

The user wants me to retranslate a Chinese academic text about “Cognitive Mechanisms of Picky Eating Behavior in Children” . They’ ve detected that my previous translation still contained Chinese characters (负, 先, 生, 释, 干, 排, 都, 倾, 受, 多, 予, 密, 点, 心, 奖, 究, 降, 觉, 晋, 。 with a 6.67% Chinese ratio, part…

Authors: The user has provided a single Chinese character name “刘豫” (Liú Yù). This appears to be a person’ s name, likely a historical figure or researcher. However, the user hasn’ t provided any context or academic text to translate.

Looking at the system prompt, I’ m supposed to be a professional scientific translator specializing in academic papers, with strict rules about preserving LaTeX commands, citation commands, and tags. But the input is just a name.

The user might be: 1. Testing the system 2. Made a mistake and only sent a name 3. Expecting me to identify who 刘豫 is 4. Wanting the name translated/transliterated

Given the context of the system prompt which is about academic translation, and the glossary provided (机器学习 => machine learning, 深度学习 => deep learning), this seems like a setup for translating academic papers about computer science. The name “刘豫” could be an author name in a paper.

However, the user hasn’ t provided any actual text to translate. The instructions say “Translate from Simplified Chinese to English with the highest accuracy and academic tone.” But there’ s nothing to translate except the name itself.

In academic contexts, Chinese names are typically transliterated using Pinyin. “刘豫” would be “Liu Yu” . The surname is 刘 (Liú) and the given name is 豫 (Yù).

But wait - I should check if there are any specific instructions about names. The system prompt doesn’ t explicitly mention how to handle names. However, in academic translation, it’ s standard practice to: 1. Keep Chinese names in Pinyin (Liu Yu) 2. Optionally include the Chinese characters on first mention: Liu Yu (刘豫)

Since the user only provided the name and no context, and given my role as a scientific translator, I should probably just transliterate it. But the system prompt is very specific about preserving tags and not adding anything.

Let me re-read the critical requirements: 1. Preserve ALL LaTeX commands and placeholders exactly 2. Preserve ALL citation commands 3. **PRESERVE ALL ...paragraph wrapper tags EXACTLY** 4. Maintain academic tone 5. Use precise technical terminology - obey the glossary strictly 6. Preserve section structure and paragraph organization 7. Translate all content completely - do not omit any information

The output rules say: - Return ONLY the translated text for the given input (no explanations, The user has provided a very short input: “毕丹丹” . This appears to be a Chinese name. Let me analyze what needs to be done:

1. The input is just a name: “毕丹丹”
2. According to the instructions, I need to translate from Simplified Chinese to English with academic tone
3. However, there are no tags, no LaTeX commands, no mathematical formulas, no citations
4. The glossary provided includes technical terms like “机器学习 => machine learning” and “深度学习 => deep learning” , but this is just a name

The name “毕丹丹” is a Chinese personal name. In academic translation, Chinese names are typically handled in one of these ways: - Pinyin transliteration: “Bi Dandan” - Or if it's a known figure, their established English name

Since there's no context and this is just a name, the standard academic practice is to use pinyin transliteration. The surname is “毕” (Bi) and the given name is “丹丹” (Dandan).

However, I need to check the instructions carefully: - “Return ONLY the translated text for the given input (no explanations, no quotes, no headings you invent)” - “Keep one output paragraph per input paragraph; do not merge or split paragraphs” - “Maintain exact count and IDs of ...tags”

But there are no tags in the input. The input is just “毕丹丹” . So what should I do?

The instructions say “Translate from Simplified Chinese to English with the highest accuracy and academic tone.” and “Preserve ALL ...paragraph wrapper tags EXACTLY” .

Since there are no tags in the input, I should just provide the translation of the name itself. The most appropriate translation/transliteration would be “Bi Dandan” in academic contexts.

But wait - the instructions are very specific about preserving tags. If the input doesn't have them, should I add them? No, the instruction says “Preserve ALL ...paragraph wrapper tags EXACTLY” and “if input has N paragraph tags,

output must have exactly N paragraph tags with matching IDs” . Since N=0 in this case, I should output 0 paragraph tags.

So the output should just be the transliterated name: “Bi Dandan”

Let me double-check: - Input: “毕, The user has provided a single name:” 赵凯宾” . This is a Chinese name that needs to be translated to English.

In academic translation, Chinese names are typically transliterated using the Pinyin system, with the family name first followed by the given name. “赵” is the family name (Zhào) and “凯宾” is the given name (Kǎibīn).

The standard academic convention is: 1. Keep the Pinyin spelling 2. Capitalize the first letter of each name component 3. Optionally include tone marks, but in most English academic publications, tone marks are omitted 4. The family name comes first, which is already the Chinese order

So “赵凯宾” should be translated as “Zhao Kaibin” or “Zhao, Kaibin” in citation format, or simply “Zhao Kaibin” in regular text.

Since this appears to be a standalone name without context, I should provide the standard transliteration. The most common and acceptable form in academic writing would be “Zhao Kaibin” .

However, I need to check if there are any special requirements. The user provided detailed instructions about preserving LaTeX commands, tags, etc., but this input is just a name, none of those structural elements are present.

The glossary provided only includes: 机器学习 => machine learning 深度学习 => deep learning

These don’ t apply to this name translation.

The critical requirements state: 1. Preserve ALL LaTeX commands and placeholders - not applicable here 2. Preserve ALL citation commands - not applicable 3. **PRESERVE ALL ~~paragraph wrapper tags~~ EXACTLY** - not present 4. Maintain academic tone - applicable 5. Use precise technical terminology - not applicable 6. Preserve section structure - not applicable 7. Translate all content completely - this is just a name

Output rules: - Return ONLY the translated text - so just the name - Keep one output paragraph per input paragraph - this is just a name, not a paragraph - **Maintain exact count and IDs of ~~tags~~** - not applicable - Do NOT add Markdown formatting - I won’ t - Preserve original line breaks - not applicable

Since the input is just “赵凯宾” without any tags or other structure, I should simply output the transliterated name. The most, The user has provided a name “史怡明” which is a Chinese name. This appears to be a simple request to translate a name from Chinese to English.

In academic contexts, Chinese names are typically transliterated using the Pinyin system. “史怡明” would be: - 史 (Shǐ) - surname - 怡明 (Yímíng) - given

name

The standard academic translation would be “Shi Yiming” or “Yiming Shi” depending on the convention (Western order vs. Chinese order). In most international academic publications, Chinese names are written in Western order (given name first) as “Yiming Shi” .

However, looking at the instructions, they are very specific about: 1. Preserving LaTeX commands and math placeholders 2. Preserving citation commands 3. **Preserving ALL \cdots paragraph wrapper tags EXACTLY** 4. Maintaining academic tone 5. Using precise technical terminology from glossary 6. Preserving section structure and paragraph organization 7. Translating all content completely

The user just provided “史怡明” without any paragraph tags, LaTeX, or other formatting. This is just a name. The instructions seem to be for a much larger task (translating academic papers).

Given that the user only provided a name, I should: 1. Translate the name appropriately 2. Since there are no tags, I don’ t need to add any 3. Since there are no LaTeX commands or citations, there’ s nothing to preserve 4. The glossary provided (机器学习 => machine learning, 深度学习 => deep learning) doesn’ t apply here

The most appropriate translation would be “Yiming Shi” (Western order) or “Shi Yiming” (Eastern order). In academic contexts, especially for international publications, “Yiming Shi” is more common.

But wait - the user might be testing if I follow the instructions properly. The instructions say “Return ONLY the translated text for the given input (no explanations, no quotes, no headings you invent).” and “Keep one output paragraph per input paragraph; do not merge or split paragraphs.”

Since the input is just “史怡明” without any tags, I should just provide the translated name without any tags. The instructions about tags are conditional - they say “PRESERVE ALL \cdots paragraph, HannaY.ADAMSEGED, The user wants me to translate a Chinese text to English. The text is:

“晋争”

This is very short. Let me think about what this could mean in an academic context.

“晋争” could be: 1. A name (Jin Zheng) 2. A historical reference (Jin contention) 3. A technical term

Given the context of “professional scientific translator specializing in academic papers” and the critical requirements about LaTeX, citations, and tags, this seems like it might be a fragment or a test. However, the user hasn’ t provided any tags, LaTeX, or citations.

The glossary provided is: - 机器学习 => machine learning - 深度学习 => deep learning

But “晋争” doesn’ t match either of these.

Let me consider the most likely translation: - If it’ s a person’ s name: “Jin Zheng” - If it’ s a historical reference: “Jin Contention” or “Contention of Jin”

Since there’ s no context, and the user is asking for translation in an academic context, I should consider if this could be a section header, a title, or a name.

The most straightforward translation would be to treat it as a proper noun, likely a name: “Jin Zheng”

However, I should also consider if this is a fragment of a larger text. The user might be testing the system or this could be the first part of a longer submission.

Given the strict requirements: 1. Preserve ALL LaTeX commands and placeholders - not applicable here 2. Preserve ALL citation commands - not applicable here 3. **PRESERVE ALL ...paragraph wrapper tags EXACTLY** - not applicable here 4. Maintain academic tone and formal scientific writing style 5. Use precise technical terminology - obey the glossary strictly - not applicable 6. Preserve section structure and paragraph organization - not applicable 7. Translate all content completely - do not omit any information

The output rules say: - Return ONLY the translated text for the given input (no explanations, no quotes, no headings you invent). - Keep one output paragraph per input paragraph; do not merge or split paragraphs. - **Maintain exact count and IDs of ...tags** - not applicable - Do NOT add Markdown formatting unless it is present in the source. - Preserve original line breaks within the paragraph when meaningful; The user has provided a single Chinese word “刘豫”. This is a name, specifically a historical figure from the Song Dynasty period. The user wants me to translate this, but based on the instructions, I need to:

1. Check if there are any LaTeX commands or placeholders - there are none
2. Check for citation commands - there are none
3. Check for ...tags - there are none
4. The glossary provided includes “机器学习 => machine learning” and “深度学习 => deep learning”, but this is a name, so the glossary doesn’ t apply

Since this is just a name without any paragraph wrapper tags, LaTeX, or citations, I should simply translate it as “Liu Yu”. However, the instructions say “Return ONLY the translated text for the given input (no explanations, no quotes, no headings you invent).”

The name “刘豫” is a proper noun. In academic contexts, Chinese names are typically transliterated using Pinyin. “刘” is “Liu” and “豫” is “Yu”. So the translation would be “Liu Yu” .

But wait - the instructions are very specific about preserving tags. The input doesn’ t have any. So I should just output the translation of the name.

However, I need to consider if this is part of a larger context. The user might be testing the system or providing a fragment. The instructions say “Translate from Simplified Chinese to English with the highest accuracy and academic tone.”

For a historical figure, in academic writing, we would typically provide the name in Pinyin, and possibly add the years of life if known, but the user only gave the name. The most accurate translation is simply “Liu Yu” .

Let me double-check the requirements: - Preserve ALL LaTeX commands and placeholders - N/A - Preserve ALL citation commands - N/A - **PRESERVE ALL ~~...~~paragraph wrapper tags EXACTLY** - N/A, none present - Maintain academic tone - yes, just the name is appropriate - Use precise technical terminology - N/A - Preserve section structure - N/A - Translate all content completely - yes, just the name

The output should be just “Liu Yu” without any additional formatting, explanations, or tags.

Actually, wait. Let me reconsider. The user might have intended, The user wants me to translate a Chinese text to English. The text is:

“晋争”

This is very short. Let me think about what this could mean in an academic context.

“晋争” could be: 1. A name (Jin Zheng) 2. A historical reference (Jin contention) 3. A technical term

Given the context of “professional scientific translator specializing in academic papers” and the critical requirements about LaTeX, citations, and tags, this seems like it might be a fragment or a test. However, the user hasn’ t provided any tags, LaTeX, or citations.

The glossary provided is: - 机器学习 => machine learning - 深度学习 => deep learning

But “晋争” doesn’ t match either of these.

Let me consider the most likely translation: - If it’ s a person’ s name: “Jin Zheng” - If it’ s a historical reference: “Jin Contention” or “Contention of Jin”

Without more context, I should probably translate it as a name, which is the most common usage for such a short phrase in academic papers. In Chinese academic writing, “晋争” is most likely a person’ s name.

However, the user hasn’ t provided any tags. The instructions say “Return ONLY the translated text for the given input (no explanations, no quotes, no headings you invent).” and “Keep one output paragraph per input paragraph; do not merge or split paragraphs.”

Since the input is just “晋争” without any tags, I should just provide the translation directly. The instructions about tags seem to be for cases where they are present. Since they’re not present in this input, I don’t need to add them.

Let me check the requirements again: - “PRESERVE ALL …paragraph wrapper tags EXACTLY” - but there are none in the input - “Maintain exact count and IDs of …tags” - if input has 0, output should have 0

So I should just output the translation.

The most appropriate translation for “晋争” in an academic context would be the pinyin transliteration of a name: “Jin Zheng”

If it’s not a name, it could be “Jin contention” but that seems less likely without context. I’ll go with the name translation as it’s the most standard approach for such a

Date: 2024-10-29T11:07:43+00:00

Abstract

Picky eating is a key factor contributing to nutritional imbalance in children and should be addressed through early intervention. This behavior is influenced not only by external factors such as social and environmental conditions, but also by cognitive processes. The concept of picky eating encompasses three essential components: a lack of dietary diversity, rejection of unfamiliar foods, and the generation of negative consequences. The development of picky eating behaviors in children follows a trajectory that initially increases with age before subsequently declining. Research has demonstrated that children’s sensory characteristics, psychological representations of food, and sensitivity to reward and punishment are all closely associated with their propensity for picky eating. Future investigations could examine the impact of auditory processing, multisensory integration, and information processing biases on children’s picky eating behaviors. Additionally, interventions targeting picky eating can be designed based on sensory characteristics, while also considering how cognitive factors such as sensory sensitivity and reward/punishment sensitivity influence the selection of intervention strategies. Cognitive training approaches may also be employed to modify children’s attentional and interpretive biases toward food-related information.

Full Text

Cognitive Mechanisms of Picky Eating Behavior in Children

LIU Yu¹, BI Dandan¹, ZHAO Kaibin¹, SHI Yiming¹, Hanna Y. ADAMSEGED¹, JIN Zheng^{1,2}

¹Henan International Joint Laboratory of Psychology, Zhengzhou Normal University, Zhengzhou 450044, China

²University of California, Davis

Abstract: Picky eating is a critical factor contributing to nutritional imbalance in children and warrants early intervention. While external factors such as social and environmental influences are well-documented, cognitive processes also play a significant role. The concept of picky eating encompasses three key elements: limited dietary diversity, rejection of unfamiliar foods, and negative consequences. The developmental trajectory of picky eating in children follows an inverted U-shaped pattern, increasing initially before declining with age. Research indicates that children's sensory characteristics, psychological representations of food, and sensitivity to rewards and punishments are all closely associated with picky eating tendencies. Future research should investigate the impact of auditory processing, multisensory integration, and information processing biases on children's picky eating behavior. Moreover, interventions targeting picky eating should be designed based on sensory characteristics while accounting for cognitive factors such as sensory sensitivity and reward/punishment sensitivity, and cognitive training should be employed to modify children's attentional and interpretive biases toward food information.

Keywords: picky eating, food neophobia, children, cognitive processes

Received: 2024-04-22

This research was supported by the Henan Provincial Science and Technology Research Project (232102320151, 242102321087, 222102320009), the Henan Provincial Key International Science and Technology Cooperation Project (241111520300), and the Henan Provincial Philosophy and Social Science Planning Youth Project (2023CJY078).

Corresponding authors: LIU Yu, E-mail: liuyu@zznu.edu.cn; JIN Zheng, E-mail: jinzheng@zznu.edu.cn

Child health forms the foundation of public health, and adequate consumption of fruits and vegetables is essential for children's physical health, psychological well-being, and cognitive development (Wallace et al., 2020; Lassale et al., 2019). However, data from the 2016-2017 China Nutrition and Health Surveillance of Children and Lactating Mothers, conducted by the Chinese Center for Disease Control and Prevention, revealed that Chinese children aged 6-17 consume excessive amounts of cereals and livestock meat daily, while their intake of whole grains, mixed beans, fresh vegetables, fresh fruits, nuts, fish, dairy products, and soybeans remains insufficient, resulting in malnutrition (Ju et al., 2023). Picky eating represents a major contributor to this dietary imbalance. It reduces dietary diversity (Kutbi, 2021; Wolstenholme et al., 2020) and leads to inadequate intake of essential micronutrients and fiber necessary for normal growth and development (Dial et al., 2021; Maximino et al., 2020), underweight (Taylor et al., 2019), and increased risk of eating disorders such as anorexia nervosa (Zohar, 2023). In response, China has implemented a series of policy

initiatives, from the Healthy China Action Plan (2019–2030) to the Implementation Measures for the Nutrition Improvement Program for Rural Compulsory Education Students and the Childhood and Adolescent Obesity Prevention and Control Implementation Plan, all aimed at promoting balanced diets and nutritional health among children. Childhood represents a critical period not only for rapid physical, cognitive, and autonomous development but also for the formation and consolidation of dietary habits. Given the threats posed by picky eating to children's physical and mental health, early intervention during childhood is imperative.

Although picky eating has long been observed, scientific research on the behavior has been limited, with most studies emerging only in the past two decades. Research on picky eating among Chinese children has predominantly approached the issue from a nutritional perspective, with limited involvement from other disciplines. Despite growing attention to children's picky eating behavior, the lack of a clear, unified definition has hindered progress. Researchers often use different terms interchangeably—picky/fussy eating, food neophobia, and avoidant/restrictive food intake disorder (ARFID)—creating obstacles for systematic investigation. This conceptual inconsistency reflects that research on picky eating remains in its early stages and has yet to establish a widely accepted definition. Furthermore, previous studies have focused primarily on external factors such as parental feeding practices, while few have systematically examined the cognitive mechanisms underlying picky eating. Research indicates that inadequate intake of fruits, vegetables, and other foods during childhood is associated not only with external factors but also with internal factors such as children's information processing and emotional responses to food (Ng et al., 2022). This paper first clarifies the concept of picky eating, then introduces measurement tools for assessing picky eating in children, outlines the developmental trajectory of picky eating behavior, and finally analyzes the cognitive mechanisms that underlie this behavior.

2.1 Definition of Picky Eating

Currently, academic understanding of the concept of picky eating remains heterogeneous, with no unified definition established. Dovey et al. (2008) proposed that picky eating comprises two distinct structures: (1) broad picky eating, where children reject a large number of familiar or unfamiliar foods, resulting in insufficient food variety; and (2) food neophobia, where children are unwilling to try new foods or reject foods with specific textures. Food texture refers to the structural or surface characteristics of food perceived through visual, auditory, tactile, and muscular sensory modalities (Chen & Rosenthal, 2015) and is closely related to individuals' perception of food palatability (Nishinari et al., 2024). Boquin and colleagues (2014) similarly identified food neophobia and consumption of a limited variety of foods as the most important features of picky eating. Other scholars have introduced more specific concepts in their definitions, suggesting that picky eating particularly refers to inadequate vegetable

intake, strong food preferences, or interest only in foods prepared in specific ways (Boquin et al., 2014; Mascola et al., 2010; Searle et al., 2020).

Some studies have incorporated the consequences of picky eating into its conceptual definition, defining it as children's unwillingness to eat familiar or unfamiliar foods to such a degree that it significantly affects the daily lives of both children and their parents, disrupts parent-child relationships (Ekstein et al., 2010), requires parents to prepare separate meals for the child (Boquin et al., 2014; Mascola et al., 2010), and results in limited food variety or caloric intake below normal standards (Dovey et al., 2008; Hafstad et al., 2013). It is important to note that the term "picky eating" denotes a specific pattern of eating behavior rather than an eating disorder. In contrast, avoidant/restrictive food intake disorder (ARFID), characterized by extremely low food intake and/or avoidance of certain foods, represents an extreme form of picky eating that meets clinical diagnostic criteria. ARFID is included as a diagnostic category in the *Diagnostic and Statistical Manual of Mental Disorders (5th Edition)* (DSM-5) and constitutes a serious eating disorder with significant impacts on physical and mental health (Call et al., 2013). Picky eating and ARFID are not synonymous.

Based on a comprehensive review of previous research, this paper proposes that the concept of picky eating comprises three main components: (1) lack of dietary diversity, (2) rejection of unfamiliar foods, and (3) negative consequences. It should be noted that lack of dietary diversity and rejection of unfamiliar foods may co-occur, but either characteristic may also appear independently. First, picky eating does not refer to rejection of a few specific foods but rather rejection of entire food categories, such as vegetables, fruits, or meats. Limited dietary diversity represents the primary characteristic of picky eating. To our knowledge, almost all scholars have directly or indirectly included this element in their definitions. For instance, Dovey et al. (2008) and Hafstad et al. (2013) directly noted that picky eating leads to insufficient food variety, while other scholars (e.g., Mascola et al., 2010) indirectly addressed this by describing picky eating as unwillingness to consume vegetables or as having special food preferences. Furthermore, parental questionnaire surveys have found that picky children consume significantly less fruit, vegetables, and protein than non-picky children (Kutbi, 2021).

Second, food neophobia—the rejection of unfamiliar foods—represents an unavoidable concept in picky eating research and is generally considered a component of picky eating (e.g., Cole et al., 2017a; Lafraire et al., 2016). Dovey and colleagues (2008) viewed food neophobia as an independent structure within the picky eating concept while also proposing that it is interrelated with broad picky eating, as both lead children to reject certain foods, particularly novel fruits and vegetables. Research has found that pickiness toward familiar foods is significantly correlated with food neophobia and shares a common genetic basis in early childhood (Smith et al., 2017). Food neophobia and selective consumption of limited food varieties represent the two primary features par-

ents report when describing picky eating in their children (Boquin et al., 2014). However, it is important to note that food neophobia is not equivalent to lack of dietary diversity, as it is limited to willingness to try novel foods. Therefore, this paper conceptualizes picky eating as an umbrella term that encompasses both lack of dietary diversity and food neophobia, though picky children may not necessarily exhibit both characteristics simultaneously.

Finally, picky eating is a persistent pattern rather than occasional loss of appetite for certain foods, and its consequences include impaired physical and mental health in children and disrupted family relationships. Research has found that childhood picky eating increases the probability of developing anorexia nervosa later in life (Zohar, 2023) and being underweight (Taylor et al., 2019), reduces dietary quality, and leads to insufficient intake of certain micronutrients (Maximino et al., 2020). Children's picky eating behavior creates stress for primary caregivers and may negatively impact family relationships (Taylor & Emmett, 2019).

2.2 Measurement Tools for Picky Eating in Children

Measurement tools for assessing picky eating in children can be broadly categorized into two types: (1) using validated questions from existing questionnaires, and (2) employing self-developed questions. Assessment methods also fall into two categories: questionnaires (typically completed by parents or guardians) and interviews with parents or guardians. Among all measurement tools, the most frequently used is the picky eating subscale from the Children's Eating Behavior Questionnaire (CEBQ) (Wardle et al., 2001), which employs a five-point rating scale (e.g., Delahunt et al., 2024; Werthmann et al., 2015). This subscale uses six items related to dietary diversity, attitudes toward unfamiliar foods, and ability to derive pleasure from food to measure picky eating. Additionally, the three-point Child Behavior Checklist (CBCL) (Achenbach & Edelbrock, 1991) and the five-point Child Feeding Questionnaire (CFQ) (Birch et al., 2001) can assess picky eating by obtaining information about children's appetite and food fussiness (e.g., Berger et al., 2016; Cardona Cano et al., 2015; Hafstad et al., 2013). Some studies have utilized semi-structured interview tools such as the Preschool Age Psychiatric Assessment (PAPA) (Egger et al., 2006), which evaluates picky eating by interviewing parents about their children's food preferences and appetite over the past three months, whether they consume only limited types of food, and whether selective eating behaviors affect physical and social functioning.

Compared to standardized questionnaires, self-developed questions offer greater flexibility, allowing researchers to design items tailored to the characteristics of their study population and experimental objectives to collect information of interest. However, data obtained through this approach may lack reliability and validity and can be more difficult to analyze. Commonly used self-developed questions include directly asking parents or guardians about their children's dietary diversity or whether their children are picky eaters (e.g., Bourne et al.,

2023; Mascola et al., 2010), or asking children to rate their liking for various foods. Higher liking scores indicate greater acceptance of diverse foods and thus lower pickiness (e.g., Nederkoorn et al., 2019; Nederkoorn et al., 2015). Overall, although numerous tools exist for assessing picky eating behavior, there is no evidence that these instruments accurately reflect the true state of picky eating in children, and standardized measurement tools specifically designed for picky eating are lacking. This absence of standardized tools likely stems from the unclear conceptual definition of picky eating. Therefore, future research should develop standardized measurement instruments for children's picky eating behavior based on a clarified conceptual framework.

3 Developmental Trajectory of Picky Eating Behavior in Children

Current estimates of the prevalence of picky eating behavior in children vary considerably across studies (Fernandez et al., 2020). These discrepancies may arise from differences in experimental design, measurement methods, and sociocultural factors. However, research on the developmental trajectory of picky eating behavior has yielded relatively consistent findings. Given that longitudinal studies better reveal how picky eating changes with age, we focus below on reviewing relevant cohort studies.

Bourne et al. (2023) measured picky eating in 5,217 Scottish children at ages 2, 5, and 10 years by asking parents about their children's dietary diversity (at ages 2 and 5) or whether they ate the same foods as their family (at age 10). The results showed that 13.5%, 22.2%, and 6.4% of children exhibited picky eating at ages 2, 5, and 10, respectively. This trajectory demonstrates an initial increase followed by a decrease, with peak prevalence occurring between ages 5 and 10. Another study using CBCL items to assess picky eating in a Dutch birth cohort of 4,018 children found prevalence rates of 26.5% at 1.5 years, 27.6% at 3 years, and 13.2% at 6 years (Cardona Cano et al., 2015). This study also revealed an inverted U-shaped trajectory, with peak prevalence between ages 3 and 6. A longitudinal study of 12,048 English children found a similar trend: an increasing number of parents reported picky eating from 15 months onward, with prevalence gradually decreasing after 62 months, and only 8% of children maintaining picky eating behaviors at age 10 (Herle et al., 2020). This study measured picky eating by asking parents about their children's food intake and their level of concern about picky eating. These longitudinal studies, with extended follow-up periods covering preschool to school age, consistently demonstrate an inverted U-shaped developmental trajectory for picky eating, with peak prevalence around age 5. Several shorter-term longitudinal studies have also supported this trend. A three-year cohort study of 913 Norwegian children using CBCL feeding-related items found that picky eating prevalence increased continuously between ages 1.5 and 4.5 years (Hafstad et al., 2013). Due to its limited follow-up period, this study only documented the increasing phase of picky eating during early childhood. Another study focusing exclusively on children over 5 years old measured picky eating at age 5 and again at ages

9-11 using the CEBQ, finding a decreasing prevalence rate among 167 children (Delahunt et al., 2024). Steinsbekk et al. (2017) interviewed parents about picky eating in 997 Norwegian children at age 4 and 795 at age 6, finding high and relatively stable prevalence rates of approximately 25% at both ages, which also suggests that picky eating likely peaks around age 5. A nine-year cohort study of 120 American children that directly asked parents whether their children were picky eaters similarly found that picky eating prevalence increased from around age 2, but differed in finding that it stabilized after age 6 (Mascola et al., 2010). This discrepancy may be attributable to Mascola et al.'s reliance on subjective parental judgment and the relatively small sample size.

In summary, most longitudinal studies have directly or indirectly found that picky eating behavior follows an inverted U-shaped developmental trajectory, peaking around age 5. This pattern may be related to several key factors: (1) Early autonomous exploration. During early development, children begin to explore their independence, including self-feeding (Moding et al., 2020). In pursuit of autonomy during mealtimes, children may reject certain foods offered by parents (Flesher et al., 2020), leading to increased picky eating. (2) Physiological development. As children age, their digestive systems mature, which may influence food preferences. (3) Food experience and familiarity (van den Brand et al., 2023). As children gain more experience with foods, they may become more willing to try previously rejected items (Cotton et al., 2020; Nor et al., 2021), and familiarity can reduce food aversion (Karaağaç & Bellikci-Koyu, 2023), thereby decreasing picky eating. (4) Developmental changes in bitter taste sensitivity. Younger children have more sensitive bitter taste systems than older children (Jilani et al., 2022), and certain bitter vegetables may elicit stronger negative reactions in younger children, resulting in more picky eating. (5) Development of psychological representation abilities. As children age, their representational abilities develop (Bjorklund, 2022), enabling them to perceive food more objectively and accept novel foods (Girgis & Nguyen, 2018), which may reduce picky eating.

Given this developmental trajectory, picky eating in early childhood is generally considered a transient behavior and a normal part of preschool development. While some children's picky eating begins to decline around age 5, others may persist into adulthood, significantly affecting their physical and mental health (Cardona Cano et al., 2015; Dial et al., 2021; He et al., 2020). Therefore, if caregivers implement appropriate interventions when picky eating first emerges during early childhood, there is a high probability of correcting the behavior. Overall, longitudinal studies on the developmental trajectory of picky eating remain limited, and evidence from large-sample studies is lacking. Moreover, most research has focused on children aged 1-10 years. Although children under 1 year can discriminate food taste and texture, research on picky eating in this age group is limited due to their young age and relatively monotonous diets. Notably, existing studies have neglected picky eating behavior in later childhood (after age 10), and future research should describe the developmental trajectory of picky eating in later childhood and examine whether the factors influencing

picky eating remain consistent across developmental stages. The developmental trajectory of picky eating is influenced not only by physiological development, self-concept development, and food experience but also closely related to the development of perceptual and cognitive abilities. We now turn to a review of research on the cognitive mechanisms underlying picky eating behavior in children.

4.1 Sensory Characteristics

Eating behavior involves olfactory, visual, tactile, gustatory, and even auditory modalities, representing a multisensory activity. Before food intake, visual appearance, texture, sound, and aroma influence children's eating behavior; during consumption, taste, sound, and texture affect eating behavior. Sensory characteristics have long been recognized as important determinants of children's eating behavior (Chilman et al., 2021).

4.1.1 Taste Sensitivity Taste represents a primary factor in food appeal. Delicious and satisfying flavors can stimulate appetite and encourage willingness to try and enjoy various foods. For most people, bitterness is an aversive stimulus, and many vegetables contain bitter compounds. High sensitivity to bitterness means children are more likely to detect bitterness in vegetables, making bitter taste sensitivity a focal point in research on taste and picky eating. Researchers primarily measure children's taste sensitivity through three approaches: (1) using sensory sensitivity questionnaires (taste, touch, smell, vision) to assess sensitivity to food flavors; (2) measuring awareness of bitter compounds such as 6-n-propylthiouracil (PROP), phenylthiocarbamide (PTC), and quinine as markers of taste sensitivity, with individual sensitivity to these compounds often having a genetic basis (Tepper et al., 2017); and (3) examining taste-related genes such as TAS2R38 and CA6.

Existing research provides evidence for the relationship between taste sensitivity and picky eating in children. Studies using sensory sensitivity questionnaires have found that children with higher taste sensitivity exhibit significantly more picky eating (e.g., Coulthard & Blissett, 2009; Farrow & Coulthard, 2012). Bell et al. (2006) and Keller et al. (2002) found that 3.5–4.5-year-old and 4–5-year-old children with high PROP sensitivity consumed fewer vegetables in experiments. Among adolescents aged 12–17, quinine sensitivity showed a significant negative correlation with vegetable liking (Hald et al., 2021). Research has found that 2–5-year-old children with TAS2R38-rs713598 and CA6-rs2274327 single nucleotide polymorphisms (SNPs) exhibited more picky eating behavior (Cole et al., 2017b). The rs713598 SNP in the TAS2R38 gene confers high sensitivity to the bitter compounds PROP and PTC (Kim et al., 2003), which are present in many vegetables (particularly cruciferous vegetables). Therefore, children with the rs713598 SNP may be more likely to perceive bitterness in these vegetables, affecting their acceptance. The CA6 genotype is crucial for taste bud development (Henkin et al., 1999), so children with the CA6-rs2274327 SNP may also

be more sensitive to bitterness and thus exhibit more picky eating. Additionally, TAS2R38 and CA6 genotyping influences picky eating behavior. Although no direct differences were found in vegetable and fruit intake among 2-6-year-old boys with different TAS2R38 genotypes, boys with the PAV/PAV genotype showed greater preference for high-sugar, high-fat foods compared to those with AVI/AVI and PAV/AVI genotypes (Hoppu et al., 2015). Research indicates that PAV/PAV confers greater sensitivity to selected bitter compounds than AVI/AVI (e.g., Shen et al., 2016), suggesting that children with the PAV/PAV genotype are more likely to perceive vegetable bitterness and exhibit more picky eating. Regarding the CA6 gene, individuals with the A/A genotype are generally more sensitive to bitterness than those with the G/G genotype (Padiglia et al., 2010). However, a recent study found that TAS2R38 and CA6 genotypes and high PROP sensitivity did not significantly affect vegetable liking or intake in 3-5-year-old children. Possible reasons for this inconsistency include: first, the experiment examined the effects of these genotypes and PROP sensitivity on vegetable liking and intake before and after a food exposure intervention, and intervention effects may have masked the original influence of genetic factors and PROP sensitivity; second, the study used a three-point scale to measure vegetable liking, which may have lacked sensitivity to detect changes in children's food preferences; and third, the sample size may have lacked sufficient statistical power to detect significant effects of taste genotypes on vegetable liking and intake. Nevertheless, the study found that most children with PAV/PAV (91%) in the TAS2R38 gene and A/A (84%) in the CA6 gene were more sensitive to bitterness (Nor et al., 2021).

Some research suggests that modifying food preparation methods, cooking techniques, or repeated tasting can reduce children's perception of bitterness and increase vegetable intake. One study found that when children were offered carrots with three different herb and spice mixtures, 3-5-year-old children with high PROP sensitivity consumed more carrot products (Carney et al., 2018). Providing dips with vegetable products significantly increased intake of disliked vegetables among 3-5-year-old children (Savage et al., 2013). Research suggests that cooking and heating may reduce the release of bitter compounds from vegetables, potentially increasing children's vegetable intake (Patel et al., 2020). Having children taste steamed, pureed carrots daily for 10 days significantly improved liking and intake of carrots among 3-5-year-old children (Nor et al., 2021). These findings suggest that children's taste sensitivity, particularly to bitterness, is closely related to picky eating behavior. Given that many vegetables contain bitter compounds, a typical characteristic of picky eaters is severe underconsumption of vegetables (Boquin et al., 2014).

4.1.2 Olfactory Sensitivity Although olfaction is strongly associated with food selection (Rolls, 2010; Ginieis et al., 2021), few studies have examined the relationship between olfaction and picky eating in children. The limited available research has used Dunn's (1999) Short Sensory Profile (SSP) to explore this relationship. In a study of fruit and vegetable intake and variety among

2-5-year-old children and their mothers, Coulthard and Blissett (2009) found that children with higher taste/smell sensitivity liked and consumed fewer types and amounts of fruits and vegetables and were less likely to imitate their mothers' fruit and vegetable consumption patterns. This suggests that children's taste/smell sensitivity influences the effectiveness of parental modeling of eating behaviors. Other studies have examined olfactory sensitivity and picky eating in special populations. Research has found significant negative correlations between olfactory sensitivity and food variety and intake in children with autism spectrum disorder and attention-deficit/hyperactivity disorder (e.g., Nimbley et al., 2022; Smith et al., 2020; Page et al., 2022). Additionally, research indicates that olfaction not only identifies food aromas but also influences overall flavor perception (Stevenson, 2010). Therefore, future research should not only further validate the relationship between olfactory sensitivity and picky eating but also examine whether cross-modal transfer occurs between olfaction and taste, whereby olfaction influences taste and thereby affects children's food choices.

4.1.3 Tactile Sensitivity As noted earlier, food texture is closely related to children's picky eating behavior (Dovey et al., 2008). Touch is an important modality for perceiving food texture, and theoretically, children with high tactile sensitivity are better able to perceive food texture and thus more likely to be picky about food. In the domain of eating psychology, tactile sensitivity can be divided into two types: lingual/oral tactile sensitivity and non-oral tactile sensitivity. Common methods for measuring children's tactile sensitivity include: (1) the Short Sensory Profile (Dunn, 1999), which uses questionnaires to measure various aspects of tactile sensitivity (both lingual and non-oral); (2) tactile play tasks, which assess children's hand tactile sensitivity through pleasantness ratings of touching different objects (Nederkoorn et al., 2015); and (3) letter-identification tasks, in which blindfolded children identify letters made of Teflon placed on their tongues to measure lingual tactile sensitivity (Essick et al., 1999).

Survey research has found that preschool children with higher tactile sensitivity questionnaire scores consume fewer vegetables and fruits (Coulthard & Blissett, 2009) and exhibit more picky eating behavior (Rendall et al., 2022). Tactile play tasks have revealed that 4-10-year-old children who dislike touching various food and non-food items (e.g., velvet fabric, candy, or cookies) give lower liking ratings to foods (Nederkoorn et al., 2015); 2-5-year-old children who dislike participating in food and non-food tactile tasks show higher fear of novel foods (Coulthard & Thakker, 2015); and non-food tactile sensitivity is significantly correlated with parent-reported rejection of novel foods in 2-5-year-old children (Coulthard & Sahota, 2016). Lukasewycz and Mennella (2012) used letter-identification tasks to examine the relationship between tactile sensitivity and picky eating, finding that 7-10-year-old American children with high tactile sensitivity did not exhibit more picky eating. However, research suggests that different letters vary in perceptual complexity, which may compromise the reliability and validity of letter-identification tasks (Appiani et al., 2020), and that this task is only suitable for populations familiar with the English alphabet

(Cattaneo et al., 2020).

Expanding children's contact with foods or other objects may influence their picky eating behavior. Researchers have found that gradual exposure to different textures from early childhood may help improve picky eating, increase fruit and vegetable intake, and enhance acceptance of novel foods (Johnson et al., 2019; Tournier et al., 2021). Engaging preschool children with foods through play can also improve picky eating behavior (Coulthard & Sealy, 2017; Coulthard et al., 2018). In summary, tactile sensitivity is related to picky eating in children, and this relationship is more readily captured by tactile sensitivity questionnaires and tactile tasks. Coulthard and Blissett (2009) proposed that children's tactile sensitivity represents an important mechanism through which food texture influences acceptance of certain foods. Tactile contact can improve picky eating to some extent, but evidence remains limited, and how parents can implement these strategies in home settings and their practical effectiveness in improving children's picky eating require further investigation.

4.1.4 Visual Characteristics of Food The visual system provides substantial information about food before consumption, which to some extent determines our expectations about food. However, compared to other sensory characteristics, research examining the relationship between vision and picky eating is scarce. Studies have found that children's picky eating is significantly associated with visual features such as food size and shape (Gotow et al., 2023; Olsen et al., 2012). Additional indirect evidence suggests that visual features may influence picky eating. Research has shown that 4-7-year-old children are more attracted to aesthetically pleasing foods (Jansen et al., 2010), 5-12-year-old children exhibit more positive emotional responses to round apple shapes (da Quinta et al., 2023), 6-12-year-old children are more likely to reject green vegetables (Raggio & Gámbaro, 2018), and 5-10-year-old children often rely on visual features to decide whether to taste unfamiliar fruits (Dovey et al., 2012). However, one experimental study found that changing yogurt color did not significantly alter yogurt intake in 32-48-month-old children (Werthmann et al., 2015). While green color may affect vegetable selection but not yogurt intake, suggesting that the influence of visual features on food choice may depend on food category. Existing research has only examined relationships between food shape and color and children's food selection and attitudes, but no studies have investigated the relationship between visual sensitivity and picky eating. Children with high visual sensitivity may be more likely to notice dissatisfying aspects of food appearance or eating environments, potentially triggering more picky eating. Future research should therefore explore both food visual features and visual sensitivity in relation to picky eating.

Overall, both the sensory characteristics of foods themselves (taste, smell, touch, and auditory features) and children's sensory thresholds or sensory sensitivity are closely related to picky eating in childhood. Children with high sensory sensitivity—whether in taste, smell, touch, or vision—are more likely to exhibit

picky eating. Research has found that individuals with high sensory sensitivity not only notice more sensory details (involving taste, touch, smell, and vision) but also detect sensory stimuli such as food texture more quickly (Steinsbekk et al., 2017). Furthermore, a recent resting-state fMRI study on picky eating in children revealed a relationship between sensory sensitivity and picky eating at the neurophysiological level. The study found that picky eating in 9–12-year-old children was positively correlated with regional homogeneity in the right caudate nucleus and with functional connectivity between the right caudate nucleus and left putamen. Since the caudate nucleus is involved in sensory information encoding, sensory sensitivity may play an important role in explaining individual differences in picky eating (Cui et al., 2024). According to Dunn’s (1999) model, sensory thresholds interact with behavioral responses: individuals with low sensory thresholds are more sensitive to stimuli and actively avoid unpleasant stimuli, while those with high thresholds are less sensitive and may even seek additional stimulation for more intense sensory experiences. This suggests that children with high sensory sensitivity have lower sensory thresholds and are therefore more likely to avoid foods that produce unpleasant experiences, leading to picky eating. Conversely, children with low sensory sensitivity may seek stimulation by trying novel foods. Moreover, sensory thresholds are not fixed and can be modulated through habituation (Wardle et al., 2003). Specifically, through repeated exposure, the central nervous system gradually learns to perceive a stimulus as familiar, safe, or less important, thereby adjusting its sensitivity. Therefore, repeated exposure to environments containing vegetables and fruits may lead to habituation and reduce picky eating. Research has found that this exposure effect is most effective during early childhood (Costa & Oliveira, 2023), suggesting that frequent food contact interventions should be implemented during the preschool years to reduce picky eating.

4.2 Psychological Representation

Psychological representation refers to individuals’ internal mental representation of an object, concept, or experience. When children begin consuming complementary foods, they form various psychological representations of food. These representations can be perceptual and concrete or conceptual and abstract (Martin, 2007). The level of abstraction in individuals’ mental representations determines how they understand and process information, thereby influencing their categorization abilities (Holyoak & Morrison, 2012; Rumiati & Foroni, 2016). For example, if children habitually represent food based on perceptual features, they will use these perceptual characteristics as criteria for categorization. Thus, children’s categorization abilities reflect their psychological representations. Food categorization abilities are very limited before age two. For instance, when categorizing foods, 9-month-old infants show no significant difference in looking time between food-related and non-food-related features (Shutts et al., 2009). Additionally, 20-month-old children cannot reliably distinguish between food and animal categories in sequential touching tasks (Brown, 2010). However, by age 2, children can accurately differentiate food

categories, and their food categorization abilities improve with age (Rioux et al., 2016). Three-year-old children can correctly categorize toys and foods in abstract conceptual tasks (Bovet et al., 2005). Nguyen and Murphy (2003) found that 3-year-old children could categorize fruits and vegetables both taxonomically (e.g., fruit, animal) and scripturally (e.g., breakfast). Girgis and Nguyen (2018) also found that children's categorization abilities increase with age, with 5-6-year-old children accurately identifying food types and making health judgments based on food characteristics rather than packaging. A recent study found that children's food-related knowledge improved significantly between ages 3 and 5, and that 3-7-year-old children could categorize foods taxonomically or scripturally (Pickard et al., 2023). Thus, children in early childhood (ages 2-3) begin forming abstract, conceptual representations of food, and their understanding becomes increasingly abstract and sophisticated with age.

Although few studies have examined the relationship between picky eating and food representation in children, existing research consistently finds an association. Studies have shown significant negative correlations between preschool children's picky eating and their inductive categorization abilities regarding food (Rioux, Lafraire, & Picard, 2018; Rioux, Leglaye, & Lafraire, 2018), and that picky school-age children perform poorly on food categorization tasks (Foinant et al., 2022; Rioux et al., 2016). However, the underlying mechanisms of this relationship remain unexplored. Generally, children hold negative expectations about novel foods, perceiving them as potentially unpalatable and slightly dangerous (Cole et al., 2017; Lafraire et al., 2016). When a food is identified as unfamiliar, it means children have not formed correct, conceptual representations of it, increasing the likelihood of rejection. Children who can form more abstract food representations may more easily identify foods correctly and have more accurate taste expectations, resulting in lower rejection of novel foods and less picky eating. Future research should therefore explore whether guiding children to use more abstract food representations can enhance food identification accuracy and taste expectation precision, ultimately improving acceptance of selective or novel foods.

4.3 Reward and Punishment Sensitivity

Reward sensitivity refers to the degree to which an individual's behavior is driven by reward-related stimuli, while punishment sensitivity refers to the degree to which behavior is inhibited by punishment-related stimuli. Direct evidence on the relationship between reward/punishment sensitivity and picky eating is limited. Some indirect evidence suggests that children with high reward sensitivity consume more food and are more likely to become obese (Guerrieri et al., 2008; Ramalho et al., 2023; Vandeweghe et al., 2017). Preschool children with high reward sensitivity are more likely to immediately try disliked vegetables when offered rewards, whereas those with low reward sensitivity may hesitate even with verbal encouragement (Vandeweghe, Verbeken et al., 2016). More direct evidence indicates that parent-reported reward sensitivity in preschool children

is significantly positively correlated with food approach behaviors, while parent-reported punishment sensitivity is significantly positively correlated with food avoidance behaviors (Vandeweghe, Vervoort et al., 2016). A recent study using the Candy Gambling Game to measure risk aversion for aversive tastes found that 4-15-year-old children who self-reported higher levels of vegetable neophobia made fewer risky decisions in the game (Hendriks-Hartensveld et al., 2023).

These limited direct and indirect findings suggest an association between reward/punishment sensitivity and picky eating in childhood, but more evidence is needed. Reinforcement Sensitivity Theory posits that seeking and actively responding to rewards (reward sensitivity) and avoiding and preventing punishment (punishment sensitivity) represent two biological instincts (Gray, 1982). Individuals vary considerably in their sensitivity to rewards and punishments. We infer that when children with higher reward sensitivity than punishment sensitivity encounter novel foods, they may be driven by the potential reward of delicious taste, unwilling to miss any positive food experience, and thus make more adventurous decisions to try more foods. Conversely, children more sensitive to negative experiences may be inhibited by the possibility of unpleasant experiences, unwilling to risk any negative food experience, and thus make more conservative decisions, rejecting more foods.

5 Summary and Outlook

With socioeconomic development, “eating well” has received increasing attention. A balanced diet is crucial for children’s physical health, growth, and cognitive development. Most research on picky eating has approached the issue from a nutritional perspective, focusing on external factors such as parental feeding practices, meal presentation, and dietary diversity, while few studies have examined cognitive factors. Through a comprehensive review of existing literature, this paper first clarifies the core concept of picky eating and its measurement tools, then proposes that the developmental trajectory of picky eating follows an inverted U-shaped pattern, and finally focuses on the cognitive mechanisms underlying picky eating, elaborating on cognitive factors related to picky eating: children’s sensory sensitivity to food, the abstractness of food representations, and children’s reward/punishment sensitivity. Specifically, children with high sensory sensitivity to food sensory characteristics, those who represent food primarily through perceptual features, or those with high sensitivity to food-related punishment are more likely to exhibit picky eating behavior (see Figure 1 [Figure 1: see original paper]).

Additionally, children’s information processing biases may represent another cognitive factor influencing picky eating, which we discuss below. Current research on the cognitive mechanisms of picky eating is in its infancy, with numerous limitations. Future research should explore the following directions.

Figure 1. Integrated model of cognitive mechanisms underlying picky eating behavior in children

5.1 Exploring Additional Sensory Modalities Most existing research on picky eating has focused on olfactory, gustatory, and tactile modalities, with limited exploration of visual processing, while studies examining how audition influences picky eating are virtually absent. However, research has found that eating sounds can alter adults' food perception: amplifying eating sounds significantly enhanced perceived crispness, saltiness, sourness, fullness, and overall flavor intensity (Kleinberger, Van Troyer, & Wang, 2023). External environmental sounds also affect adults' perception of food aroma, taste, and satisfaction (Guedes et al., 2023). We therefore infer that background sounds during meals or chewing sounds may also influence children's food perception and subsequently affect their picky eating behavior. Beyond environmental sounds, children's individual sound sensitivity may also impact picky eating. For example, children with high auditory sensitivity may feel uncomfortable in noisy environments, and this environmental discomfort may lead to negative associations with food, exacerbating picky eating. Understanding individual differences in children's sound sensitivity and attention to dining environment comfort may help improve children's eating experiences and reduce picky eating.

Furthermore, existing research has examined only single sensory characteristics in relation to picky eating, whereas real-life food experiences involve a multisensory integration process that engages multiple modalities simultaneously rather than a single sense. On one hand, one sensory modality can influence another. Research has found that devaluation effects between color and taste associations undergo cross-modal transfer, with color influencing taste perception (Jiang et al., 2024). Motoki et al. (2023) systematically reviewed existing research and found that visual cues can significantly influence taste/flavor perception under specific conditions. Future research could therefore manipulate the valence of visual food cues to alter children's taste perception. For example, using a Go/no-go task to train children to associate green with go signals could examine whether this association increases acceptance of leafy green vegetables. On the other hand, combinations of two or more sensory characteristics may produce additive effects (Motoki & Togawa, 2022), further influencing children's food preferences and aversions. A recent intervention study found that having children interact with vegetables visually (single modality), olfactorily and visually (dual modality), or olfactorily, tactilely, and visually (multimodal) all improved vegetable preferences, but multimodal interventions were more effective than single-modality interventions, with effectiveness increasing as more sensory modalities were involved (Roberts et al., 2022). Future research should examine how different sensory characteristics jointly influence children's food acceptance and whether specific sensory combinations are particularly effective in encouraging children to try novel foods. For instance, studies could investigate how different dining environments (various combinations of visual, auditory, olfactory, and tactile stimuli) affect children's picky eating. A virtual reality study found that adult participants' liking for healthy foods increased significantly in beautiful virtual natural environments, while liking for unhealthy foods did not change (Pennanen et al., 2020). Thus, multisensory virtual environments may

enhance children' s acceptance of vegetables and novel foods. Future research could use virtual reality technology to simulate multisensory environments, such as a playground restaurant setting, to test whether this increases children' s selection and consumption of healthy foods.

5.2 Examining the Influence of Information Processing Biases on Picky Eating

In addition to the cognitive factors discussed above, future research should examine the role of information processing biases in picky eating (see Figure 1). Incentive Sensitization Theory (Berridge, 2009) posits that cognitive biases toward unhealthy food information reinforce unhealthy eating behaviors (e.g., Folkvord et al., 2015). A recent study found that although presenting nutritional information to consumers can change eating intentions, cognitive biases lead to overattention to calorie information while neglecting other information, resulting in unwise eating decisions (Dube et al., 2023). This suggests that cognitive biases toward calorie information reduce the probability of choosing healthier foods. During development, children receive vast amounts of food information from environments, family, peers, media, and television—some objective but much of it subjective. When processing this information, children may develop similar processing biases that trigger fear of certain foods and subsequent rejection.

Information processing biases include attentional bias and interpretation bias. First, children may selectively seek information consistent with their beliefs while ignoring contradictory information. Previous research has found that anxious children are more likely to attend to fear stimuli matching their anxiety objects while ignoring positive information (Shi et al., 2022), and obese adolescents are more easily distracted by food stimuli (Woltering et al., 2021). Therefore, picky children may seek information confirming that disliked foods are unpalatable or dangerous while ignoring information indicating they are delicious or healthy. This attentional bias may in turn strengthen children' s existing picky eating beliefs. Second, children may also tend to interpret ambiguous situations in threatening or negative ways, and such interpretation biases have been found to increase anxiety and behavioral avoidance (Dibbets & Meesters, 2022; Zhang & Miao, 2019). When encountering ambiguous mealtime situations, negative interpretations can easily produce negative associations with food. For example, seeing a poorly packaged food may lead children to assume the contents are unpalatable and refuse to eat it. Both types of cognitive bias can generate negative food-related experiences that may intensify picky eating over time; conversely, picky children may also exhibit more of these biases. Currently, research on the relationship between picky eating and information processing biases remains virtually nonexistent, making this an urgent area for future investigation.

5.3 Intervention Studies Targeting Cognitive Factors of Picky Eating

The ultimate goal of exploring the mechanisms of picky eating is to help children improve this behavior, yet few intervention studies targeting picky eating exist. Given the close relationship between cognitive factors and picky eating, future

intervention designs should comprehensively consider these cognitive factors.

5.3.1 Designing Sensory Characteristic-Based Interventions for Picky Eating Throughout childhood, sensory characteristics are closely related to picky eating behavior. Existing interventions targeting sensory characteristics have primarily involved touch and taste, finding that sensory stimulation can improve picky eating to some extent. For example, studies have improved picky eating by having children interact with foods (tactile) or using cooking techniques (taste) to enhance positive food perception (e.g., Carney et al., 2018; Coulthard et al., 2018; Johnson et al., 2019; Patel et al., 2020; Tournier et al., 2021). However, children's food choices are not only related to touch and taste but also to vision and audition. Visually, food packaging, shape, and color all influence eating behavior (da Quinta et al., 2023; Jansen et al., 2010; Raggio & Gámbaro, 2018). Research has shown that food packaging can change children's food selection (Ares et al., 2022; Ogle et al., 2017), and future studies should examine packaging effects on picky eating. Auditorily, certain food or environmental sounds may trigger disgust or curiosity about food, affecting eating behavior. Therefore, future research should investigate how manipulating auditory features of foods or environments can improve picky eating. The sounds of fruits or vegetables can elicit different emotional experiences in children (Zeinstra et al., 2010), suggesting that cooking methods could be adjusted to modify food sound characteristics and improve eating habits. If children prefer crisp fruits and vegetables, cooking methods that soften foods (e.g., steaming, stewing) should be minimized; conversely, if children dislike noisy foods, steaming, stewing, or pureeing could be used. A recent study found that compared to rock music, playing jazz and classical music during food selection increased adults' preference for healthy salty foods (e.g., vegetable sandwiches); compared to classical music, rock, hip-hop, and jazz increased preference for unhealthy salty foods (e.g., beef sandwiches); and compared to rock, hip-hop, and jazz, classical music increased preference for both healthy (e.g., low-fat milk) and unhealthy (e.g., milk chocolate) sweet foods (Motoki et al., 2022). Thus, background music type can influence adult food preferences, and future research should explore how manipulating background music can reduce picky eating in children. Furthermore, given that eating is a multisensory activity, future research should examine multisensory dietary interventions that combine visual, auditory, tactile, and gustatory stimuli to create comprehensive dietary improvement programs. Research has found that children prefer foods with fine, non-granular textures (Chow et al., 2023; Coulthard & Thakker, 2015; Werthmann et al., 2015) and harder, crisper vegetables (Zeinstra et al., 2010). Future studies could use cooking techniques to create foods with specific textures (fine texture), colors (using edible dyes), sounds (by modifying texture), and flavors (by adding spices), combined with dining environment design, to increase children's acceptance of healthy foods.

5.3.2 Considering Sensory Sensitivity in Modeling Interventions

Parental feeding practices and eating habits during early childhood are considered key factors shaping children's picky eating behavior (Brown et al., 2022; Costa & Oliveira, 2023). Although parental modeling of healthy eating reduces children's picky eating, children's sensory sensitivity may moderate the effectiveness of parental modeling (Coulthard & Blissett, 2009; Gray, Buro, & Sinha, 2023). As discussed earlier, children with high sensory sensitivity may be more sensitive to food texture, taste, and smell, potentially leading to stronger resistance to new foods or certain textures. Therefore, parental modeling may have more complex effects in these children. For example, if parents frequently try new foods and show enjoyment, this may encourage children with low sensory sensitivity to imitate their behavior. However, for children with high sensory sensitivity, simply seeing parents eat a food may be insufficient to overcome their resistance. In such cases, more positive encouragement, repeated exposure, and even food modifications (e.g., changing cutting shapes, cooking methods, or mixing with liked foods) may be needed to help children gradually accept new foods.

5.3.3 Examining the Influence of Reward/Punishment Sensitivity on Intervention Selection

Vandeweghe, Verbeken et al. (2016) found that children with high reward sensitivity were more willing to try unfamiliar foods when encouraged by parents. This suggests that providing positive external feedback and rewards may be an effective method for promoting acceptance of healthy foods in children who are highly responsive to rewards. Therefore, interventions using feeding rewards and persuasive feeding may be more suitable for children with high reward sensitivity. Conversely, acquiring more food-related knowledge can help children form accurate food representations and more precise taste expectations, making knowledge-based interventions potentially more appropriate for children with high punishment sensitivity. However, when providing food knowledge to children, age-appropriate educational methods must be considered. Thus, incorporating cognitive factors such as reward/punishment sensitivity into intervention research can help optimize and design more effective interventions.

5.3.4 Using Cognitive Bias Training and Educational Interventions to Modify Cognitive Biases

Finally, given that information processing biases likely influence picky eating, future research should consider using cognitive training to modify children's cognitive processes or educational interventions to change cognitive biases about healthy foods. Cognitive Bias Modification (CBM) is an intervention that modifies cognitive biases by guiding individuals to prioritize positive or neutral stimuli while avoiding negative or threatening stimuli (Fodor et al., 2020). Existing research has demonstrated that CBM can change children's cognitive biases toward certain stimuli (e.g., Pettit et al., 2020). For children who overly attend to negative food information, future studies could attempt to use this training to correct attentional biases toward

food-related information. Additionally, research has shown that nutrition education teaching food-related knowledge to children, especially school-age children (e.g., Cotton et al., 2020; Elrakaiby et al., 2022), and interactive nutrition education activities involving children in cooking (e.g., Collado-Soler, 2023; Højer, Wistoft, & Frøst, 2021) can improve dietary quality. Both approaches can modify children's cognitive biases toward disliked or novel foods and promote correct food cognition (Cotton et al., 2020; Ng et al., 2022). For children with interpretation biases about food, educational or interactive learning activities could teach them to identify and challenge incorrect beliefs or negative thoughts about healthy foods, replacing them with more accurate and positive food information. This may reduce interpretation biases, making children more willing to accept and try disliked or novel foods, thereby improving eating habits. Again, age-appropriate educational or activity designs must be considered.

References

Cui, Y., Zhang, Y., Chen, X., Xiao, M., Liu, Y., Song, S., ...& Chen, H. (2024). The effect of instrumental feeding on picky eating behavior in 9-12-year-old children: Evidence from resting-state functional magnetic resonance imaging. *Acta Psychologica Sinica*, (06), 731-744.

General Office of the National Health Commission, et al. (2020). Implementation plan for the prevention and control of obesity in children and adolescents. Retrieved from https://www.gov.cn/zhengce/zhengceku/2020-10/24/content_{5553848}.htm

Healthy China Action Promotion Committee. (2019). Healthy China Action Plan (2019-2030). Retrieved from http://www.gov.cn/xinwen/2019-07/15/content_{5409694}.htm

Ministry of Education, et al. (2022). Implementation measures for the nutrition improvement program for rural compulsory education students. Retrieved from https://www.gov.cn/zhengce/zhengceku/2022-11/11/content_{5726234}.htm

Ju, L., Zhao, L., Fang, H., Guo, Q., Piao, W., Xu, X., ...& Yu, D. (2023). Status and evaluation of main food intake among 6-17-year-old children in China, 2016-2017. *Chinese Journal of Public Health*, 39(5), 550-555.

Zhang, L., & Miao, L. (2019). The relationship between hostile interpretation bias and aggression. *Advances in Psychological Science*, 27(12), 2097-2108.

Achenbach, T. M., & Edelbrock, C. (1991). Child behavior checklist. *Burlington (vt)*, 7, 371-392.

Appiani, M., Rabitti, N. S., Methven, L., Cattaneo, C., & Laureati, M. (2020). Assessment of lingual tactile sensitivity in children and adults: Methodological suitability and challenges. *Foods*, 9(11), 1594.

Ares, G., Velázquez, A. L., Vidal, L., Curutchet, M. R., & Varela, P. (2022). The

role of food packaging on children's diet: Insights for the design of comprehensive regulations to encourage healthier eating habits in childhood and beyond. *Food Quality and Preference*, 95, 104366.

Bell, K. I., & Tepper, B. (2006). Short-term vegetable intake by young children classified by 6-n-propylthiouracil bitter-taste phenotype. *The American Journal of Clinical Nutrition*, 84(1), 245-251.

Berger, P. K., Hohman, E. E., Marini, M. E., Savage, J. S., & Birch, L. L. (2016). Girls' picky eating in childhood is associated with normal weight status from ages 5 to 15 y. *The American Journal of Clinical Nutrition*, 104(6), 1577-1582.

Berridge, K. C. (2009). 'Liking' and 'wanting' food rewards: brain substrates and roles in eating disorders. *Physiology & Behavior*, 97(5), 537-550.

Birch, L. L., Fisher, J. O., Grimm-Thomas, K., Markey, C. N., Sawyer, R., & Johnson, S. L. (2001). Confirmatory factor analysis of the Child Feeding Questionnaire: A measure of parental attitudes, beliefs and practices about child feeding and obesity proneness. *Appetite*, 36(3), 201-210.

Bjorklund, D. F. (2022). *Children's thinking: Cognitive development and individual differences*. Sage publications.

Boquin, M. M., Moskowitz, H. R., Donovan, S. M., & Lee, S. Y. (2014). Defining perceptions of picky eating obtained through focus groups and conjoint analysis. *Journal of Sensory Studies*, 29(2), 126-138.

Bourne, L., Bryant-Waugh, R., Mandy, W., & Solmi, F. (2023). Investigating the prevalence and risk factors of picky eating in a birth cohort study. *Eating Behaviors*, 50, 101780.

Bovet, D., Vauclair, J., & Blaye, A. (2005). Categorization and abstraction abilities in 3-year-old children: A comparison with monkey data. *Animal Cognition*, 8, 53-59.

Brown, S. (2010). The rejection of known and previously accepted foods in early childhood [Unpublished doctoral dissertation]. University of Birmingham.

Brown, C. L., Ip, E. H., Skelton, J., Lucas, C., & Vitolins, M. (2022). Parental concerns about picky eating and undereating, feeding practices, and child's weight. *Obesity Research & Clinical Practice*, 16(5), 373-378.

Call, C., Walsh, B. T., & Attia, E. (2013). From DSM-IV to DSM-5: Changes to eating disorder diagnoses. *Current Opinion in Psychiatry*, 26(6), 532-536.

Cardona Cano, S., Tiemeier, H., Van Hoeken, D., Tharner, A., Jaddoe, V. W., Hofman, A., ...& Hoek, H. W. (2015). Trajectories of picky eating during childhood: A general population study. *International Journal of Eating Disorders*, 48(6), 570-579.

Carney, E. M., Stein, W. M., Reigh, N. A., Gater, F. M., Bakke, A. J., Hayes, J. E., & Keller, K. L. (2018). Increasing flavor variety with herbs and spices

improves relative vegetable intake in children who are propylthiouracil (PROP) tasters relative to nontasters. *Physiology & Behavior*, 188, 48-57.

Cattaneo, C., Liu, J., Bech, A. C., Pagliarini, E., & Bredie, W. L. (2020). Cross-cultural differences in lingual tactile acuity, taste sensitivity phenotypical markers, and preferred oral processing behaviors. *Food Quality and Preference*, 80, 103803.

Chen, J., & Rosenthal, A. (Eds.). (2015). *Modifying food texture: Novel ingredients and processing techniques*. Woodhead Publishing.

Chilman, L., Kennedy-Behr, A., Frakking, T., Swanepoel, L., & Verdonck, M. (2021). Picky Eating in Children: A Scoping Review to Examine Intrinsic and Extrinsic Features and How They Relate Identification. *International Journal of Environmental Research and Public Health*, 18(17), 9067.

Chow, C. Y., Bech, A. C., Sørensen, H., Olsen, A., & Bredie, W. L. (2023). Food texture preferences in early childhood: Insights from 3-6 years old children and parents. *Food Quality and Preference*, 113, 105063.

Cole, N. C., An, R., Lee, S. Y., & Donovan, S. M. (2017a). Correlates of picky eating and food neophobia in young children: A systematic review and meta-analysis. *Nutrition Reviews*, 75(7), 516-532.

Cole, N. C., Wang, A. A., Donovan, S. M., Lee, S. Y., & Teran-Garcia, M. (2017b). Variants in chemosensory genes are associated with picky eating behavior in preschool-age children. *Journal of Nutrigenetics and Nutrigenomics*, 10(3-4), 84-92.

Collado-Soler, R., Alférez-Pastor, M., Torres, F. L., Trigueros, R., Aguilar-Parra, J. M., & Navarro, N. (2023). A systematic review of healthy nutrition intervention programs kindergarten primary education. *Nutrients*, 15(3), 541.

Costa, A., & Oliveira, A. (2023) Parental Feeding Practices and Children's Eating Behaviours: An Overview of Their Complex Relationship. *Healthcare*, 11(3), 400.

Cotton, W., Dudley, D., Peralta, L., & Werkhoven, T. (2020). The effect of teacher-delivered nutrition education programs on elementary-aged students: An updated systematic review and meta-analysis. *Preventive Medicine Reports*, 20, 101178.

Coulthard, H., & Blissett, J. (2009). Fruit and vegetable consumption in children and their mothers. Moderating effects of child sensory sensitivity. *Appetite*, 52(2), 410-415.

Coulthard, H., & Thakker, D. (2015). Enjoyment of tactile play is associated with lower food neophobia in preschool children. *Journal of the Academy of Nutrition and Dietetics*, 115(7), 1134-1140.

Coulthard, H., & Sahota, S. (2016). Food neophobia and enjoyment of tactile play: Associations between preschool children and their parents. *Appetite*, 97,

155-159.

Coulthard, H., & Sealy, A. (2017). Sensory play is associated with tasting of fruits and vegetables in preschool children. *Appetite*, 113, 84-90.

Coulthard, H., Williamson, I., Palfreyman, Z., & Lyttle, S. (2018). Evaluation of a pilot sensory play intervention to increase fruit acceptance in preschool children. *Appetite*, 120, 609-615.

da Quinta, N., Ríos, Y., Llorente, R., Naranjo, A. B., & Baranda, A. B. (2023). The effect of food shape on children' s implicit and explicit emotional response. *Food Quality and Preference*, 109, 104921.

Delahunt, A., Killeen, S. L., O' Brien, E. C., Geraghty, A. A., O' Reilly, S. L., McDonnell, C. M., ...& McAuliffe, F. M. (2024). Stability of child appetitive traits and association with diet quality at 5 years and 9-11 years old: Findings from the ROLO longitudinal birth cohort study. *European Journal of Clinical Nutrition*, 1-8.

Dial, L. A., Jordan, A., Emley, E., Angoff, H. D., Varga, A. V., & Musher-Eizenman, D. R. (2021). Consequences of picky eating in college students. *Journal of Nutrition Education and Behavior*, 53(10), 822-831.

Dibbets, P., & Meesters, C. (2022). Disconfirmation of confirmation bias: the influence of counter-attitudinal information. *Current Psychology*, 41, 2327-2333.

Dovey, T. M., Aldridge, V. K., Dignan, W., Staples, P. A., Gibson, E. L., & Halford, J. C. (2012). Developmental differences in sensory decision making involved in deciding to try a novel fruit. *British Journal of Health Psychology*, 17(2), 258-272.

Dovey, T. M., Staples, P. A., Gibson, E. L., & Halford, J. C. (2008). Food neophobia and 'picky/fussy' eating in children: a review. *Appetite*, 50(2-3), 181-193.

Dube, S., Tsvakirai, C. Z., Mabuza, L. M., & Makgopa, T. (2023). The influence of cognitive bias on the use of menu nutritional information among consumers in Mahikeng city, South Africa. *Applied Food Research*, 3(2),

Dunn, W. (1999). *Sensory Profile: User' s Manual*. Psychological Corporation.

Egger, H. L., Erkanli, A., Keeler, G., Potts, E., Walter, B. K., & Angold, A. (2006). Test-retest reliability of the preschool age psychiatric assessment (PAPA). *Journal of the American Academy of Child & Adolescent Psychiatry*, 45(5), 538-549.

Ekstein, S., Laniado, D., & Glick, B. (2010). Does picky eating affect weight-for-length measurements in young children?. *Clinical Pediatrics*, 49(3), 217-220.

Elrakaiiby, M., Hasnin, S., Stage, V. C., & Dev, D. A. (2022). 'Read for Nutrition' programme improves preschool children' s liking and consumption of

target vegetable. *Public Health Nutrition*, 25(5), 1346-1354.

Essick, G. K., Chen, C. C., & Kelly, D. G. (1999). A letter-recognition task to assess lingual tactile acuity. *Journal of Oral and Maxillofacial Surgery*, 57(11), 1324-1330.

Farrow, C. V., & Coulthard, H. (2012). Relationships between sensory sensitivity, anxiety and selective eating in children. *Appetite*, 58(3), 842-846.

Fernandez, C., McCaffery, H., Miller, A. L., Kaciroti, N., Lumeng, J. C., & Pesch, M. H. (2020). Trajectories of picky eating in low-income US children. *Pediatrics*, 145(6), e20192018.

Flesher, A., Moding, K., Davis, K., Montalvo, A., & Johnson, S. (2020). Is self-feeding related to food consumption and observed child eating behaviors in infants and toddlers? *Current Developments in Nutrition*, 4(Supplement_2), nzaa054_{057}.

Fodor, L. A., Georgescu, R., Cuijpers, P., Szamoskozi, S., David, D., Furukawa, T. A., & Cristea, I. A. (2020). Efficacy of cognitive bias modification interventions in anxiety and depressive disorders: A systematic review and network meta-analysis. *The Lancet Psychiatry*, 7(6), 506-514.

Foinant, D., Lafraire, J., & Thibaut, J. P. (2022). Tears for pears: Influence of children's neophobia on categorization performance and strategy in the food domain. *Frontiers in Nutrition*, 9, 951890.

Folkvord, F., Anschütz, D. J., Wiers, R.W., & Buijzen, M. (2015). The role of attentional bias in the effect of food advertising on actual food intake among children. *Appetite*, 84, 251-258.

Ginieis, R., Abeywickrema, S., Oey, I., Franz, E. A., Perry, T., Keast, R. S., & Peng, M. (2021). The role of an individual's olfactory discriminability in influencing snacking and habitual energy intake. *Appetite*, 167,

Girgis, H., & Nguyen, S. P. (2018). Shape or substance? Children's strategy when labeling a food and its healthfulness. *Cognitive Development*, 48, 289-301.

Gotow, N., Nagai, Y., Taguchi, T., Kino, Y., Ogino, H., & Kobayakawa, T. (2023). Change in preference for vegetables and their perceptual attributes as a function of age and pickiness. *Food Research International*, 170, 112967.

Gray, J. A. (1982). Précis of The neuropsychology of anxiety: An enquiry into the functions of septo-hippocampal system. *Behavioral and Brain Sciences*, 5(3), 469-484.

Gray, H. L., Buro, A. W., & Sinha, S. (2023). Associations Among Parents' Eating Behaviors, Feeding Practices, and Children's Eating Behaviors. *Maternal and Child Health Journal*, 27(2), 202-209.

Guedes, D., Garrido, M. V., Lamy, E., Cavalheiro, B. P., & Prada, M. (2023). Crossmodal interactions between audition and taste: A systematic review and

narrative synthesis. *Food Quality and Preference*, 104856.

Guerrieri, R., Nederkoorn, C., & Jansen, A. (2008). The interaction between impulsivity and a varied food environment: Its influence on food intake and overweight. *International Journal of Obesity*, 32(4), 708–714.

Hafstad, G. S., Abebe, D. S., Torgersen, L., & von Soest, T. (2013). Picky eating in preschool children: The predictive role of the child's temperament and mother's negative affectivity. *Eating Behaviors*, 14, 274–277.

Hald, M., Hald, M. O., Stankovic, J., Niklassen, A. S., & Ovesen, T. (2021). Positive association between bitter taste threshold and preference of vegetables among adolescents. *Acta Paediatrica*, 110(3), 875–880.

He, J., Zickgraf, H. F., Essayli, J. H., & Fan, X. (2020). Classifying and characterizing Chinese young adults reporting picky eating: A latent profile analysis. *International Journal of Eating Disorders*, 53(6), 883–893.

Hendriks-Hartensveld, A. E., Nederkoorn, C., van den Brand, A. J., & Havermans, R. C. (2023). Child-reported vegetable neophobia is associated with risk avoidance for distaste in children aged 4–15 years. *Appetite*, 189,

Henkin, R. I., Martin, B. M., & Agarwal, R. P. (1999). Decreased parotid saliva gustin/ carbonic anhydrase VI secretion: An enzyme disorder manifested by gustatory and olfactory dysfunction. *The American Journal of the Medical Sciences*, 318(6), 380–391.

Herle, M., Stavola, B. D., Hübel, C., Ferreira, D. L. S., Abdulkadir, M., Yilmaz, Z., ...& Micali, N. (2020). Eating behavior trajectories in the first 10 years of life and their relationship with BMI. *International Journal of Obesity*, 44(8), 1766–1775.

Holyoak, K. J., & Morrison, R. G. (Eds.). (2012). *The Oxford handbook of thinking and reasoning*. Oxford University Press.

Hoppu, U., Laitinen, K., Jaakkola, J., & Sandell, M. (2015). The hTAS2R38 genotype is associated with sugar and candy consumption in preschool boys. *Journal of Human Nutrition and Dietetics*, 28, 45–51.

Højer, R., Wistoft, K., & Frøst, M. B. (2021). Yes I can cook a fish; effects of a five week sensory-based experiential theme course with fish on 11-to 13-year old children's food literacy and fish eating behaviour—A quasi-experimental study. *Food Quality and Preference*, 92, 104232.

Jansen, E., Mulken, S., & Jansen, A. (2010). How to promote fruit consumption in children. Visual appeal versus restriction. *Appetite*, 54(3), 599–602.

Jiang, J., Yang, Z., Liu, M., & Huang, J. (2024). Love the color, love its flavor: Preference transfer between visual and gustatory modalities. *International Journal of Gastronomy and Food Science*, 35, 100891.

Jilani, H., Intemann, T., Buchecker, K., Charalambos, H., Gianfagna, F., De Henauw, S., ...& Antje, H. (2022). Correlates of bitter, sweet, salty and umami taste sensitivity in European

Note: Figure translations are in progress. See original paper for figures.

Source: ChinaXiv –Machine translation. Verify with original.