The Negative Footprint Illusion: Why Our 'Green' Choices Might Not Be So Green?

Gizem UZLU DOLANBAY*, Hilal YILDIRAN**

Abstract

The Negative Footprint Illusion (NFI) is a cognitive bias that leads individuals to falsely assume that adding an environmentally friendly product or behavior reduces the overall environmental impact. This illusion distorts sustainability assessments, as people rely on averaging bias, compensatory green beliefs (CGB), framing effects, and quantity insensitivity instead of objectively evaluating total environmental impact. This review examines NFI as a cognitive barrier to sustainable nutrition, exploring its underlying mechanisms and their role in shaping environmental decision-making. Empirical evidence highlights how individuals miscalculate their carbon footprint, particularly in food consumption and energy-related decisions and how perceptual biases reinforce this illusion. Addressing these biases through strategic sustainability communication and evidence-based decision-making frameworks is crucial for fostering truly sustainable consumption behaviors.

Keywords: Negative footprint ılusion, averaging bias, sustainable consumption, green halo effect, cognitive bias, compensatory green beliefs.

Negatif Ayak İzi Yanılsaması: 'Yeşil' Seçimlerimiz Gerçekten O Kadar Yeşil mi?

Öz

Negatif Ayak İzi Yanılsaması (NAİY), bireylerin çevre dostu bir ürün veya davranış eklediğinde toplam çevresel etkinin azaldığını yanlış bir şekilde varsaymasına neden olan bilişsel bir yanılgıdır. Bu yanılsama, sürdürülebilirlik değerlendirmelerini sistematik olarak çarpıtarak bireylerin toplam çevresel etkiyi nesnel bir şekilde değerlendirmesi yerine ortalama alma yanılgısı, telafi edici yeşil inançlar (TEYİ), çerçeveleme etkisi ve miktar duyarsızlığı gibi faktörlere dayanmasına yol açar. Bu derleme, NAİY'yi sürdürülebilir beslenme açısından kritik bir bilişsel engel olarak ele almakta ve bu yanılsamanın temel mekanizmalarını, çevresel karar alma süreçleri üzerindeki etkilerini kapsamlı bir şekilde analiz etmektedir. Ampirik bulgular, bireylerin özellikle besin tüketimi ve enerjiyle ilgili kararlar sırasında karbon ayak izlerini yanlış hesapladığını ve algısal yanılgıların bu yanılsamayı nasıl güçlendirdiğini göstermektedir. Bu yanılgıların azaltılması, etkili sürdürülebilirlik iletişimi ve kanıta dayalı karar alma çerçeveleri ile mümkündür ve gerçekten sürdürülebilir tüketim davranışlarını teşvik etmek için hayati bir gerekliliktir.

Anahtar Sözcükler: Negatif ayak izi yanılsaması, ortalama alma yanılgısı, sürdürülebilir tüketim, yeşil hale etkisi, bilişsel yanılgılar, telafi edici yeşil inançlar.

Introduction

Sustainability, encompassing environmental, economic, and social dimensions, aims to protect human health and ecosystems while ensuring a livable world for future

Derleme Makale (Review Article)
Geliş / Received: 06.03.2025 & **Kabul / Accepted:** 20.03.2025
DOI: https://doi.org/10.38079/igusabder.1652929
* (Corresponding Author) Res. Asst., Department of Nutrition and Dietetics, Faculty of Health Sciences, Istanbul Gelişim University, İstanbul, Türkiye ; PhD Candidate, Nutrition and Dietetics PhD Program, Institute of Health Sciences, Gazi University, Ankara, Türkiye. E-mail: guzlu@gelisim.edu.tr ORCID https://orcid.org/0000-0002-3049-2259
** Prof., PhD. Department of Nutrition and Dietetics, Faculty of Health Sciences, Gazi University, Ankara, Türkiye. E-mail: hilalciftci@gazi.edu.tr ORCID https://orcid.org/0000-0001-7956-5087

Istanbul Gelisim University Journal of Health Sciences (IGUSABDER) is indexed by TUBITAK ULAKBIM TR Index.
Web site: https://dergipark.org.tr/en/pub/igusabder
Contact: igusabder@gelisim.edu.tr

generations[1]. In this context, integrating sustainability principles into lifestyles is crucial, particularly in food systems, where environmental, economic, and social impacts must be considered. Sustainable nutrition is at the heart of this approach[1], a dietary model that promotes human health and preserves natural resources, maintaining environmental balance. According to the Food and Agriculture Organization (FAO), "Sustainable diets are those diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair, and affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources."[2].

The significance of sustainable nutrition becomes increasingly evident in the face of global challenges such as a growing population, climate change, and resource depletion. According to the United Nations, the world population is projected to reach 9.7 billion by 2050[3]. The FAO estimates that feeding this expanding population will require an overall increase of approximately 70% in global food production between 2005/07 and 2050[4]. Consistent with this, the Intergovernmental Panel on Climate Change (IPCC) emphasizes that a sustainable future, including a sustainable food system, is one of the most pressing issues of this era[5].

Food production systems are a major contributor to greenhouse gas (GHG) emissions and place immense pressure on limited natural resources such as water and soil[6]. In fact, food production alone is responsible for 15-30% of total GHG emissions, making it a key driver of global warming[6,7]. According to the 1990-2021 Greenhouse Gas Emission Statistics of the Turkish Statistical Institute (TÜİK), Türkiye's total GHG emissions have risen, reaching 6.7 tons of CO_2 equivalent per capita. Among all sectors, the highest increase in GHG emissions was observed in the agricultural sector (56.5%), followed by the waste sector (32.6%)[8]. This data highlights the urgent need to adopt more sustainable food production and waste management practices to mitigate environmental impact.

Additionally, household consumption is estimated to contribute to more than 60% of global GHG emissions, underscoring the urgent need for sustainable eating behaviors at both individual and societal levels[9,10]. The adoption of a more sustainable diet is not only crucial for environmental sustainability, but is also a key public health issue[11]. Even small, daily behavioral changes can have a significant positive impact on environmental outcomes. Making informed food choices and adopting sustainable eating behaviors will help individuals mitigate climate change, preserve natural resources, and ensure global food security. This underlines the importance of individuals taking environmental responsibility and actively working toward a sustainable future[12,13]. Sustainable eating behaviors are vital as they offer the potential to minimize both health and environmental impacts while promoting nutrient-rich, sustainable, and eco-friendly dietary habits[14]. Overall, sustainable eating behaviors are essential in addressing the growing challenges of food production and consumption while simultaneously supporting both human health and environmental well-being[15].

However, economic, social, and cognitive barriers hinder the transition to sustainable nutrition. Sustainable food products are often more expensive and may have limited availability in certain regions. Cultural dietary habits can make it difficult for individuals

Istanbul Gelisim University Journal of Health Sciences (IGUSABDER) is indexed by TUBITAK ULAKBIM TR Index.
Web site: https://dergipark.org.tr/en/pub/igusabder
Contact: igusabder@gelisim.edu.tr

to modify their food choices. Additionally, cognitive biases, such as misjudging environmental impacts, can undermine sustainable eating efforts[16,17]. Individuals often struggle to accurately assess their behaviors' environmental impact. Certain activities, such as meat consumption and air travel, are often underestimated in terms of their environmental impact, whereas actions like avoiding plastic bags tend to be overestimated[10]. These misjudgments can hinder the adoption of sustainable eating behaviors, highlighting the role of cognitive biases in sustainability-related decision-making.

Cognitive biases, which lead to deviations from rational decision-making and judgment processes, can distort individuals' perceptions of food consumption and its environmental impacts. Research indicates that these biases may cause systematic errors in individuals' sustainable food choices and even reinforce unsustainable consumption behaviors within group settings[16,18]. One of the most significant cognitive barriers to sustainable nutrition is the Negative Footprint Illusion (NFI). This illusion leads individuals to believe that adding environmentally friendly food choices offsets the negative environmental impact of other, less sustainable choices, creating the false perception that their diet is more sustainable than it actually is[19] Moreover, cognitive biases can skew individuals' perceptions of their sustainable eating choices, leading to misjudgments about their actual environmental impact—such as assuming that the presence of an eco-friendly label on certain foods makes their entire diet sustainable[20]. Cognitive distortions in environmental communication can shape individuals' attitudes and perceptions toward sustainable behaviors[21]. This review aims to examine NFI as a cognitive barrier to sustainable nutrition by providing an in-depth analysis of the mechanisms underlying this illusion.

Material and Methods

This review systematically examines research on the NFI through a comprehensive literature search. The literature review was conducted using academic databases such as Web of Science, Scopus, and PubMed, with "Negative Footprint Illusion" as the sole keyword to ensure specificity in the selection process. Given that no prior studies explicitly investigated NFI before 2016, this review includes experimental and observational studies published between January 2016 and February 2025 and written in English. The selected studies were categorized based on the type of experimental design (within-participant, between-participant), sample size and demographic characteristics, research context (nutrition, transportation, energy consumption, marketing), and core cognitive mechanisms (averaging bias, compensatory green beliefs, framing effect, and quantity insensitivity). The findings were synthesized within the framework of NFI's cognitive mechanisms, its effects on sustainable consumption, and how it manifests in different contexts. Based on these criteria, 15 peer-reviewed studies were evaluated and presented in Table 1.

Negative Footprint Illusion (NFI)

Negative Footprint Illusion (NFI) is a cognitive bias that leads individuals to mistakenly believe that adding an environmentally friendly product or behavior reduces the total environmental impact. This illusion leads individuals to make systematic errors in their

Istanbul Gelisim University Journal of Health Sciences (IGUSABDER) is indexed by TUBITAK ULAKBIM TR Index.
Web site: https://dergipark.org.tr/en/pub/igusabder
Contact: igusabder@gelisim.edu.tr

evaluation of total environmental impact, assuming that the inclusion of a sustainable component offsets the harm caused by less sustainable choices[19]. However, a product or behavior perceived as sustainable does not completely eliminate environmental costs; it merely reduces them.

NFI is a part of a broader categorization effect, which arises from the human cognitive system's tendency to engage in categorical thinking[22]. Studies indicate that this illusion is robust across various domains, including food consumption[19,23], transportation[24] and building sustainability[25,26].

One factor influencing the strength of NFI is how individuals assess environmental impacts. Specifically, studies have shown that the illusion becomes stronger as the number of environmentally friendly components within a group increases[27]. These findings suggest that people tend to rely on averaging rather than summation when estimating total environmental impact. In other words, when evaluating a group containing both sustainable and conventional elements, individuals do not sum the carbon footprints of each component separately but instead take an average, leading to an underestimated total impact. This illusion is a cognitive distortion that directly influences environmental decision-making and is shaped by various psychological and social mechanisms. These cognitive processes shape individuals' sustainability perceptions and lead to systematic biases in environmental impact assessments.

Cognitive Factors

Compensatory Green Beliefs (CGB): It refers to a cognitive bias in which individuals believe that certain environmentally friendly choices can compensate for the negative effects of less sustainable ones. This misconception can lead people to an underestimation of the actual impact of sustainable food consumption, causing individuals to miscalculate their total environmental footprint[19]. A key reason behind CGB is the tendency to perceive environmental harm as a fixed budget—where individuals believe that engaging in "green" consumption behaviors neutralizes the impact of unsustainable choices[28]. As a result, people may develop a false sense of sustainability, thinking they are making a meaningful difference when their overall carbon footprint remains largely unchanged[19]. This bias is closely related to NFI, as individuals who assume that sustainable choices balance out unsustainable ones are more likely to miscalculate their total environmental impact[28]. The combined effects of CGB and NFI may hinder individuals from making more sustainable food choices. Ultimately, these biases can cause individuals to overlook the impact of their unsustainable behaviors and develop a false sense of security, leading to increased consumption rather than actual reductions in environmental harm.

Averaging Bias: Averaging bias refers to the tendency of individuals to assess the environmental impact of a group of products as an average rather than summing the individual impacts. One key factor influencing cognitive bias leads to the erroneous belief that a sustainable product's presence reduces an entire setting's total environmental footprint. The strength of NFI is how individuals assess environmental impacts[26]. Experimental studies have demonstrated that individuals perceive the presence of a sustainably labeled product as a factor that makes an unsustainable product appear more

Istanbul Gelisim University Journal of Health Sciences (IGUSABDER) is indexed by TUBITAK ULAKBIM TR Index.
Web site: https://dergipark.org.tr/en/pub/igusabder
Contact: igusabder@gelisim.edu.tr

environmentally friendly, leading to an underestimated total impact[19,25,29]. This mechanism underlies the NFI, leading individuals to mistakenly believe that incorporating a low-carbon component offsets the impact of a high-carbon component. For instance, the addition of an organic side dish to a red meat dish may create the illusion of a reduced total carbon footprint, despite the overall impact remaining unchanged or even increasing [19].

Lack of Information and Misperceptions: Lack of information and misperceptions play a crucial role in how individuals evaluate environmental impacts. Findings indicate that most individuals do not fully understand the relationship between diet and environmental effects, often miscalculating the carbon footprint of their food choices[23,30]. This misjudgment leads individuals to overlook the actual environmental impact of their food choices when making sustainable food consumption decisions. In particular, individuals tend to focus solely on the presence of sustainable products, disregarding the overall environmental impact of their whole dietary habits and total consumption levels[19,23]. Consequently, they may assume that selecting certain products labeled as "sustainable" significantly reduces the carbon footprint of their whole diet. This cognitive error is one of the primary factors contributing to NFI, as it systematically distorts individuals' environmental impact evaluations, making sustainability goals more challenging to achieve.

Green Halo Effect: The Green Halo Effect is a cognitive bias in which a product or behavior is perceived as fully sustainable simply because it possesses some environmentally friendly attributes[31]. This illusion leads individuals to disregard other environmental impacts of products labeled as sustainable. Research indicates that consumers often overestimate the environmental benefits of eco-labeled products while neglecting to account for their full lifecycle impact[32]. This cognitive bias fosters a misleading sense of confidence in one's sustainable choices, leading individuals to assume that a single environmentally friendly product or behavior extends to their entire consumption pattern. The Green Halo Effect has a significant influence on sustainable food choices. Consumers may mistakenly believe that the purchase of food items marketed as ethical or environmentally friendly automatically makes their overall diet sustainable. For instance, an individual purchasing organic meat may disregard the environmental costs associated with meat consumption, incorrectly perceiving their choice as entirely eco-friendly[33]. When combined with the NFI, this bias reinforces the mistaken belief that making a few sustainable choices compensates for unsustainable behaviors, leading to misjudgments in overall environmental impact.

Negative Calorie Illusion: The Negative Calorie Illusion refers to a cognitive bias in which individuals believe that consuming a healthy food item alongside a high-calorie item reduces the total caloric intake. This bias arises from individuals' tendency to categorize foods into virtue (healthy, low-calorie) and vice (unhealthy, high-calorie) categories[22]. For instance, when a burger is consumed alongside a salad, individuals may mistakenly believe that the overall calorie intake is lower than it actually is. In reality, although the total calorie intake increases, individuals perceive the combination as a balanced choice, reinforcing the illusion that they are making a healthier decision overall[34]. A similar cognitive mechanism is observed in NFI[25,35]. Consumers may assume

Istanbul Gelisim University Journal of Health Sciences (IGUSABDER) is indexed by TUBITAK ULAKBIM TR Index.
Web site: https://dergipark.org.tr/en/pub/igusabder
Contact: igusabder@gelisim.edu.tr

that adding a sustainable product or component offsets the The impact of an environmentally harmful product can lead to an underestimation of the total environmental footprint.

Rebound Effect: The Rebound Effect occurs when individuals engage in an environmentally friendly behavior and subsequently compensate for it by increasing their overall consumption, believing that their initial action has offset any negative impact[36]. This mechanism is directly linked to NFI, as individuals may believe that making a sustainable choice significantly reduces their environmental impact, leading them to underestimate their total footprint. The rebound effect can be categorized into direct and indirect effects. Direct rebound effects occur when improvements in energy efficiency lead individuals to use the service more frequently. For instance, someone who purchases a fuel-efficient car may drive longer distances, offsetting the potential environmental benefits. Indirect rebound effects occur when savings from sustainable actions are redirected toward environmentally costly activities, such as using the money saved from fuel efficiency to take a longer vacation with high carbon emissions from air travel[37]. Both types of rebound effects contribute to the perception of moral licensing, where individuals feel justified in engaging in environmentally harmful behaviors after making a sustainable choice[37]. In the context of food consumption, individuals who consume sustainable foods may develop the belief that they are significantly reducing their environmental impact, leading them to increase their total food consumption. This perception ultimately hinders the adoption of truly sustainable dietary habits and may increase overall environmental burden instead of reducing it[38].

Affect Heuristic: Consumers often make decisions about environmentally friendly products based on emotional and intuitive responses rather than analytical reasoning, a process known as the Affect Heuristic[39]. This heuristic leads individuals to judge a product's sustainability based on superficial attributes, such as its label, color, packaging, or marketing language, rather than evaluating its actual environmental impact[32]. The reliance on affective cues rather than objective analysis can distort sustainability perceptions, further reinforcing NFI.

Social Factors

Societal Diet Norms: Popular diet trends and cultural expectations play a significant role in shaping individuals' dietary choices. Social norms may encourage individuals to choose foods perceived as sustainable; however, these norms do not always align with actual sustainability[40]. In particular, the rapid spread of sustainability trends through social media can encourage individuals to adopt specific dietary models without critically evaluating their environmental impact, as seen in the case of plant-based diets or superfoods marketed as "eco-friendly," which may lead individuals to underestimate the overall environmental footprint of their dietary choices[19,23]. Research suggests that younger consumers are more influenced by sustainability trends on social media[41]. This phenomenon may make younger individuals more susceptible to NFI, as they may believe that adopting certain diets promoted within their social circles automatically makes their overall dietary patterns more sustainable. As a result, they may miscalculate their total carbon footprint, assuming that these choices significantly reduce their environmental impact.

Istanbul Gelisim University Journal of Health Sciences (IGUSABDER) is indexed by TUBITAK ULAKBIM TR Index.
Web site: https://dergipark.org.tr/en/pub/igusabder
Contact: igusabder@gelisim.edu.tr

Social Pressures: Social environment is among the key social pressures that shape individuals' sustainable food choices. People may choose sustainable foods to to make a positive impression[40]. However, some diet choices encouraged by social circles may, in reality, lead to greater environmental harm than expected[42]. These social pressures can reinforce the belief that sustainable choices compensate for other unsustainable behaviors[43]. Consequently, individuals may unknowingly make decisions under the influence of NFI, miscalculating their total environmental impact.

Studies on the NFI

Studies on NFI demonstrated that consumers frequently misjudge environmental impacts, and these miscalculations significantly influence purchasing decisions[19,23-29,35]. This cognitive bias has been observed and extensively studied in various contexts, including food consumption, transportation, and energy use. The literature highlights that NFI causes individuals to misjudge environmental impacts, which in turn negatively influences sustainable consumption behaviors.

In the context of nutrition and food choices, research has shown how individuals misinterpret products marketed as organic and environmentally friendly. For example, consumers may make misleading choices by assuming that products with green labels significantly reduce their carbon footprint[19]. The methodological approaches and key findings of studies addressing NFI across different domains are summarized in Table 1.

Table 1. Summary of studies investigating the Negative Footprint Illusion (NFI)

	Experiment	Objective	Sample	Experimental Design	Main Findings
Andersson et al.(2024) [27]	**Experiment a**	To test whether the NFI increases with the number of "green" items added to a fixed set of conventional items.	n = 66 (General population, 67% female, mean age = 31.15 ± 10.74 years)	Within-participant	The magnitude of NFI increased as more green items were added to a fixed set of conventional items, supporting the averaging-bias account. Participants perceived a greater reduction in environmental impact when the number of green additions was large rather than small.
	Experiment b	To test whether response scale design influences the NFI and whether participants misinterpret green items as having zero carbon emissions.	n = 128 (General population, 59% female, mean age = 33.68 ± 12.41 years)	Within-participant	The NFI was only observed when a large number of green additions were present, while smaller additions resulted in a zero-footprint illusion. A significant portion of participants correctly recognized that green buildings still had a carbon footprint, suggesting that the illusion is not driven solely by misinterpretation of green buildings as carbon neutral.
	Experiment c	To examine whether category size (i.e., the total number of items) affects the magnitude of NFI, independent of the proportion of green vs. conventional items.	n = 150 (General population, 61% female, mean age = 34.62 ± 11.70 years)	Between-participant	NFI magnitude increased as category size increased, even when the ratio of green to conventional items remained constant. This finding contradicts the pure averaging-bias explanation and suggests that a category-size bias also contributes to NFI.
Gorissen et al. (2024)[44]		To investigate whether framing environmental impact ratings in terms of eco-friendliness ("green" framing) versus environmental damage ("grey" framing) influences the NFI.	n = 396 (General population, 42.68% female, mean age = 43.78 ± 14.02 years)	Between-participant	The NFI was observed only in the "green" framing condition, where environmental impact was rated in terms of eco-friendliness. No significant effect was found in the "grey" framing condition. Environmental concern was positively associated with NFI susceptibility in the green condition.
Sörqvist & Marsh (2024)[45]		To examine the role of attribute substitution in the NFI and assess whether environmental friendliness and environmental damage judgments produce different effects.	n = 59 (University students, 70% women, 70% female, mean age = 26.04 ± 7.20 years)	Within-participant	NFI is driven more by attribute substitution than by scale framing, meaning participants rely on simpler heuristics rather than an in-depth evaluation of environmental impact. Environmental friendliness and damage judgments produced similar patterns, contradicting prior research. NFI persisted regardless of whether

Istanbul Gelisim University Journal of Health Sciences (IGUSABDER) is indexed by TUBITAK ULAKBIM TR Index.
Web site: https://dergipark.org.tr/en/pub/igusabder
Contact: igusabder@gelisim.edu.tr

					participants evaluated positive (green) or negative (damage) attributes.
Sörqvist et al. (2022)[46]		To investigate whether spatial (ir)regularity influences the magnitude of the NFI in environmental impact judgments.	n = 160 (18–30 years of aged participants, 65.6% female, mean age = 23.21 ± 3.67 years)	Within-participant	Irregular spatial distribution increased the NFI, as participants relied on perceived numerosity rather than actual quantity when estimating carbon footprint.
Threadgold et al. (2022) [47]	**Experiment a**	To examine individual differences in susceptibility to the NFI, focusing on environmental concerns, compensatory green beliefs, and reflective reasoning.	n = 120 (General population, 40% female, mean age = 36 ± 13 years)	Within-participant	NFI was observed for buildings but not for apples. Susceptibility to the illusion was unrelated to environmental concerns or compensatory green beliefs. Actively open-minded thinking weakly predicted reduced susceptibility to NFI in the buildings condition.
	Experiment b	To replicate and extend experiment 1, testing whether the illusion generalizes to cars and whether a revised CGB scale predicts susceptibility.	n = 269 (General population, 35% female, mean age = 31 ± 11 years)	Within-participant	NFI was observed for buildings and cars but not for apples. Environmental concerns and CGB did not predict susceptibility. Higher actively open-minded thinking scores were associated with reduced NFI susceptibility for buildings and cars.
Sörqvist & Holmgren (2022)[29]		To examine whether the NFI persists when using a ratio scale and whether response time pressure influences the effect.	n = 102 (General population, 70% female, mean age = 34.25 ± 10.94 years)	Mixed-design (both within-participant and between-participant)	The NFI was stronger when estimates were made on an ordinal scale and under time pressure. When using a ratio scale, the illusion was weaker. The effect was also confirmed in a within-participant design, contradicting earlier studies suggesting that it only appears in between-participant designs.
Holmgren, Andersson, Ball, & Marsh (2021)[39]	**Experiment a**	To examine whether summative priming can reduce the NFI in environmental impact judgments.	n = 60 (University students, 63% female, mean age = 28.52 ± 10.04 years)	Between-participant	Participants who were exposed to a summative priming task prior to making environmental impact judgments showed a significant reduction in the NFI compared to the control group. However, limitations in the priming task and potential confounds required further refinement.
	Experiment b	To refine the summative priming method and test its effectiveness across different environmental contexts, addressing the methodological limitations of experiment a.	n = 265 (General population, 67.2% female, mean age = 34.54 ± 11.74 years	Between-participant	Summative priming reduced the NFI, while summative priming strengthened it, confirming that averaging bias underlies the illusion. Improved priming procedures and better control for confounding factors enhanced the reliability and generalizability of the findings.
	Experiment c	To test whether a fully domain-general summative priming task can eliminate the NFI, further refining the methods from experiment b.	n = 319 (General population, 67.4% female, mean age = 34.98 ± 12.39 years)	Between-participant	Summative priming fully eliminated NFI, supporting a domain-general explanation of the effect. Methodological concerns from Experiment b were addressed, demonstrating that priming effects extended beyond specific environmental contexts.
	Experiment d	To assess whether neutral cognitive engagement (non-mathematical priming) is sufficient to eliminate NFI.	n = 102 (General population, 62% female, mean age = 31.56 ± 11.05 years)	Between-participant	A neutral priming task (where participants engaged in non-mathematical reasoning, such as color selection) failed to eliminate NFI, confirming that mathematical reasoning is necessary to override the averaging bias. This suggests that general cognitive engagement alone is not enough to mitigate NFI.
Ateş (2020)[48]		To examine pre-service science teachers' perceptual biases regarding sustainable food consumption and the presence of NFI.	n = 165 (Pre-service science teachers, 64.85% female)	Within-participant	Participants perceived the 'sustainable-addition condition' as having a lower environmental impact than the 'standard menu condition,' despite its objectively higher footprint. NFI persisted across different rating scales, indicating that pre-service science teachers exhibit perceptual biases in sustainable food consumption, even with sufficient environmental knowledge.
MacCutcheon et al. (2020)[28]		To investigate whether individual differences in CGB predict susceptibility to the NFI.	n = 112 (General population, 41.1% female, mean age = 39.4 ± 15.37 years)	Within-participant	Individuals with higher CGB were found to be more susceptible to the NFI, as buildings labeled as 'green' were perceived to reduce the total carbon footprint.
Holmgren et al. (2019)[49]	**Experiment a**	To examine the presence of the NFI in people's mental models of CO_2	n = 20 (University students, 50% female, mean	Within-participant	Participants believed that a high emission period followed by a low emission period contributed less CO_2 to the atmosphere than a high

Istanbul Gelisim University Journal of Health Sciences (IGUSABDER) is indexed by TUBITAK ULAKBIM TR Index.
Web site: https://dergipark.org.tr/en/pub/igusabder
Contact: igusabder@gelisim.edu.tr

		accumulation in the atmosphere.	age = 26.15 ± 4.48 years)		emission period alone, demonstrating the NFI.
	Experiment b	To test whether an averaging bias underpins the NFI in CO_2 accumulation judgments.	n = 47 (University students, 47% female, mean age = 29.32 ± 7.84 years)	Within-participant	Participants estimated the total CO_2 contribution based on the average of emissions rather than the accumulated sum, supporting the role of averaging bias.
	Experiment c	To test whether the NFI in CO_2 accumulation judgments is influenced by symbolic wording in the problem statement.	n = 29 (University students, 21% female, mean age = 25.14 ± 7.84 years)	Within-participant	The NFI persisted even when wording related to sustainability interventions was removed, indicating that the bias is robust to framing effects.
Kusch & Fiebelkorn (2019)[23]		To examine the presence of the NFI and Quantity Insensitivity in environmental impact judgments of meat, vegetarian, and insect burgers.	n = 501 (General population, 48.9% female, mean age = 47.8 ± 16.8 years)	Between-participant	Participants did not differentiate between the environmental impact of a vegetarian or insect burger and a meal without a burger, while a meat burger increased the footprint rating, demonstrating NFI. Quantity insensitivity was observed, as participants reacted only to burger type rather than number. Green consumer values had no significant effect on footprint estimations.
Holmgren et al. (2018) [25]	**Experiment a**	To examine whether the NFI occurs in environmental impact estimates of green and conventional buildings.	n = 90 (University students, 56% female, mean age = 26.31 ± 6.56 years)	Between-participant	Participants estimated the total carbon footprint as lower when green buildings were added to conventional buildings, despite the actual footprint increasing.
	Experiment b	To test whether the NFI is driven by an averaging bias in environmental impact judgments.	n = 79 (University students, 56% female, mean age = 26.33 ± 7.69 years)	Between-participant	Participants estimated the carbon footprint of a mix of green and conventional buildings as the average of their individual estimates rather than the sum, confirming the role of averaging bias in the illusion.
Holmgren et al. (2018)[26]		To investigate whether expertise in energy systems reduces susceptibility to the NFI	n = 55 (22 energy experts (expert group), 33 undergraduate students (novice group), 42% female, mean age = 27.58 ± 6.18 years)	Within-participant	Both experts (energy systems graduates) and novices estimated a lower environmental impact when green buildings were added to conventional buildings, demonstrating the NFI. Expertise did not reduce susceptibility to the bias.
Kim & Schuldt (2018)[24]	**Experiment a**	To examine whether individuals exhibit quantity insensitivity when judging the environmental impact of green vs. conventional products.	n = 370 (Online sample from Amazon Mechanical Turk, 52.2% female, mean age = 40.25 ± 13.58 years)	Between-participant	Participants judged two conventional vehicles as having a greater environmental impact than one, but did not perceive a difference between one and two hybrid vehicles, demonstrating quantity insensitivity for green products.
	Experiment b	To test whether ecological values moderate quantity insensitivity in judgments of environmental impact.	n = 370 (Same sample)	Between-participant	No evidence of moderation was found; individuals with stronger ecological values exhibited the same quantity insensitivity as those with weaker ecological values.
Gorissen & Weijters (2016)[19]	**Experiment a**	To test the existence of the NFI in sustainable food choices.	n = 536 (General population, 48.3% female, mean age = 43.7 ± 12.7 years)	Between-participant	Participants judged meals with an organic side dish to have a lower environmental footprint than the same meal without the side dish, supporting the NFI.
	Experiment b	To examine the effect of different rating scale formats (evaluative vs. quantitative) on the NFI.	n = 580 (General population, 59.3% female, mean age = 40.5 ± 11.5 years)	Between-participant	The illusion persisted regardless of scale format, but color-coded evaluative scales elicited stronger categorical thinking, reinforcing the bias.
	Experiment c	To test whether organic labeling alone can induce the NFI.	n = 219 (University students, 89% female, mean age = 21.4 ± 1.74 years)	Between-participant	The organic-labeled yogurt was rated as having a lower footprint than the same yogurt without the label, suggesting that the illusion is at least partly driven by labeling.
	Experiment d	To determine whether the NFI persists in a within-participant design.	n = 477 (Online sample from Amazon Mechanical Turk, 47.4% female, mean age = 37.2 ± 11.9 years)	Within-participant	The illusion did not appear when participants rated multiple meals in a comparative setting, suggesting that relative comparisons may help mitigate the effect.

Istanbul Gelisim University Journal of Health Sciences (IGUSABDER) is indexed by TUBITAK ULAKBIM TR Index.
Web site: https://dergipark.org.tr/en/pub/igusabder
Contact: igusabder@gelisim.edu.tr

Studies have shown that the NFI arises from systematic cognitive biases that effect how individuals evaluate environmental impacts[23-29,44-49]. Individuals often miscalculate the total environmental impact of products they perceive as sustainable, with various cognitive mechanisms contributing to this misjudgment. Averaging bias[19,24-29,39], framing effect[44], CGB[19,28], quantity insensitivity[23,24], perceptual bias[48], category-size bias[27] and the green halo effect[19,24] are among the key mechanisms underlying NFI.

One of the most common explanations for NFI is averaging bias. When evaluating mixed-content items, individuals tend to make assessments based on the average impact of components rather than considering the total environmental effect. It demonstrated that individuals assess products with both positive and negative attributes by focusing on the average effect rather than summing the impact[22]. In one experiment, participants were presented with scenarios involving items with "virtuous" (morally positive) and "vice" (morally negative) attributes, and their evaluations reflected an averaging tendency rather than a summation of effects. For instance, when a high-calorie meal includes a healthy component (such as a broccoli salad), individuals underestimate the total calorie count, believing that the meal has become significantly healthier. This tendency is also observed in environmental sustainability assessments, making NFI one of the primary cognitive mechanisms shaping individuals' evaluations of environmental impact. Individuals assume that adding a sustainable component to an unsustainable system directly reduces the total impact, leading to systematic miscalculations.

Numerous studies have investigated the relationship between NFI and averaging bias. Gorissen & Weijters have shown that participants systematically underestimate the total carbon footprint of meals containing sustainable accompaniments. Further research by the same researchers showed that non-numerical, colour-coded rating scales increased NFI compared to numerical scales[19]. Holmgren et al. observed in Experiment b that when participants evaluated a combination of eco-friendly and conventional buildings, they displayed an averaging tendency, estimating a lower total carbon footprint than the actual impact[25]. Andersson et al. found that increasing the number of green products within a set strengthens NFI in experiment a. However, Andersson et al. revealed in Experiment b that although individuals did not explicitly perceive green products as having zero carbon emissions, NFI only emerged when a large number of green items were present. In Experiment c, Andersson et al. demonstrated that NFI intensifies with category size, suggesting that category-size bias interacts with averaging bias[27]. Additionally, Holmgren et al. showed in Experiment 2 that individuals rely on averaging heuristics when estimating CO_2 emissions, leading to miscalculations in high-low emission scenarios[49]. The way environmental information is framing effect also plays a crucial role in NFI, as the way information is presented significantly influences individuals' decision-making processes. Gorissen et al. demonstrated that NFI was more pronounced when environmental impact was framed positively ("eco-friendliness") rather than negatively ("harmful effects")[44]. However, Sörqvist & Marsh found no significant difference between framing conditions, suggesting that NFI may not solely result from framing but also from attribute substitution effects[45].

Another major cognitive mechanism contributing to NFI is CGB, which refers to the tendency of individuals to believe that environmentally friendly choices can offset the

Istanbul Gelisim University Journal of Health Sciences (IGUSABDER) is indexed by TUBITAK ULAKBIM TR Index.
Web site: https://dergipark.org.tr/en/pub/igusabder
Contact: igusabder@gelisim.edu.tr

impact of unsustainable ones. MacCutcheon et al. found in Experiment a that individuals with higher CGB levels were more prone to NFI, believing that buildings labeled as 'green' significantly reduced total carbon emissions. Interestingly, environmental concern does not necessarily reduce NFI susceptibility[28]. Threadgold et al. found no significant correlation between environmental awareness and NFI, suggesting that even individuals who actively engage in sustainable behaviors can miscalculate their environmental impact[47]. Similarly, Ateş[48] and Holmgren et al.[26] observed that NFI persisted even among highly educated individuals, highlighting that environmental literacy does not necessarily protect against this illusion. Holmgren et al. further demonstrated that even energy systems experts incorrectly assumed that adding green buildings to a conventional structure reduced total emissions, suggesting that expertise alone does not eliminate NFI[26].

Another factor linked to NFI is quantity insensitivity, where individuals disregard the impact of consumption quantity when assessing environmental effects. Kim & Schuldt found in Experiment a that participants estimated the environmental impact of two conventional vehicles as higher than one but did not perceive a difference between one and two hybrid vehicles, indicating a failure to account for total quantity in their judgments[24]. Similarly, Kusch & Fiebelkorn found that participants underestimated the environmental impact of sustainable ingredients in meals, neglecting the overall consumption volume[23].

Additionally, perceptual biases also play a role in NFI. Sörqvist et al. found that spatial irregularity in visual displays increased NFI by altering perceived numerosity46. Holmgren et al. demonstrated in Experiment a that participants believed a high-emission period followed by a low-emission period contributed less to total CO_2 accumulation than a continuous high-emission period, despite the actual impact being the same[49].

Several studies have explored strategies to reduce the effects of NFI. Holmgren et al. tested summative priming as a strategy to reduce NFI with three experiments, finding that while summative priming decreased NFI, averaging priming reinforced it. These findings suggest that developing cognitive strategies that encourage individuals to focus on summation rather than averaging may help improve environmental impact assessments[39].

Overall, these studies demonstrate that NFI emerges across various contexts and is driven by multiple cognitive mechanisms. These findings highlight the need for greater transparency in sustainability communication and structured information presentation to help consumers make more informed decisions regarding their environmental footprint.

Conclusion

In conclusion, research demonstrates that NFI emerges across various domains and is driven by multiple cognitive mechanisms, including averaging bias, framing effects, compensatory green beliefs, quantity insensitivity, and perceptual distortions. These biases lead individuals to systematically miscalculate their environmental impact, making it more challenging to make truly sustainable choices. To combat NFI, greater

Istanbul Gelisim University Journal of Health Sciences (IGUSABDER) is indexed by TUBITAK ULAKBIM TR Index.
Web site: https://dergipark.org.tr/en/pub/igusabder
Contact: igusabder@gelisim.edu.tr

transparency in sustainability communication is essential. Providing consumers with structured, data-driven sustainability assessments—rather than relying on general eco-labeling—could help improve environmental decision-making and reduce misjudgments related to sustainable consumption.

REFERENCES

1. FAO and WHO. 2019. Sustainable healthy diets – Guiding principles. Rome. https://doi.org/10.4060/CA6640EN
2. Food and Agriculture Organization (FAO). Sustainable Diets and Biodiversity: Directions and Solutions for Policy, Research and Action. Rome, Italy: FAO; Published date 2012. Accessed February 3, 2025. https://www.fao.org/3/i3004e/i3004e.pdf
3. United Nations. World Population Prospects 2019: Highlights. New York, NY: United Nations Department of Economic and Social Affairs; Published date 2019. Accessed February 3, 2025. https://www.un.org/es/desa/world-population-prospects-2019-highlights
4. Food and Agriculture Organization (FAO). Global Agriculture Towards 2050. Rome, Italy: FAO; 2009. December 10, 2025. https://www.fao.org/fileadmin/templates/wsfs/docs/Issues_papers/HLEF2050_Global_Agriculture.pdf
5. Intergovernmental Panel on Climate Change (IPCC). Climate Change and Land: An IPCC Special Report. Geneva, Switzerland: IPCC; 2019. January 10, 2025. https://www.ipcc.ch/srccl/
6. Intergovernmental Panel on Climate Change (IPCC). Global Warming of 1.5°C. Geneva, Switzerland: IPCC; 2021. Accessed November 16, 2025. https://www.ipcc.ch/sr15/
7. British Dietetic Association. The Impact of Diet on Climate Change. Birmingham, UK: BDA Reports; Published date, 2021. Accessed February 3, 2025. https://www.bda.uk.com/resource/the-impact-of-diet-on-climate-change.html
8. Turkish Statistical Institute (TÜİK). Greenhouse Gas Emission Statistics, 1990-2021. Ankara, Turkey: TÜİK; Published date, 2024. Accessed January 10, 2025. https://data.tuik.gov.tr/Bulten/Index?p=Greenhouse-Gas-Emissions-Statistics-1990-2022-53701
9. Liu L, Qu J, Maraseni TN, et al. Household CO_2 emissions: Current status and future perspectives. *Int J Environ Res Public Health*. 2020;17(19):7077.
10. Weitensfelder L, Heesch K, Arnold E, et al. Areas of individual consumption reduction: a focus on implemented restrictions and willingness for further cut-backs. *Sustainability*. 2023;15(6):4956. doi: 10.3390/su15064956.
11. Principato L, Pice G, Pezzi A. Understanding food choices in sustainable healthy diets: a systematic literature review on behavioral drivers and barriers. *Environ Sci Policy*. 2025;163:103975. doi: 10.1016/j.envsci.2025.103975.

12. Campbell-Arvai V, Árvai J, Kalof L. Motivating sustainable food choices: the role of consumer information. *Appetite*. 2012;59(3):661-668. doi: 10.1016/j.appet.2012.08.039.

13. Tilman D, Clark M. Global diets link environmental sustainability and human health. *Nature*. 2014;515(7528):518-522. doi: 10.1038/nature13959.

14. Yassıbaş E, Bölükbaşı B. Evaluation of adherence to the Mediterranean diet with sustainable nutrition knowledge and environmentally responsible food choices. *Front Nutr*. 2023;10:1158155. doi: 10.3389/fnut.2023.1158155.

15. Gazan R, et al. Sustainable diets: a path toward environmental and health improvement. *Nat Sustain*. 2018;1:714-724. doi: 10.1038/s41893-018-0189-6.

16. Korteling JE, Paradies GL, Sassen-van Meer J. Cognitive bias and how to improve sustainable decision making. *Front Psychol*. 2023;14:1007131.

17. Muñoz-Martínez J, Cussó-Parcerisas I, Carrillo-Álvarez E. Exploring the barriers and facilitators for following a sustainable diet: a holistic and contextual scoping review. *Sustain Prod Consum*. 2024;41:327-341. doi: 10.1016/j.spc.2024.03.002.

18. Engler JO, Abson DJ, von Wehrden H. Navigating cognition biases in the search of sustainability. *Ambio*. 2019;48:605-618. doi: 10.1007/s13280-018-01168-5.

19. Gorissen P, Weijters B. The negative footprint illusion: perceptual bias in sustainable food consumption. *J Environ Psychol*. 2016;45:50-56. doi: 10.1016/j.jenvp.2015.11.009.

20. Sánchez-Bravo G, Villena-Escribano M, Rivera-Torres MP, et al. Consumers' attitude towards the sustainability of different food categories. *Foods*. 2020;9(11):1608.

21. Vries J. Public communication as a tool to implement environmental policies. *Soc Issues Policy Rev*. 2019;13(1):61-88. doi: 10.1111/sipr.12061.

22. Chernev A, Gal D. Categorization effects in value judgments: averaging bias in evaluating combinations of vices and virtues. *J Mark Res*. 2010;47(4):738-747.

23. Kusch S, Fiebelkorn F. Environmental impact judgments of meat, vegetarian, and insect burgers: unifying the negative footprint illusion and quantity insensitivity. *Food Qual Prefer*. 2019;78:103731. doi: 10.1016/j.foodqual.2019.103731.

24. Kim B, Schuldt JP. Judging the environmental impact of green consumption: evidence of quantity insensitivity. *J Environ Psychol*. 2018;60:122-127.

25. Holmgren M, Andersson H, Sörqvist P. Averaging bias in environmental impact estimates: evidence from the negative footprint illusion. *J Environ Psychol*. 2018;55:48-52.

26. Holmgren M, Kabanshi A, Marsh JE, Sörqvist P. When A + B < A: cognitive bias in experts' judgment of environmental impact. *Front Psychol*. 2018;9:823.

27. Andersson H, Holmgren M, Sörqvist P, et al. The negative footprint illusion is exacerbated by the numerosity of environment-friendly additions: unveiling the

underpinning mechanisms. *J Cogn Psychol*. 2024;36(2):295-307. doi: 10.1080/20445911.2024.1234567.

28. MacCutcheon D, Holmgren M, Haga A. Assuming the best: individual differences in compensatory "green" beliefs predict susceptibility to the negative footprint illusion. *Sustainability*. 2020;12(8):3414. doi: 10.3390/su12083414.

29. Sörqvist P, Holmgren M. The negative footprint illusion in environmental impact estimates: methodological considerations. *Front Psychol*. 2022;13:990056.

30. Camilleri AR, Larrick RP, Hossain S, Patino-Echeverri D. Consumers underestimate the emissions associated with food but are aided by labels. *Nat Clim Change*. 2019;9(1):53-58.

31. Sundar A, Kardes FR. The role of perceived variability and the health halo effect in nutritional inference and consumption. *Psychol Mark*. 2015;32(5):512-521.

32. Steenis ND, Van Herpen E, Van Der Lans IA, Ligthart TN, Van Trijp HC. Consumer response to packaging design: the role of packaging materials and graphics in sustainability perceptions and product evaluations. *J Clean Prod*. 2017;162:286-298.

33. Lazzarini GA, Visschers VH, Siegrist M. How to improve consumers' environmental sustainability perception of food products: The effectiveness of different types of eco-labels. *Food Quality and Preference*. 2018;68:215-223.

34. Chernev A. The dieter's paradox. *J Consum Psychol*. 2011;21(2):178-183.

35. Sörqvist P, Langeborg L. Why people harm the environment although they try to treat it well: an evolutionary-cognitive perspective on climate compensation. *Front Psychol*. 2019;10:434719. doi: 10.3389/fpsyg.2019.00434.

36. Sorrell S. The rebound effect: definition and estimation. In: Evans J, Hunt L, eds. *International Handbook on the Economics of Energy*. Cheltenham, UK: Edward Elgar Publishing; 2009:199-233.

37. Chitnis M, Sorrell S, Druckman A, Firth SK, Jackson T. Turning lights into flights: estimating direct and indirect rebound effects for UK households. *Energy Policy*. 2013;55:234-250. doi: 10.1016/j.enpol.2012.12.008.

38. Grabs J. The rebound effects of switching to vegetarianism: a microeconomic analysis of Swedish consumption behavior. *Ecol Econ*. 2015;116:270-279.

39. Holmgren M, Andersson H, Ball LJ, Marsh JE. Can the negative footprint illusion be eliminated by summative priming? *J Cogn Psychol*. 2021;33(3):337-356.

40. White K, Habib R, Hardisty DJ. How to SHIFT consumer behaviors to be more sustainable: A literature review and guiding framework. *J Mark*. 2019;83(3):22-49.

41. Xie P, Zhang Y, Chen R, Lin Z, Lu N. Social media's impact on environmental awareness: a marginal treatment effect analysis of WeChat usage in China. *BMC Public Health*. 2024;24(1):3237. doi: 10.1186/s12889-024-12337-5.

42. Ge J, Scalco A, Craig T. Social influence and meat-eating behaviour. *Sustainability*. 2022;14(13):7935. doi: 10.3390/su14137935.

43. Kaklamanou D, Jones CR, Webb TL, Walker SR. Using public transport can make up for flying abroad on holiday: Compensatory green beliefs and environmentally significant behavior. *Environ Behav*. 2015;47(2):184-204. doi: 10.1177/0013916513488784.

44. Gorissen K, Weijters B, Deltomme B. Green versus grey framing: Exploring the mechanism behind the negative footprint illusion in environmental sustainability assessments. *Sustainability*. 2024;16(4):1411. doi: 10.3390/su16041411.

45. Sörqvist P, Marsh JE. Conceptual and methodological considerations to the negative footprint illusion: A reply to Gorissen et al. (2024). *J Cogn Psychol*. 2024;36(8):954-963.

46. Sörqvist P, Volna I, Zhao J, Marsh JE. Irregular stimulus distribution increases the negative footprint illusion. *Scand J Psychol*. 2022;63:530-535. doi: 10.1111/sjop.12833.

47. Threadgold E, Marsh JE, Holmgren M, Andersson H, Nelson M, Ball LJ. Biased estimates of environmental impact in the negative footprint illusion: The nature of individual variation. *Front Psychol*. 2022;12:648328. doi: 10.3389/fpsyg.2021.648328.

48. Ateş H. Pre-service science teachers' perceptual biases regarding sustainable food consumption: Negative footprint illusion. *Int J Res Educ Sci*. 2020;6(4):599-612.

49. Holmgren M, Kabanshi A, Langeborg L, et al. Deceptive sustainability: Cognitive bias in people's judgment of the benefits of CO2 emission cuts. *J Environ Psychol*. 2019;64:48-55.

Istanbul Gelisim University Journal of Health Sciences (IGUSABDER) is indexed by TUBITAK ULAKBIM TR Index.
Web site: https://dergipark.org.tr/en/pub/igusabder
Contact: igusabder@gelisim.edu.tr