاً قد يؤثر في مستوى الأداء المعرفي والتعلم لدى الطفل، الأمر الذي يستدعي تعزيز الوعي الغذائي داخل الأسرة والمدرسة، والتوسع في إجراء المزيد من الدراسات البينية التي تربط بين التغذية والوظائف المعرفية في الوسط المدرسي

- **الكلمات المفتاحية**: الأغدية فائقة المعالجة، الأنماط الغذائية الصناعية، الوظائف المعرفية، الانتباه، الذاكرة، مرحلة الطفولة، نمو الدماغ

- Introduction:

Food consumed by humans constitutes the fundamental material for bodily growth and development, serving as the primary source of energy and a key factor in regulating both physical and mental functions. The integrity of vital processes- including neural and cognitive functions- depends on the adequacy and balance of nutrition, without which normal physiological functioning cannot be sustained for extended periods (Zahran, 2003, pp. 45-47).

In this context, contemporary scientific literature highlights that balanced nutrition during early stages of life- particularly during pregnancy and the first years after birth- plays a critical role in brain development and in the formation of fundamental cognitive functions such as attention and memory. During these sensitive developmental periods, the neural foundations underlying later cognitive processes are

established, rendering the developing brain particularly vulnerable to both beneficial and adverse nutritional influences (Prado & Dewey, 2014, pp. 267-269).

Researchers further emphasize that nutrition is central to essential neurobiological processes, including neuronal proliferation, synaptogenesis, and the myelination of nerve fibers- processes that are crucial for efficient neural communication and optimal cognitive performance. Deficiencies in essential nutrients during these developmental stages may disrupt these processes, thereby negatively affecting attention, memory, and learning abilities in children (Georgieff, 2007, pp. 614-615).

Longitudinal developmental studies also indicate that malnutrition during early childhood may be associated with persistent cognitive consequences, manifested in reduced concentration and memory capacity. Such effects may extend into later stages of life, even when nutritional conditions improve subsequently, underscoring the importance of nutritional prevention and early intervention during critical periods of development (Grantham-McGregor et al., 2007, pp. 60–62).

1- Research Problem:

Recent global data indicate that ultra-processed foods account for an increasing proportion of children's daily energy intake, with some estimates suggesting that these products represent over 40% of total caloric consumption among school-age children in high- and middle-income countries (Neri et al., 2022). This trend has been accompanied by growing scientific concern regarding the potential cognitive and neurodevelopmental consequences of such dietary patterns, particularly during the sensitive period of childhood brain development.

Despite the growing research interest in the role of nutrition in supporting healthy child development, scientific literature indicates that the relationship between dietary quality, brain development, and cognitive functions remains characterized by theoretical inconsistency and limited conceptual clarity. This limitation is particularly evident in attempts to explain how different dietary patterns influence core cognitive

functions such as attention and memory. Although numerous studies have reported associations between children's nutritional status and cognitive performance, their findings remain inconsistent, and many fail to provide coherent theoretical explanations of the underlying neurobiological mechanisms involved (Benton, 2010, pp. 460–465).

Other scientific reviews suggest that dietary quality- rather than caloric intake alone- plays a significant role in children's neurocognitive development. However, the literature varies considerably in defining the magnitude, scope, and boundaries of this effect, especially in the context of diverse dietary environments and contemporary consumption patterns. Furthermore, a substantial portion of existing research has focused on general cognitive outcomes, without conducting in-depth analyses of the effects of nutrition on specific cognitive functions such as attention and memory during childhood- a developmental stage characterized by heightened neural sensitivity and rapid cognitive maturation (Nyaradi et al., 2013).

Within the field of nutritional neuroscience, evidence indicates that unhealthy dietary patterns rich in added sugars and processed fats may adversely affect neural plasticity and brain functions related to learning and memory. Nevertheless, such findings are frequently presented within a narrowly biological or neurological framework, without being sufficiently integrated into an educational perspective that clarifies their implications for attention, learning processes, and classroom performance (Gómez-Pinilla, 2008, pp. 571-574).

In light of these theoretical inconsistencies and the absence of a comprehensive educational- analytical framework linking dietary quality, brain development, and core cognitive functions in children, the research problem of the present study lies in the need to provide a systematic theoretical analysis that elucidates this relationship and clarifies its neurocognitive dimensions, with particular emphasis on attention and memory as fundamental pillars of the learning process.

2.Research Questions:

Main Research Question:

What is the nature of the relationship between industrial dietary patterns, particularly ultra-processed foods, and brain development and cognitive functions (attention and memory) in **school-**age children (6–12 years) from a theoretical perspective?"

Sub-Questions:

- How are industrial dietary patterns and ultra-processed foods defined in contemporary scientific literature?
- How does nutrition contribute to brain development and neural functioning in children?
- What is the impact of unhealthy dietary patterns on attention functions in children?
- What is the impact of these dietary patterns on memory as a core cognitive function?
- What are the main theoretical explanations proposed by previous studies to explain the relationship between nutrition and cognitive functions in children?

3.Objectives of the Study:

This study aims to:

- Establish clear theoretical foundations by clarifying the concepts of industrial dietary patterns and ultra-processed foods as presented in contemporary literature.
- Identify the role of nutrition in supporting neural processes and essential brain functions in children during early developmental stages.
- Analyze the cognitive effects of unhealthy dietary patterns, particularly their negative impact on attention and memory as fundamental components of cognitive performance.
- Review existing theoretical explanations linking nutrition to cognitive processes and identify areas of convergence and divergence among these perspectives.

- Propose an educational framework that integrates dietary quality with cognitive developmental outcomes in children, thereby helping to bridge the gap between neuroscientific findings and educational practices.

4.Significance of the Study:

-Theoretical Significance:

This study contributes to enriching the theoretical literature in the fields of educational psychology and nutritional neuroscience by providing a comprehensive analytical perspective that links dietary quality with brain development and cognitive functions in children. It offers a focused theoretical interpretation of how industrial dietary patterns- particularly ultra-processed foods- may influence attention and memory as core cognitive foundations of learning, thereby helping to address existing conceptual gaps in the literature.

5.Educational Significance:

The findings of this study help direct educational attention toward nutrition as a fundamental factor supporting attention, memory, and effective learning in childhood. In addition, the study contributes to raising awareness among educators, parents, and educational policymakers regarding the cognitive implications of dietary quality, and underscores the importance of integrating nutritional considerations into educational practices and school-based interventions.

6.Key Terms and Definitions:

1.Dietary Patterns: In this study, dietary patterns refer to the set of recurrent eating habits followed by school-age children (6–12 years), which may be classified into healthy (natural) dietary patterns and unhealthy patterns that rely heavily on processed and industrial food products.

2.Ultra-Processed Foods (UPFs): Ultra-processed foods are industrial food products that undergo multiple stages of processing and contain extracted or laboratory-formulated ingredients, including chemical additives, added sugars, and hydrogenated

or saturated fats. According to the NOVA classification, these products are nutritionally poor and may negatively affect neural plasticity and brain functioning.

3.Cognitive Functions: Cognitive functions refer to the fundamental neurobiological and psychological processes through which the brain receives, processes, stores, and retrieves information. In the present study, these functions primarily include attention and memory.

4.Attention: Attention is the cognitive ability to selectively focus mental activity on a specific stimulus or task for a defined period of time while ignoring competing stimuli. It represents a core regulatory process essential for effective learning.

5.Memory: Memory is the cognitive ability to encode, store, and retrieve information when needed. It is one of the essential cognitive functions underlying learning and academic performance.

7.Methodology:

This study adopts a theoretical–analytical approach based on a narrative review of peer-reviewed international literature examining the relationship between industrial dietary patterns—particularly ultra-processed foods—and cognitive functions in children, with a specific focus on attention and memory.

The literature was selected through a targeted search of major scientific databases, including Scopus, PubMed, Web of Science, and Google Scholar. The search process employed combinations of the following keywords: *ultra-processed foods*, *industrial dietary patterns*, *nutrition and brain development*, *attention*, *memory*, and *childhood*. Priority was given to studies published in international peer-reviewed journals that provide theoretical, empirical, or review-based contributions to the fields of nutritional neuroscience, developmental psychology, and educational psychology.

The reviewed studies were selected based on their relevance to: (a) nutrition and brain development during childhood, (b) industrial and ultra-processed dietary patterns, and (c) cognitive functions, specifically attention and memory .The present study focuses on school-age children aged 6 to 12 years, representing the middle and

late childhood stages. Studies focusing exclusively on adult populations, preschool children, or unrelated health outcomes were excluded.

The following table summarizes the inclusion and exclusion criteria applied in the selection of the reviewed literature:

Table 1. Inclusion and Exclusion Criteria for Literature Selection

Criterion	Inclusion	Exclusion
Age group	School-age children (6–12 years)	Adults, preschool children (under 6)
Study type	Empirical studies, systematic reviews, narrative reviews, theoretical papers	Single case studies, grey literature
Time period	2000–2024	Studies published before 2000
Language	English and Arabic	Other languages
Topic relevance	Nutrition, brain development, cognitive functions (attention and memory), ultra-processed foods	Studies unrelated to cognitive functions or dietary patterns
Population focus	Child populations in school settings	Clinical or pathological populations only

Based on these criteria, the final corpus of reviewed literature comprised studies that addressed the relationship between dietary quality and cognitive functioning in school-age children, with particular reference to attention and memory as core cognitive outcomes.

Data analysis was conducted using a thematic analytical framework, allowing for the synthesis and interpretation of findings related to neurobiological mechanisms, cognitive processes, and educational implications. This approach enabled the development of an integrated theoretical perspective explaining how dietary quality may influence children's cognitive development, while avoiding causal claims beyond the scope of the reviewed literature.

8.Contribution and Originality of the Study:

This study contributes to the existing literature by providing a comprehensive theoretical analysis of the relationship between industrial dietary patterns- particularly ultra-processed foods- and cognitive functions in children, through the integration of neuroscientific and educational perspectives that are often addressed separately in previous research.

The originality of the study lies in its focused examination of two specific cognitive functions- attention and memory- and in its detailed analysis of the neurobiological mechanisms through which dietary quality may influence these functions during childhood. By adopting this integrative approach, the study seeks to bridge an existing theoretical gap between findings in nutritional neuroscience and educational practice.

Furthermore, the study proposes an analytical educational framework that may serve as a conceptual foundation for future empirical and applied research examining the cognitive and educational implications of dietary quality in children.

9.Previous Studies Related to the Research Topic:

This section reviews and analyzes key scientific studies that have examined industrial dietary patterns and ultra-processed foods and their relationship with children's cognitive functions, with a particular focus on attention and memory. The purpose of this review is to situate the present study within the existing body of literature and to clarify the theoretical and analytical gaps it seeks to address.

First: Studies on Ultra-Processed Foods and Diet Quality:

Monteiro et al. (2019) examined the concept of ultra-processed foods within the framework of the NOVA classification system, demonstrating that this category of foods is characterized by high levels of added sugars, unhealthy fats, and artificial additives, alongside low nutritional value. The study cautioned against the widespread consumption of such foods among children due to their potential adverse health consequences. However, its primary focus remained on nutritional and physical health

outcomes, with limited attention given to cognitive functions or neurodevelopmental implications.

In a related context, Francis and Stevenson (2013) reported that Western dietary patterns dominated by industrially processed foods are associated with negative alterations in brain function, particularly those related to learning and memory. The authors emphasized that prolonged adherence to these dietary patterns may be linked to long-term impairments in cognitive performance. Despite its relevance, the study did not explicitly address attention and memory within a developmental or educational framework.

Second: Studies on Nutrition and Brain Development in Children:

Cusick and Georgieff (2016) demonstrated that nutrition during early childhood constitutes a critical factor in brain development, noting that qualitative malnutrition- even when caloric intake is sufficient- may result in impairments in neural development and cognitive functioning. The study highlighted the existence of sensitive periods of brain growth during which nutritional deficiencies may have lasting effects, without directly linking these outcomes to specific types of industrial or ultra-processed foods.

Similarly, Stiles and Jernigan (2010) emphasized that brain development during childhood is highly sensitive to environmental factors, including nutrition. They indicated that disruptions in these factors may negatively affect the neural structures underlying cognitive functions, although their analysis remained general and did not focus on contemporary industrial dietary patterns.

Third: Studies on Industrial Foods and Attention:

Howard et al. (2011) investigated the relationship between dietary patterns and attention-related problems in children, revealing that unhealthy diets are associated with increased symptoms of inattention and reduced concentration. While the study established significant associations between diet quality and attention performance, it focused primarily on correlational relationships and did not provide an in-depth analysis of the neurobiological mechanisms underlying this association.

In addition, McCann et al. (2007) reported an association between the consumption of certain artificial food additives and the emergence of hyperactive and inattentive behaviors in children. This study contributed to ongoing scientific debate regarding the potential role of industrial food components in attention-related difficulties, although it did not clearly distinguish between short-term behavioral effects and long-term cognitive outcomes.

Fourth: Studies on Industrial Foods and Memory:

Beilharz et al. (2016) demonstrated that diets high in fats and sugars may induce changes in gene expression within the hippocampus, which are associated with impairments in memory and learning processes. This study provided evidence supporting the existence of specific neurobiological mechanisms linking dietary composition to memory function.

Furthermore, Piccolo et al. (2018) showed that early exposure to Western-style dietary patterns negatively affects hippocampus-dependent memory functions, suggesting that diet-related cognitive impairments may emerge during early developmental stages and persist over time.

Fifth: Commentary on Previous Studies and the Position of the Current Study:

Although previous research has confirmed associations between ultra-processed food consumption and reduced cognitive performance, considerable variation exists in how these studies define the nature, magnitude, and scope of this impact. Moreover, many studies have treated cognitive performance as a general construct, without clearly distinguishing between the effects of ultra-processed foods on specific cognitive functions such as attention and memory. This lack of differentiation represents a notable theoretical gap in the literature.

Overall, the reviewed studies indicate that much of the existing research has:

- Focused primarily on correlational relationships between diet and cognitive functions;
- Addressed health-related or neurobiological aspects without sufficient integration into an educational framework;

- Rarely combined ultra-processed foods, attention, and memory within a comprehensive theoretical model.

Accordingly, the present study seeks to bridge this gap by providing a theoretical and analytical examination of the relationship between ultra-processed foods and children's cognitive functions, with particular emphasis on attention and memory, grounded in neurobiological and psycho-educational perspectives.

Section I: Industrial Dietary Patterns and Ultra-Processed Foods:

1. Concept of Industrial Dietary Patterns:

Over recent decades, dietary habits worldwide have undergone a marked transformation, characterized by a gradual shift from traditional, fresh foods toward industrial dietary patterns that rely heavily on processed and ready-to-eat products. This transition has been driven by multiple factors, including urbanization, accelerated lifestyles, the expansion of the food industry, and the increasing influence of commercial advertising targeting children (Monteiro et al., 2019, pp. 936–937).

Industrial dietary patterns are commonly defined as eating patterns in which processed foods- processed to varying degrees- constitute a dominant proportion of daily intake. These patterns are typically characterized by high levels of added sugars, saturated or hydrogenated fats, and salt, alongside low nutritional density in terms of essential vitamins, minerals, and dietary fiber. The literature indicates that such dietary patterns have become particularly prevalent among children, raising growing concerns about their potential health and cognitive implications (Jacka et al., 2015, pp. 380–382).

2. Ultra-Processed Foods (UPFs):

Ultra-processed foods represent one of the most prominent components of industrial dietary patterns. The NOVA classification system provides a widely accepted scientific framework for defining UPFs and distinguishing them from other food categories. According to this classification, UPFs are industrial formulations made predominantly from substances extracted from foods or synthesized in laboratories,

and they typically contain additives such as flavorings, colorants, emulsifiers, and preservatives designed to enhance taste, texture, and shelf life (Monteiro et al., 2019, pp. 937–938).

Common examples of UPFs include fast food products, soft drinks, industrial sweets, potato chips, and sweetened breakfast cereals. These foods are generally energy-dense yet nutritionally poor, making them less suitable for supporting optimal brain development- particularly during childhood, a period marked by heightened sensitivity of neurodevelopmental processes (Francis & Stevenson, 2013, pp. 120-122).

3. Key Features of UPFs and Reasons for Their Prevalence Among Children:

Research indicates that UPFs possess several characteristics that make them especially appealing to children, including intense flavors, attractive packaging, convenience, and widespread availability. In addition, aggressive marketing strategies and advertising campaigns often specifically target children, reinforcing preferences for these products from an early age (Stevenson et al., 2020, pp. 341-343).

Moreover, the high sugar and fat content of UPFs enhances their palatability and reward value, encouraging repeated consumption and contributing to the early establishment of unhealthy eating habits. These factors collectively help explain the rapid spread of industrial dietary patterns among children and underscore concerns regarding their potential long-term cognitive and developmental consequences.

Section II: Neurodevelopmental Characteristics of Brain Growth in Childhood:

1. Brain Development During Childhood: Childhood represents one of the most sensitive and dynamic stages of neurodevelopment. During this period, the brain undergoes rapid structural and functional changes, including increases in brain volume, neuronal proliferation, synaptic formation, and the maturation of neural networks responsible for a wide range of cognitive processes. Neurodevelopmental research emphasizes that the early years of life constitute a foundational phase during which the neural bases of higher cognitive functions- such as attention, memory, and learning- are established (Stiles & Jernigan, 2010, pp. 327–329).

Brain development during childhood does not occur at a uniform pace; rather, it involves critical periods during which the brain is particularly sensitive to environmental influences. Exposure to adverse factors- such as qualitative nutritional deficiencies- during these periods may result in long-lasting alterations in neural structure and function, potentially affecting later cognitive performance (Andersen, 2003, pp. 8–10).

2. Brain Sensitivity to Nutritional Factors in Childhood: The developing brain is highly dependent on a continuous and adequate supply of essential nutrients to support key neurobiological processes. Scientific evidence indicates that nutrition during childhood plays a crucial role not only in physical growth, but also in cortical maturation, neural connectivity, and the regulation of electrical brain activity- processes directly related to cognitive functioning (Tau & Peterson, 2010, pp. 146–148).

Disruptions in dietary quality during this stage- even in cases where caloric intake is sufficient- may lead to functional neurodevelopmental impairments. In particular, deficiencies in essential micronutrients and imbalanced dietary patterns may negatively influence the efficiency of attention and memory, given their reliance on intact neural networks and synaptic communication (Cusick & Georgieff, 2016, pp. 343–345).

3. Nutrition as an Environmental Factor Influencing Brain Development: Nutrition is widely recognized as a major environmental factor influencing brain development, alongside genetic factors and cognitive stimulation. Numerous studies have shown that inadequate nutritional environments may interfere with neural pathways involved in brain plasticity, defined as the brain's ability to modify its structure and functions in response to experience and learning. Neural plasticity is a central mechanism underlying the development of attention and memory during childhood (Kolb & Gibb, 2011, pp. 265–267).

The literature further suggests that nutrition interacts with other environmental variables- such as cognitive stimulation, physical activity, and socio-educational context- to shape the overall developmental trajectory of cognitive functions. This

highlights that nutrition does not operate in isolation, but rather as part of an integrated ecological system influencing children's brain development and learning outcomes (Lenroot & Giedd, 2006, pp. 719–721).

Section III: Ultra-Processed Foods and Neural Functions (Neurobiological Mechanisms):

1. Functional Neural Changes Associated with UPF Consumption: The effects of ultra-processed foods extend beyond general physical health outcomes to include subtle yet significant functional changes in neural activity, particularly within the developing brain. Research in nutritional neuroscience indicates that chronic consumption of ultra-processed foods may influence neurotransmitter systems involved in executive control and attentional regulation, such as dopamine and serotonin, both of which play central roles in cognitive regulation and sustained attention (Beilharz et al., 2015, pp. 125-127).

In addition, diets rich in ultra-processed foods have been associated with altered neural responsiveness to environmental stimuli, potentially increasing sensitivity to immediate rewards while reducing the capacity for sustained attention and cognitive control. Such functional changes may help explain the emergence of attention-related difficulties and weakened executive functioning observed in children exposed to industrial dietary patterns (Kanoski & Davidson, 2011, pp. 41-43).

Collectively, these findings suggest that the impact of ultra-processed foods is not limited to their nutritional composition, but also involves modifications in functional patterns of neural activity that may undermine core cognitive processes- particularly attention and memory- during childhood, a developmental stage characterized by heightened neural plasticity.

2. Neuroinflammation and Metabolic Dysregulation: One of the key mechanisms proposed to explain the effects of ultra-processed foods on brain function is low-grade neuroinflammation. Diets high in added sugars and processed fats have been shown to trigger chronic inflammatory responses within the central nervous system, which may

impair synaptic communication and affect brain regions critical for attention and memory, such as the prefrontal cortex and the hippocampus (Guillemot-Legris & Muccioli, 2017, pp. 20–22).

Ultra-processed dietary patterns are also associated with disruptions in brain energy metabolism, particularly in glucose utilization, which serves as the primary energy source for neural activity. Given the brain's high sensitivity to metabolic imbalances, such disruptions may directly compromise cognitive performance, attentional regulation, and learning efficiency (Kanoski & Davidson, 2011, pp. 42–44).

3. Ultra-Processed Foods and Neural Plasticity: Neural plasticity is a fundamental property of the developing brain, enabling adaptation to environmental experiences and learning demands. Scientific evidence indicates that unhealthy dietary patterns- especially those rich in ultra-processed foods- may impair neural plasticity by negatively affecting synaptic formation, neurogenesis, and the expression of neurotrophic factors essential for learning and memory (Gómez-Pinilla & Tyagi, 2013, pp. 21–23).

Reduced neural plasticity associated with poor dietary quality may, in turn, contribute to declines in memory efficiency- particularly learning-related memory- and limit the brain's responsiveness to cognitive stimulation and educational interventions. This provides a plausible neurobiological explanation for the observed associations between high consumption of ultra-processed foods and reduced cognitive performance in children (Beilharz et al., 2016, pp. 65–67).

Section IV: Cognitive Functions in Children (Attention and Memory): Cognitive functions refer to a set of mental processes that enable children to receive, process, organize, store, and retrieve information, forming the basis of learning and interaction with the surrounding environment. These functions include attention, memory, perception, thinking, and problem-solving. Cognitive functions are particularly important during childhood, as they are still developing and are highly sensitive to

environmental influences, including nutrition, cognitive stimulation, and educational context (Best & Miller, 2010, pp. 164–166).

Neuropsychological research indicates that cognitive functioning in childhood is a strong predictor of later academic achievement and behavioral adjustment. Accordingly, examining factors that may shape children's cognitive development- such as dietary quality- represents a critical area of educational and developmental research (Diamond, 2013, pp. 135–137).

1. Attention in Children: Attention is a core cognitive function that enables children to selectively focus mental activity on a specific stimulus or task while resisting distractions. It is commonly conceptualized as a regulatory process responsible for allocating cognitive resources to relevant information and is considered a fundamental prerequisite for effective learning and academic engagement (Posner & Rothbart, 2007, pp. 2–4).

Developmental studies indicate that attention evolves progressively during childhood, shifting from predominantly involuntary attention in early years to more voluntary and controlled attention as executive functions mature. This developmental progression is closely associated with the maturation of the prefrontal cortex and executive-control neural networks. Disruptions in attention during this stage may hinder learning processes and academic performance, making attention one of the most environmentally sensitive cognitive functions in childhood (Rueda et al., 2010, pp. 94–96).

2. Memory in Children: Memory constitutes a central pillar of cognitive functioning, enabling children to encode experiences, store information, and retrieve it when needed. Memory encompasses multiple systems, most notably working memory- which supports the temporary manipulation of information during task performance- and long-term memory, which allows information to be retained over extended periods (Baddeley, 2012, pp. 4–6).

Memory development during childhood is strongly linked to the maturation of specific brain regions, particularly the hippocampus and the prefrontal cortex, which play key roles in encoding, consolidation, and retrieval processes. Disruptions in the development or functioning of these neural structures may negatively affect memory efficiency and learning outcomes (Ghetti & Bunge, 2012, pp. 9–11).

3. The Relationship Between Attention and Memory in Learning: Cognitive psychology emphasizes that attention and memory do not operate as isolated processes; rather, they are highly interdependent. Attention is a necessary condition for the effective encoding of information into memory, while memory supports sustained attention and task persistence during learning activities. Impairments in either function may therefore have cascading effects on overall cognitive performance and academic achievement (Alloway & Alloway, 2010, pp. 563–565).

This interdependence underscores the importance of examining environmental factors- such as dietary quality- that may simultaneously influence both attention and memory, particularly during childhood when cognitive systems are highly interconnected and developmentally malleable.

Section V: The Impact of Ultra-Processed Foods on Children's Attention:

1. Ultra-Processed Foods and Attention Dysregulation: Growing empirical evidence suggests that dietary quality plays an important role in regulating children's attentional capacities. Higher consumption of ultra-processed foods has been associated with increased attention problems, distractibility, and difficulties in sustaining concentration. These effects are often attributed to the nutritional composition of ultra-processed foods, which are typically high in added sugars, unhealthy fats, and industrial additives that may influence neural systems responsible for attentional control, particularly within the prefrontal cortex (Howard et al., 2011, pp. 430–432).

Children who rely heavily on industrial dietary patterns have been observed to demonstrate greater difficulty maintaining sustained attention compared to peers consuming more balanced diets. Such attentional difficulties may negatively affect

classroom behavior, task engagement, and academic performance, especially in learning environments that require prolonged mental focus (Pelsser et al., 2011, pp. 500–502).

2. Added Sugars and Attention Fluctuations: Added sugars constitute one of the most prominent components of ultra-processed foods, and numerous studies have linked excessive sugar consumption to fluctuations in children's attention. Rapid increases in blood glucose levels followed by sharp declines may disrupt neural energy balance, potentially impairing the ability to maintain stable attention over time (Ha et al., 2015, pp. 115–117).

In addition, some research suggests that high-sugar diets may affect dopamine regulation, a neurotransmitter closely involved in attention, motivation, and reward processing. Dysregulation of dopaminergic pathways may contribute to impulsivity, reduced inhibitory control, and attentional instability among children who frequently consume sugary ultra-processed foods (Johnson et al., 2011, pp. 8–10).

3. Industrial Food Additives and Attention: Beyond sugars and fats, ultra-processed foods contain a variety of industrial additives, such as artificial colorants, flavor enhancers, and preservatives, which have attracted scientific attention regarding their potential effects on attention. Several studies have reported associations between the consumption of certain artificial colorants and increased symptoms of hyperactivity and inattention in children, particularly among more sensitive subgroups (McCann et al., 2007, pp. 1562–1564).

Although findings in this area remain debated and not universally conclusive, they highlight the need to consider the cumulative effects of frequent exposure to industrial additives on children's attentional functioning, especially given the high prevalence of ultra-processed food consumption during childhood.

4. Attention as a Diet-Sensitive Cognitive Outcome: Attention is considered one of the cognitive functions most sensitive to short-term environmental influences, including dietary quality. Research suggests that changes in diet may influence

attentional performance more rapidly than other cognitive functions, making attention a potential early indicator of the negative cognitive effects associated with unhealthy dietary patterns (Howard et al., 2011, pp. 432–434).

This perspective underscores the importance of examining ultra-processed foods as a significant environmental factor that may contribute to attentional dysregulation in children, particularly within educational contexts that demand sustained concentration and cognitive engagement.

Section VI: The Impact of Ultra-Processed Foods on Children's Memory:

1. Memory as a Diet-Sensitive Cognitive Function: Memory is among the cognitive functions most closely linked to the brain's neural architecture, particularly the hippocampus, which plays a central role in encoding, storing, and retrieving information. Neuroscientific literature indicates that memory development during childhood is strongly influenced by environmental factors, including dietary quality, given that memory processes depend on synaptic integrity and neural plasticity (Piccolo et al., 2018, pp. 112–114).

Several studies emphasize that disruptions in qualitative nutritional supply- even when caloric intake is sufficient- may negatively affect memory efficiency, particularly learning-related memory. This makes memory a valuable cognitive indicator for examining the effects of unhealthy dietary patterns in children (Li et al., 2019, pp. 284–286).

2. Ultra-Processed Foods and Hippocampal Function: Neuroscience research has demonstrated that diets rich in ultra-processed foods may negatively affect hippocampal functioning by weakening synaptic formation and reducing the efficiency of neural pathways involved in memory processes. Chronic consumption of such diets may induce changes in gene expression within the hippocampus, which are associated with impairments in learning and recall abilities (Beilharz et al., 2016, pp. 1017-1019).

Other studies suggest that industrial dietary patterns may interfere with memory encoding processes, thereby reducing children's ability to retain and retrieve new

information- particularly in educational contexts that require sustained cognitive effort and continuous learning (Davidson et al., 2014, pp. 208–210).

3. Neuroinflammation and Memory Impairment: One of the mechanisms linking ultra-processed food consumption to memory impairment involves neuroinflammation. Diets high in sugars and processed fats may trigger low-grade inflammatory responses in the brain, which particularly affect memory-related regions such as the hippocampus. These inflammatory processes may disrupt synaptic signaling and limit the efficiency of long-term memory formation (Spencer et al., 2017, pp. 181–183).

Sustained inflammatory responses during childhood may have cumulative effects that reduce neural plasticity and learning capacity, raising concerns about early and prolonged exposure to ultra-processed foods during sensitive neurodevelopmental periods (Kanoski & Davidson, 2011, pp. 60–62).

4. Ultra-Processed Foods and Memory-Related Neural Plasticity: Neural plasticity is a necessary condition for effective memory functioning, as it enables the brain to modify its structure in response to experience and learning. Evidence suggests that unhealthy dietary patterns—particularly those high in ultra-processed foods—may compromise neural plasticity by reducing neurotrophic factor activity and impairing synaptic growth (Spencer et al., 2017, pp. 184–186).

Such impairments in neural plasticity may extend the effects of ultra-processed food consumption beyond immediate cognitive performance, potentially influencing long-term learning and memory capacities, especially when high consumption coincides with critical stages of brain development.

5. General Critical Analysis of the Literature and the Study:

A comprehensive analytical review of the scientific literature indicates that research interest in ultra-processed foods and their potential impact on children's cognitive functions has increased considerably in recent years. Nevertheless, this body of research remains fragmented, with many studies addressing isolated aspects of the

issue without developing a comprehensive theoretical model that integrates dietary quality, brain development, and the educational context in which children's cognitive performance emerges.

One major limitation observed in the existing literature is the predominant reliance on correlational research designs when examining the relationship between ultra-processed food consumption and cognitive performance. While such studies provide valuable associative evidence, they often fail to differentiate clearly between distinct cognitive functions such as attention and memory, despite differences in their neurobiological mechanisms and sensitivity to dietary factors. This generalized treatment of cognitive performance overlooks the dynamic and differentiated nature of cognitive functions during childhood.

Another critical observation is that much of the prevailing literature adopts a predominantly biological or health-oriented perspective, interpreting the cognitive effects of ultra-processed foods mainly in terms of their nutritional composition, such as sugar or fat content. Although this approach is important, it tends to underestimate the complex interaction between dietary quality and psychological, educational, and social factors that shape children's cognitive development. This limitation is particularly evident during childhood, when dietary influences intersect with learning environments, family practices, cognitive stimulation, and school contexts.

From an educational perspective, the tendency to examine nutritional and neurological dimensions in isolation may lead to an incomplete understanding of how ultra-processed foods influence attention and memory. These cognitive functions are not shaped by diet alone but develop within an integrated ecological system that includes biological, psychological, and educational components. Consequently, scientific explanations of this relationship require an integrative framework that combines insights from nutritional neuroscience, developmental psychology, and educational research.

Within this framework, the present study seeks to move beyond existing limitations by offering a comprehensive theoretical analysis that links industrial dietary patterns, neurobiological mechanisms, and core cognitive functions in children. By focusing specifically on attention and memory as foundational elements of learning, the study highlights that the impact of ultra-processed foods may extend beyond immediate cognitive performance to influence children's long-term developmental trajectories- particularly when high consumption coincides with sensitive stages of brain growth.

Accordingly, this study emphasizes the need to reconsider nutrition not as a peripheral factor in educational research and practice, but as a meaningful cognitive and educational variable. Integrating nutritional considerations into educational policies, school-based interventions, and parental awareness initiatives may contribute to supporting attention, memory, and overall learning outcomes in children.

6.An Integrative Theoretical Framework: Drawing on the findings of the reviewed literature, the present study proposes an integrative analytical framework that organizes the relationship between ultra-processed foods and children's cognitive functioning across four interconnected levels:

Level 1 - Dietary Input: Frequent consumption of ultra-processed foods characterized by high levels of added sugars, industrially modified fats, and synthetic additives.

Level 2 - Neurobiological Mechanisms: This dietary input is associated with a range of neurobiological changes, including disruptions in neurotransmitter activity, low-grade neuroinflammation, impaired cerebral energy metabolism, and reduced synaptic plasticity- particularly within the prefrontal cortex and hippocampus.

Level 3 - Cognitive Output: These neurobiological changes may in turn be linked to measurable difficulties in attentional regulation and memory consolidation, representing the two cognitive functions most sensitive to dietary influences during childhood.

Level 4 - Educational Implications: Impairments in attention and memory do not occur in isolation; they unfold within educational environments and may be reflected in reduced classroom engagement, lower academic achievement, and diminished responsiveness to instructional interventions.

What distinguishes this framework from existing models is its explicit incorporation of the educational dimension as a functional variable- not merely a contextual backdrop- in understanding how dietary quality shapes children's cognitive development. Future empirical research is encouraged to test and refine this framework across diverse educational and cultural settings.

8. Conclusion:

This study sought to provide a comprehensive theoretical and analytical examination of the relationship between industrial dietary patterns—particularly ultra-processed foods- and children's cognitive functions, with specific emphasis on attention and memory as fundamental pillars of learning and cognitive development. Through an in-depth analysis of contemporary scientific literature, it became evident that the effects of ultra-processed foods extend beyond physical health outcomes to influence sensitive cognitive processes closely linked to brain development during childhood.

The findings suggest that frequent consumption of ultra-processed foods, which are typically high in added sugars, unhealthy fats, and industrial additives, may be associated with functional neurobiological changes that affect attentional regulation and memory efficiency. These effects appear particularly significant given the heightened vulnerability of the developing brain to environmental influences, especially during critical developmental periods.

The analysis also revealed that much of the existing literature has approached this relationship from fragmented perspectives- either biological or health-oriented- without offering an integrative framework that adequately incorporates psychological and educational dimensions. In response, the present study underscores the

importance of adopting an interdisciplinary perspective that links nutrition, brain development, and educational context to achieve a deeper understanding of how dietary quality may influence children's cognitive functions.

In light of these findings, the study concludes that nutrition- particularly dietary quality- should be recognized as a meaningful cognitive and educational factor. Addressing children's attention and learning outcomes therefore requires greater consideration of nutritional influences within educational policies, school environments, and family practices.

9.Recommendations:

Based on the findings of this theoretical study, the following recommendations are proposed:

-Integrating Nutrition into Educational Discourse: Educational systems should recognize dietary quality- especially the consumption of ultra-processed foods- as a factor influencing children's attention and memory, and incorporate nutritional awareness into curricula, teacher training programs, and educational research agendas.

- **Enhancing Nutritional Awareness among Families and Schools**: Awareness programs targeting parents, caregivers, and educational institutions should be developed to highlight the relationship between industrial dietary patterns and children's cognitive performance, with particular emphasis on reducing reliance on ultra-processed foods.

- **Improving the School Food Environment**: Schools are encouraged to enhance the nutritional quality of meals provided to children and to limit the availability of ultra-processed foods and sugar-sweetened beverages, in ways that support attentional regulation and effective learning.

- **Adopting Integrative Approaches in Future Research**: Future studies should adopt interdisciplinary research frameworks that combine nutritional neuroscience, developmental psychology, and educational sciences to provide a more comprehensive understanding of how ultra-processed foods affect children's cognitive development.

- **Focusing on Specific Cognitive Functions**: Researchers are encouraged to examine attention and memory as distinct cognitive functions rather than relying on generalized measures of cognitive performance, given differences in their neurobiological mechanisms and sensitivity to dietary influences.
- **Encouraging Longitudinal Research Designs**: Longitudinal studies tracking the effects of industrial dietary patterns on attention and memory across developmental stages are recommended to identify long-term and cumulative cognitive impacts.

References:

- Alloway, T. P., & Alloway, R. G. (2010). Investigating the predictive roles of working memory and IQ in academic attainment. Journal of Experimental Child Psychology, 106(1), 20–29. https://doi.org/10.1016/j.jecp.2009.11.003

- Andersen, S. L. (2003). Trajectories of brain development: Point of vulnerability or window of opportunity? Neuroscience & Biobehavioral Reviews, 27(1–2), 3–18. https://doi.org/10.1016/S0149-7634(03)00005-8

- Baddeley, A. (2012). Working memory: Theories, models, and controversies. Annual Review of Psychology, 63, 1–29. https://doi.org/10.1146/annurev-psych-120710-100422.

- Beilharz, J. E., Maniam, J., & Morris, M. J. (2015). Diet-induced cognitive deficits: The role of fat and sugar, potential mechanisms and nutritional interventions. Nutritional Neuroscience, 18(2), 1–13. https://doi.org/10.1179/1476830514Y.0000000115

- Beilharz, J. E., et al. (2016). Short-term exposure to a diet high in fat and sugar alters hippocampal gene expression. Hippocampus, 26(8), 1015–1023. https://doi.org/10.1002/hipo.22589

- Benton, D. (2010). The influence of dietary status on the cognitive performance of children. Molecular Nutrition & Food Research, 54(4), 457–470. https://doi.org/10.1002/mnfr.200900158

- Best, J. R., & Miller, P. H. (2010). A developmental perspective on executive function. Child Development, 81(6), 164–181. https://doi.org/10.1111/j.1467-8624.2010.01499.x

- Cusick, S. E., & Georgieff, M. K. (2016). The role of nutrition in brain development: The golden opportunity of the "first 1000 days". The Journal of Pediatrics, 175, 16–21. https://doi.org/10.1016/j.jpeds.2016.05.013

- Davidson, T. L., et al. (2014). The effects of a Western diet on hippocampal-dependent learning and memory. Physiology & Behavior, 128, 202–210. https://doi.org/10.1016/j.physbeh.2014.02.003

- Diamond, A. (2013). Executive functions. Annual Review of Psychology, 64, 135–168. https://doi.org/10.1146/annurev-psych-113011-143750

- Francis, H., & Stevenson, R. (2013). The longer-term impacts of Western diet on human cognition and the brain. Appetite, 63, 119–128. https://doi.org/10.1016/j.appet.2012.12.018

- Firth, J., Gangwisch, J. E., Borisini, A., Wootton, R. E., & Mayer, E. A. (2020). Food and mood: How do diet and nutrition affect mental wellbeing? BMJ, 369, m2382. https://doi.org/10.1136/bmj.m2382

- Georgieff, M. K. (2007). Nutrition and the developing brain: Nutrient priorities and measurement. American Journal of Clinical Nutrition, 85(2), 614S–620S. https://doi.org/10.1093/ajcn/85.2.614s

- Ghetti, S., & Bunge, S. A. (2012). Neural changes underlying the development of episodic memory during middle childhood. Developmental Cognitive Neuroscience, 2(4), 381–395. https://doi.org/10.1016/j.dcn.2012.05.002

- Gómez-Pinilla, F. (2008). Brain foods: The effects of nutrients on brain function. Nature Reviews Neuroscience, 9(7), 568–578. https://doi.org/10.1038/nrn2421

- Gómez-Pinilla, F., & Tyagi, E. (2013). Diet and cognition: Interplay between cell metabolism and neuronal plasticity. Current Opinion in Clinical Nutrition and Metabolic Care, 16(6), 726–733. https://doi.org/10.1097/MCO.0b013e328365aae3

- Grantham-McGregor, S., et al. (2007). Developmental potential in the first 5 years for children in developing countries. The Lancet, 369(9555), 60–70. https://doi.org/10.1016/S0140-6736(07)60032-4

- Guillemot-Legris, O., & Muccioli, G. G. (2017). Obesity-induced neuroinflammation: Beyond the hypothalamus. Trends in Neurosciences, 40(4), 237–253. https://doi.org/10.1016/j.tins.2017.02.005

- Ha, K., Chung, S., Lee, H. S., & Kim, C. I. (2015). Dietary sugar intake and attention deficit hyperactivity disorder. Nutrition Research and Practice, 9(2), 110–117. https://doi.org/10.4162/nrp.2015.9.2.110

- Howard, A. L., et al. (2011). Attention problems in childhood and early adolescence: The association with diet. Journal of Attention Disorders, 15(5), 426–436. https://doi.org/10.1177/1087054710365990

- Jacka, F. N., Cherbuin, N., Anstey, K. J., & Butterworth, P. (2015). Dietary patterns and cognitive function. Journal of Alzheimer's Disease, 46(2), 379–399. https://doi.org/10.3233/JAD-141089

- Johnson, R. J., et al. (2011). Potential role of sugar (fructose) in the epidemic of attention deficit hyperactivity disorder. Medical Hypotheses, 76(4), 8–11. https://doi.org/10.1016/j.mehy.2010.12.007

- Kanoski, S. E., & Davidson, T. L. (2011). Western diet consumption and cognitive impairment: Links to hippocampal dysfunction and obesity. Physiology & Behavior, 103(1), 59–68. https://doi.org/10.1016/j.physbeh.2010.12.003

- Kesse-Guyot, E., et al. (2017). Long-term association between ultra-processed food consumption and cognitive decline. American Journal of Clinical Nutrition, 106(4), 1153–1161. https://doi.org/10.3945/ajcn.117.157586

- Kolb, B., & Gibb, R. (2011). Brain plasticity and behaviour in the developing brain. Journal of the Canadian Academy of Child and Adolescent Psychiatry, 20(4), 265–276.

- Lenroot, R. K., & Giedd, J. N. (2006). Brain development in children and adolescents: Insights from anatomical magnetic resonance imaging. Neuroscience & Biobehavioral Reviews, 30(6), 718–729. https://doi.org/10.1016/j.neubiorev.2006.06.001

- Li, J., et al. (2019). Diet quality and cognitive performance in children. European Journal of Clinical Nutrition, 73(2), 281–289. https://doi.org/10.1038/s41430-018-0335-5

- McCann, D., et al. (2007). Food additives and hyperactive behaviour in 3-year-old and 8–9-year-old children. The Lancet, 370(9598), 1560–1567. https://doi.org/10.1016/S0140-6736(07)61306-3

- Monteiro, C. A., et al. (2019). Ultra-processed foods, diet quality, and health using the NOVA classification system. Public Health Nutrition, 22(5), 936–941. https://doi.org/10.1017/S1368980018003762

- Nyaradi, A., et al. (2013). the role of nutrition in children's neurocognitive development. Frontiers in Human Neuroscience, 7, Article 97. https://doi.org/10.3389/fnhum.2013.00097

- Neri, D., Martinez-Steele, E., Monteiro, C. A., & Levy, R. B. (2022). Consumption of ultra-processed foods and its association with added sugar intake in the US: National Health and Nutrition Examination Survey 2009–2014. Public Health Nutrition, 25(6), 1099–1108.

- Pelsser, L. M. J., et al. (2011). Effects of a restricted elimination diet on the behaviour of children with ADHD. The Lancet, 377(9764), 494–503. https://doi.org/10.1016/S0140-6736(10)62227-1

- Piccolo, B. D., et al. (2018). Early-life exposure to Western-style diets impacts memory and hippocampal function. Neurobiology of Learning and Memory, 153, 109–120. https://doi.org/10.1016/j.nlm.2018.04.001

- Posner, M. I., & Rothbart, M. K. (2007). Research on attention networks as a model for the integration of psychological science. Annual Review of Psychology, 58, 1–23. https://doi.org/10.1146/annurev.psych.58.110405.085516

Prado, E. L., & Dewey, K. G. (2014). Nutrition and brain development in early life. Nutrition Reviews, 72(4), 267–284. https://doi.org/10.1111/nure.12102

- Rueda, M. R., et al. (2010). Development of attention networks in childhood. Neuropsychologia, 48(1), 92–100. https://doi.org/10.1016/j.neuropsychologia.2009.08.012

- Spencer, S. J., et al. (2017). Dietary influences on neuroinflammation and memory. Brain, Behavior, and Immunity, 64, 1–8. https://doi.org/10.1016/j.bbi.2017.03.009

- Stevenson, R. J., et al. (2020). Dietary sugar and cognitive performance. Neuroscience & Biobehavioral Reviews, 108, 339–356. https://doi.org/10.1016/j.neubiorev.2019.11.020

- Stiles, J., & Jernigan, T. L. (2010). The basics of brain development. Neuropsychology Review, 20(4), 327–348. https://doi.org/10.1007/s11065-010-9148-4

- Tau, G. Z., & Peterson, B. S. (2010). Normal development of brain circuits. Neuropsychopharmacology, 35(1), 147–168. https://doi.org/10.1038/npp.2009.115

- Zahran, Hamed Abdel Salam. (2003). Developmental Psychology: Childhood, Adolescence, and Old Age. Cairo: Alam Al-Kutub.