Neuromarketing and Sustainability: Understanding Implicit Bias to Promote Sustainable Eating Habits

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Abstract

This study aims to evaluate the added value of neuromarketing techniques, specifically the Implicit Association Test (IAT), in analyzing consumer implicit biases toward sustainability foods, particularly insects. While edible insects are part of the culinary tradition in many Eastern countries, their consumption remains limited in Western cultures. Despite the well-known environmental and sustainability benefits of such foods, various studies have demonstrated that strong cultural barriers hinder their adoption.

By testing 200 participants through explicit questionnaires and the IAT, this research highlights the differences and convergences between these two methodologies in understanding consumer perceptions of edible insects. The results reveal a convergence between explicit and implicit attitudes, emphasizing the strength of implicit biases. The IAT proves to be a fundamental tool in accessing the unconscious dimensions of perception, providing valuable insights for marketing strategies aimed at promoting sustainable food choices.

Keywords: Food sustainability, Edible insects, Entomophagy, Psychological barriers, Neuromarketing, Implicit association test

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Introduction

Food sustainability has emerged as one of the most pressing global challenges of the 21st century. Projections indicate that the global population will exceed 9 billion by 2050, driving an escalating demand for protein sources and exerting unsustainable pressure on natural resources (FAO, 2013). Meat production, the dominant protein source in many regions, is particularly resource-intensive, requiring significant amounts of water, land, and other inputs, while contributing disproportionately to greenhouse gas emissions. In light of these concerns, the identification and adoption of sustainable alternative protein sources have become a critical priority on a global scale.

Edible insects represent a promising response to these challenges. They are highly nutritious, offering a rich source of proteins, vitamins, minerals, and essential fats, and their farming practices are substantially more sustainable than those of conventional livestock (Ceriani, 2018; Ordoñez-Araque, 2021). For instance, insect farming requires up to 12 times less feed to produce one kilogram of protein compared to cattle and generates a significantly lower carbon footprint (Van Huis *et al.*, 2013). Additionally, insects can be farmed using agricultural by-products, contributing to the reduction of food waste (EFSA Scientific Committee, 2015).

Despite these benefits, the acceptance of entomophagy – the practice of consuming insects – remains limited in Western countries. This stands in stark contrast to cultures in Asia and Africa, where insects are traditionally regarded as a normal component of the diet (Milani *et al*, 2020). The reluctance of Western consumers is frequently attributed to cultural and psychological factors, including feelings of disgust, fear, and a general unfamiliarity with insects as food (Milani *et al.,* 2021). The challenge of promoting sustainable innovations such as edible insects parallel the difficulty in enhancing public trust in vaccines, where implicit and explicit perceptions often conflict, influencing acceptance (Jacomuzzi, 2024, Jacomuzzi 2022). Understanding these dynamics is critical to designing interventions that address both conscious attitudes and unconscious biases.

Research on consumer behavior toward novel foods, such as edible insects, has traditionally relied on explicit methods, including questionnaires and interviews. These approaches focus on consciously articulated attitudes and preferences. However, such methods are constrained by significant limitations.

Firstly, the phenomenon of social desirability bias (Edwards, 1957; Grimm, 2010) can substantially influence responses. Participants may, knowingly or unconsciously, provide answers that align with socially

acceptable norms rather than reflect their true attitudes and beliefs. This effect is particularly pronounced in contexts related to sustainability, where social values and norms heavily shape declared behaviors.

In an era of growing awareness around environmental sustainability, social expectations play a pivotal role in shaping consumer-reported attitudes. For instance, when questioned about adopting sustainable practices or embracing innovative food sources such as edible insects, participants are likely to provide responses that reflect moral or socially desirable positions rather than their actual preferences or intentions. This discrepancy can result in an overestimation of consumers' willingness to adopt sustainable eating habits.

Moreover, many food-related decisions are influenced by automatic and unconscious processes (Köster, 2009). These processes are inaccessible through traditional explicit methods. Disgust, for instance, is a primary emotion triggered by stimuli perceived as contaminating, dangerous, or culturally inappropriate. From an evolutionary perspective, such responses are adaptive, protecting individuals from potentially harmful substances such as spoiled or toxic foods. However, in modern contexts, disgust may be elicited by elements that pose no actual risk but are culturally deemed unacceptable. In the case of edible insects, this reaction is particularly pronounced in Western cultures, where insects are not traditionally part of the diet. Despite the nutritional and environmental advantages of insects, the automatic disgust response represents a substantial psychological barrier to their acceptance. This response is often so deeply ingrained that consumers are unable to rationalize their rejection, resulting in a disconnect between their consciously stated support for sustainability and their implicit negative reactions.

In this context, neuromarketing offers innovative tools for analyzing consumer behavior. Among these, the Implicit Association Test (IAT) stands out for its ability to measure automatic associations between conceptual categories (e.g., "insects") and emotional attributes (e.g., "disgusting" or "appetizing"). By recording reaction times and errors, the IAT identifies the ease with which participants associate specific categories with positive or negative emotions, providing a unique window into their unconscious processes (Greenwald *et al.*, 1998).

The present study explores the role of the IAT in examining perceptions related to entomophagy. The research builds on the premise that the acceptance of novel foods requires communication strategies that target not only explicit attitudes but also, and more importantly, implicit associations (Milani *et al.*, 2021). Only by addressing the strength of automatic associations that influence behavior can meaningful changes be achieved.

This study seeks to investigate the depth of implicit biases by measuring the extent to which consumers associate insects with negative emotions. Additionally, the research compares explicit self-reported attitudes with implicit biases identified through the IAT to uncover potential discrepancies. The primary objective is to examine the conscious and unconscious associations related to edible insects to gain deeper insights into the psychological barriers hindering their acceptance as a viable food source.

Materials and Methods

This study employed an explicit questionnaire to gather self-reported data, complemented by the Implicit Association Test (IAT) to assess implicit biases through reaction time measurements. Both tools were administered entirely online. Given the well-established validity of IAT data collected on the Qualtrics platform (Carpenter, 2019), this platform was used to facilitate data collection for both the questionnaire and the IAT.

Participants

The sample consisted of 200 participants recruited via social media, university mailing lists, and online research platforms. Inclusion criteria were deliberately kept simple to ensure a diverse sample: participants had to be between 18 and 55 years old and have a stable internet connection to complete the test. No specific requirements were set for gender, education level, or familiarity with sustainable foods.

Before participating, all subjects were required to read and approve an informed consent form, which clearly explained the study's objectives, data collection procedures, and the anonymous handling of their data.

Survey

The questionnaire was divided into three main sections, each designed to gather specific data related to consumer perceptions, knowledge, and sociodemographic characteristics regarding insect-based foods.

Section 1: Evaluation of Food Preferences

In the first section, participants were presented with two questions accompanied by images of three different types of protein bars (first question) and three different types of chips (second question). Each option was labeled with letters A, B, and C, and the product packaging was

specifically designed to be colorful and visually appealing to attract attention.

Participants were not informed about the origin of the products in advance, apart from the information provided on the labels. To avoid biased responses, no details about the ingredients, including the presence of insects, were disclosed during the introductory phase.

The three options presented for each food category were characterized as follows:

Products containing insect-based ingredients with explicit packaging: These products featured stylized images of insects and labels such as "Cricket Protein Bar" or "Eat What Bugs You," making the presence of insects as a main ingredient clear.

Products containing insect-based ingredients with subtle packaging: These products mentioned the presence of insects only in the ingredients list, using less conspicuous terms like "insect flour," and employed visual messaging designed to downplay the insect content.

Products without insect-based ingredients: These products were traditional foods with no insect-derived ingredients.

Participants were asked two questions:

"How likely are you to eat these protein bars?"

"How likely are you to eat these chips?"

Responses were collected using a four-point Likert scale (very likely, likely, unlikely, very unlikely), avoiding neutral options to encourage more decisive evaluations.

Section 2: Knowledge and Attitudes Toward Insect-Based Foods

This section included a qualitative investigation through multiple-choice questions aimed at exploring participants' knowledge of insect-based foods and their consumption habits.

The first question asked: "Have you ever eaten insect-based food?" Participants who answered affirmatively proceeded with a series of questions exploring the context and frequency of consumption. These included:

"What motivated you to eat insects?" with four response options: curiosity, sustainability, cultural influence, or health-related factors.

"Do you regularly consume insect-based food?" with response options limited to "yes" or "no," distinguishing between occasional and habitual consumers.

For those who had never eaten insect-based food, the reasons for refusal were explored with options such as disgust, lack of opportunity, or doubts about food safety. Subsequently, participants were asked: "Would you like to try them in the future?" with three possible responses: "yes," "maybe,"

"no." Finally, participants were queried on the main factors that might encourage them to try insect-based foods in the future, such as sustainability or curiosity.

Section 3: Sociodemographic Survey

The final section collected participants' sociodemographic data, including gender, age, and education level. This survey aimed to analyze potential correlations between sample characteristics and the perceptions or preferences expressed in the previous sections.

Implicit Association Test (IAT)

The Implicit Association Test (IAT) was designed to assess implicit associations between emotions (pleasure and disgust) and food categories (insect-based foods and non-insect-based foods). The test was divided into four main blocks, each preceded by a brief training phase to ensure participants understood the task.

Emotion Categorization: In the first block, participants categorized words associated with positive emotions (e.g., "delicious," "appetizing") or negative emotions (e.g., "vomit," "rotten"). Responses were provided by pressing a specific key: the "E" key for negative emotions and the "I" key for positive emotions. This block aimed to familiarize participants with the emotion-based categorization task.

Food Category Categorization: In the second block, participants categorized food items into two groups: insect-based foods (e.g., "chocolate-covered crickets," "fried grasshoppers") and non-insect-based foods (e.g., "chicken," "pizza"). Again, participants used the "E" and "I" keys to make their selections. This task established an initial association between the two food categories and their corresponding responses.

Verbal Emotion-Food Combination: In the third block, emotions and food categories were combined in verbal form. Participants were presented with words representing positive or negative emotions alongside words indicating insect-based or non-insect-based foods. For example, "delicious" and "chocolate-covered crickets" might share the same response key, while "vomit" and "chicken" shared the other. This block measured implicit associations between emotions and foods in verbal form.

Visual and Verbal Stimuli Combination: The fourth block combined visual and verbal stimuli. Participants were shown a mix of words related to emotions and images of insect-based or non-insect-based foods. This block aimed to investigate whether visual stimuli reinforced or altered the implicit associations observed in the previous blocks.

Participants were instructed to respond as quickly and accurately as possible. The total duration of the IAT was approximately 10–15 minutes. Results were analyzed by calculating d-scores, which reflect the strength of implicit associations. Positive scores indicated a stronger association between non-insect-based foods and positive emotions, while negative scores indicated a stronger association between insect-based foods and positive emotions.

Results

The data collected were analyzed using SPSS software to examine explicit and implicit biases toward insect-based foods. The results are presented across three key areas: food preferences, familiarity and barriers to consumption, and IAT outcomes. A summary is provided at the end of each section for clarity.

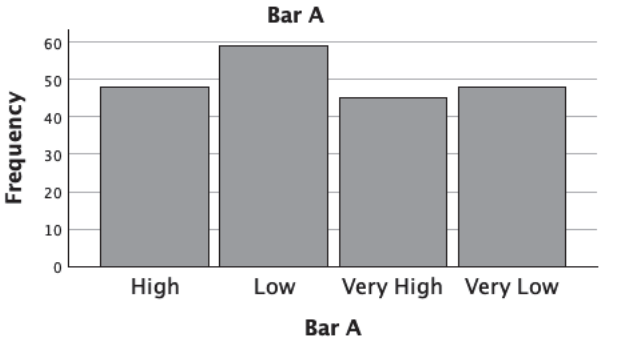
1. Food Preferences

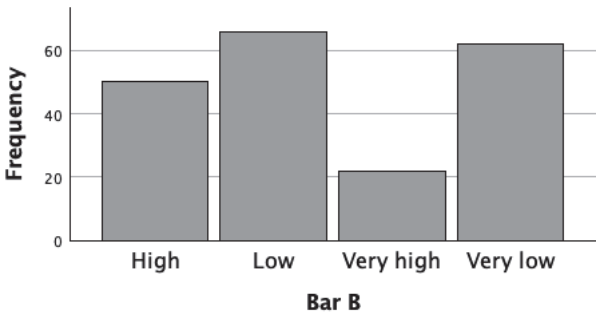
This section of the questionnaire aimed to explore participants' preferences for insect-based foods compared to traditional options, with a specific focus on the role of packaging.

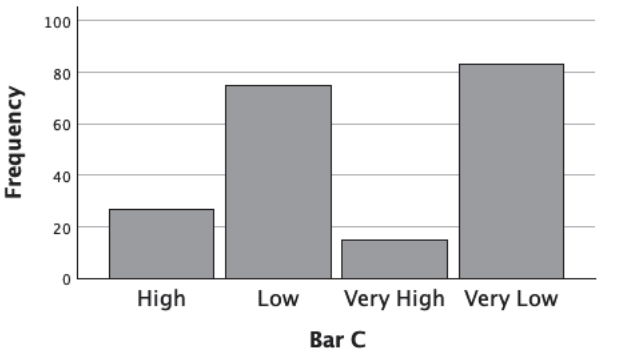
Protein Bar A: Composed of bananas, chocolate, and insect flour, with yellow packaging. Responses were almost evenly split, with 93 favorable and 107 unfavorable. This suggests slight skepticism despite the product's innovative nature.

Protein Bar B: A high-protein bar without insect ingredients received moderate interest, with participants expressing limited willingness to try it, possibly reflecting a general aversion to high-protein products.

Protein Bar C: Also insect-based, featuring stylized insect imagery on the packaging, saw a significant rejection rate, with only one in four participants willing to try it, reflecting strong cultural resistance.



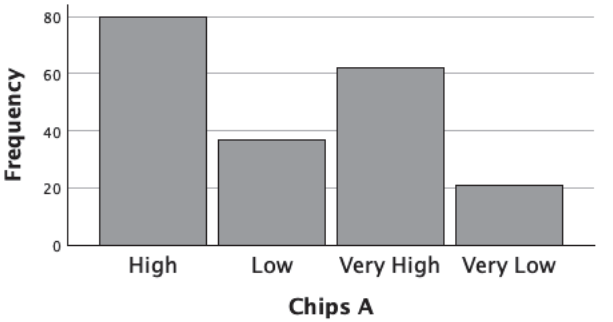


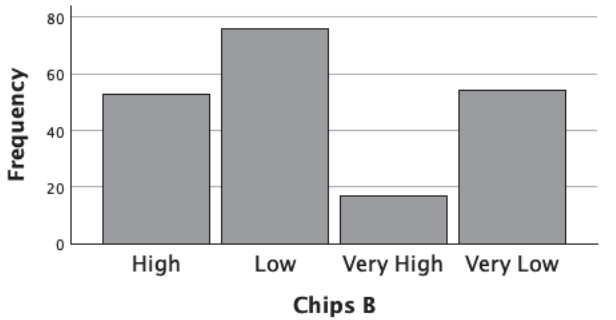


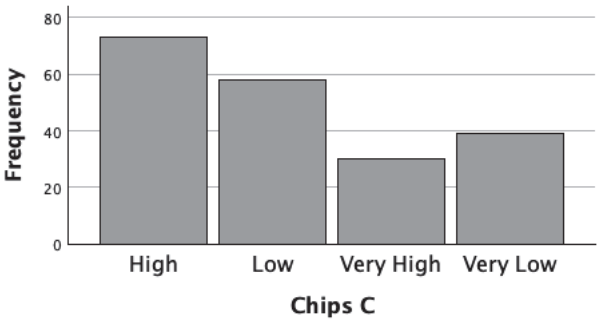
Chips A: Classic chips received overwhelmingly positive feedback, indicating strong familiarity and acceptance.

Chips B: Featuring insect-themed packaging, these chips faced skepticism.

Chips C: Pizza-flavored chips made with insect flour saw a balanced response, mirroring the results for Protein Bar A.







Summary: The analysis highlights the critical role of packaging and visual representation in influencing food preferences. Products with explicit insect references struggled to gain acceptance, underscoring cultural and psychological resistance.

2. Familiarity and Barriers to Consumption

This section examined participants' familiarity with insect-based foods and the barriers to their consumption.

Previous Experience: Only 13 participants (6.5%) reported having consumed insect-based foods, compared to 183 who had not. Common reasons for non-consumption included disgust (38.8%), lack of opportunity (22.9%), misinformation, and fear.

	Frequency	Percentage
Disgust	127	43.5%
Lack of opportunity	75	25.7%
Don't know where to buy	41	14.1%
Misinformation	36	12.3%
Fear	35	12.0%
Morality	6	2.0%
Lack of alternatives	2	0.7%
High price	1	0.3%

Future Intentions: When asked, "Would you eat insect-based food in the future?", responses were divided: 35.8% said "no," 27.3% said "yes," and 36.9% responded "maybe," indicating conditional openness.

Motivations: Among those who had tried insect-based foods, curiosity (57.1%) was the most cited reason, followed by cultural influences and sustainability perceptions.

Summary: Familiarity with insect-based foods remains low, with disgust and lack of opportunities serving as major barriers. However, conditional openness suggests that targeted education and expert recommendations could encourage adoption.

3. Sociodemographic Analysis

The sociodemographic analysis did not reveal gender differences in whether participants had tried or were willing to try insect-based foods. Similarly, no differences were observed based on education level (Chi-square test, $p = 0.362$).

Among women, 99.6% had never tried insect-based food, compared to 89.2% of men. The Chi-square test indicated no significant difference ($p = 0.078$).

Regarding future willingness to try insect-based foods:

Women: 47.37% answered "no," 34.21% answered "maybe," and 18.42% answered "yes."

Men: 45.45% answered "no," 37.88% answered "maybe," and 16.67% answered "yes." In this case, the Chi-square test revealed a statistically significant difference ($p < 0.001$) in responses between men and women.

4. IAT Results

The IAT evaluated implicit associations between emotions (positive and negative) and food categories (insect-based and everyday foods), focusing on response accuracy, reaction times, and patterns of association.

Negative Emotion/Insect-Based Foods: Participants made 97 correct categorizations out of 100, with only 3 errors, indicating a highly stable and automatic association between insect-based foods and negative emotions.

Positive Emotion/Insect-Based Foods: Participants experienced significant difficulty, with only 55 correct responses out of 100 and 45 errors, reflecting a strong implicit bias against associating positive emotions with insect-based foods.

Positive Emotion/Everyday Foods: Participants exhibited high accuracy, with 98 correct responses out of 100 and only 2 errors, demonstrating a natural and intuitive association between everyday foods and positive emotions.

Negative Emotion/Everyday Foods: Participants showed greater difficulty associating negative emotions with everyday foods, with 66 correct responses and 34 errors, suggesting incongruence.

Reaction Times: Reaction times provided additional insights into the strength of associations:

Category	Mean Reaction Time (ms)	Standard Deviation (ms)
Everyday food / Positive emotion	594.81	45.41
Everyday food / Negative emotion	801.12	47.68
Insects / Positive emotion	803.24	54.21
Insects / Negative emotion	605.43	44.21

The results show that participants were significantly faster at associating insect-based foods with negative emotions (605.43 ms) than with positive emotions (803.24 ms). Conversely, everyday foods were more easily and rapidly associated with positive emotions (594.81 ms) than with negative emotions (801.12 ms). These findings highlight the deeply ingrained and automatic nature of negative associations with insect-based foods.

Chi-Square Analysis: The Chi-square test for response accuracy across all IAT conditions revealed significant differences ($p < 0.001$):

Positive Emotion/Insects vs. Positive Emotion/Everyday Foods: Participants exhibited significantly greater difficulty associating positive emotions with insect-based foods compared to everyday foods ($p < 0.001$).

Negative Emotion/Insects vs. Negative Emotion/Everyday Foods: Negative associations were significantly stronger and faster for insect-based foods compared to everyday foods ($p < 0.001$).

Overall Associations: Aggregated across all categories (positive/negative and insect/everyday), Chi-square analysis showed that the differences in implicit associations were statistically significant ($p < 0.001$).

D-Score Calculation: To quantify the strength of implicit biases, a D-score of 4.17 was calculated, reflecting a substantial bias favoring negative associations with insect-based foods. This score underscores the participants' difficulty in associating positive attributes with insects, indicating that these biases are deeply ingrained and automatic.

Summary: The IAT results reveal a strong implicit association of insect-based foods with negative emotions, evidenced by higher error rates, slower reaction times, and a high D-score. These findings suggest that unconscious biases against insect-based foods are stable and require targeted interventions to address.

Discussion

The results obtained from the explicit questionnaire and the IAT highlight the effectiveness of implicit measurement techniques. The IAT data reveal a strong implicit negative association with insect-based foods. This negative association is evidenced not only by the high number of errors in the categorization task of positive emotions paired with insect-based foods but also by the slower reaction times. Conversely, the rapid and accurate response times in categorizing negative emotions associated with insect-based foods confirm that these negative associations are particularly stable. This finding demonstrates that insects trigger an automatic and immediate negative response, which is difficult to modify through rational processes.

The results align with previous studies (Milani *et al.*, 2020; Van Huis *et al.*, 2013), which attribute resistance toward insects to psychological and emotional factors, such as disgust, rooted in cultural and perceptual barriers. As observed in the adaptation to distance learning during the pandemic, psychological resistance and cultural norms significantly shape the acceptance of new paradigms (Jacomuzzi *et al.*, 2023, Milani *et al.*, 2022). Similarly, promoting sustainable food sources like insects requires addressing deeply ingrained societal and psychological barriers.

The IAT results further highlight how these barriers manifest at an implicit level, underscoring the need for targeted interventions. Both the questionnaire and the IAT reveal a negative perception of insect-based foods, but the IAT underscores a much stronger implicit bias. While the questionnaire suggests a moderate openness to future tasting, the strength of the implicit associations revealed by the IAT indicates that this openness

may not translate into actual behavior. This demonstrates the critical role of unconscious biases in shaping decisions, suggesting that rational attitudes captured by explicit methods may be insufficient to overcome deeply ingrained negative associations.

These findings confirm that explicit attitudes, often influenced by factors such as social desirability or context, provide only a partial understanding of consumers' real perceptions. As shown in the literature (Greenwald *et al.*, 1998; Nosek *et al.*, 2011), the IAT is a crucial tool for investigating unconscious processes, which play a key role in food-related decisions, especially those involving sustainable options.

The findings have important practical implications for communication and marketing strategies aimed at promoting the acceptance of insects as a sustainable food source.

Effective communication strategies play a pivotal role in bridging the gap between implicit biases and consumer acceptance of novel foods, such as insect-based products. Previous research has highlighted the importance of leveraging human-machine interaction to tailor messaging that resonates with diverse consumer groups, ultimately facilitating behavior change (Jacomuzzi *et al.*, 2024). Given that negative implicit associations are ingrained and automatic, it is essential to design interventions targeting the unconscious level, reducing negative biases through specific strategies, such as:

Minimizing the visual aspect of insects: Offering transformed products (e.g., protein bars, flours) instead of whole insects may reduce the automatic activation of disgust.

Emphasizing environmental and nutritional benefits: Clear messages about the sustainability and health advantages of insects could encourage a cognitive restructuring of implicit perceptions. Interactive and shareable digital media have been shown to influence consumer behavior effectively by engaging audiences on an emotional level (Bruno *et al.*, 2023). Leveraging these tools could be a game-changer in reshaping perceptions of insect-based foods, emphasizing their benefits in innovative and engaging formats.

Gradual exposure techniques: Starting with transformed products integrated into daily diets could reduce automatic negative associations over time.

Conclusions

This study has demonstrated how neuromarketing techniques,

particularly the IAT, are essential tools for understanding and addressing implicit resistance to innovative foods such as edible insects. The results highlight that while consumers may express openness toward the idea of consuming insects, their unconscious biases reveal a deeply rooted negative association that constitutes a significant barrier.

Neuromarketing techniques allow for overcoming the limitations of explicit questionnaires, providing valuable insights into consumers' unconscious perceptions. This approach is critical in the context of sustainability, as it enables the design of communication and marketing strategies that operate on both rational and emotional levels. Recent studies show that tools like the IAT can provide a deeper understanding of the unconscious factors influencing consumer decisions (Carpenter *et al.*, 2019; Ordoñez-Araque *et al.*, 2021). For example, research by Köster (2020) has highlighted how automatic and unconscious processes play a fundamental role in food preferences, often in contrast with conscious declarations.

Interventions such as product reformulation, raising awareness of environmental benefits, and gradual exposure to novel foods can help reduce negative implicit biases and promote a transition toward more sustainable food choices. Specifically, product reformulation that conceals the visual aspect of insects through transformed foods has been shown to significantly reduce the activation of negative emotions linked to disgust (Ceriani, 2020). Additionally, educating consumers on the environmental benefits of insects, such as their lower ecological impact compared to conventional meat, has been identified as an effective strategy to positively influence perceptions (Van Huis *et al.*, 2021).

In a global context characterized by increasing pressure on natural resources, integrating innovative approaches like neuromarketing into food policies and communication strategies is crucial. Only through a profound understanding of the implicit dynamics driving consumer decisions will it be possible to promote the acceptance of sustainable foods and thereby contribute to global goals of environmental sustainability and food security. The ability of neuromarketing to uncover unconscious associations that hinder behavioral change represents a critical added value in tackling global challenges such as climate change and food security (EFSA Scientific Committee, 2021; Ordoñez-Araque *et al.*, 2021).

This study represents a preliminary exploration of the implicit biases and barriers to the acceptance of insect-based foods, leveraging neuromarketing techniques to uncover unconscious associations. While the findings provide valuable insights, there are certain limitations that should be acknowledged to contextualize the results and guide future research.

Discussing Limitations and Future Directions

This is a preliminary study that highlights certain limitations but also provides insights for future research. One notable limitation lies in the sample's representativeness. Participants were primarily recruited through social media and digital platforms, which may not fully capture the diversity of the broader population. As a result, the findings might not be entirely generalizable across different demographic or cultural groups. The study may also be influenced by self-selection bias. Because participants voluntarily engaged with the research, it's possible that the sample disproportionately included individuals already interested in sustainability or open to novel food concepts, potentially skewing the results. The study's focus on insect-based foods provided valuable insights into a specific case study. However, this narrow focus does not encompass the broader range of challenges associated with other categories of novel foods, leaving room for further exploration.

The methodology presents another challenge. While the Implicit Association Test (IAT) is a powerful tool for uncovering unconscious associations, it has its limitations. Factors such as participants' familiarity with the testing interface or external distractions could influence reaction times. Moreover, the study did not employ longitudinal measures, making it difficult to assess whether sustained interventions might shift implicit biases over time. Finally, the study largely concentrated on implicit and explicit biases, without accounting for additional contextual factors. Elements such as socio-economic status, dietary habits, or exposure to media could significantly influence attitudes toward insect-based foods, yet these were not explored.

To build on this research, future studies should address these limitations and expand the scope of inquiry. Efforts should be made to include participants from a wider range of backgrounds to ensure a more representative population. Future research could adopt longitudinal designs to assess the long-term effects of marketing strategies and interventions on implicit biases. Examining factors such as cultural background, economic considerations, and environmental awareness could offer a richer understanding of consumer attitudes. Biases toward insect-based foods should be compared with attitudes toward other novel food types to identify overarching patterns and specific challenges. By addressing these areas, future research can build a more nuanced and actionable understanding of how to encourage sustainable food choices and overcome psychological and cultural barriers.

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