

Designing Food Recommender Systems: Integrating Digital Nudging and Theory of Planned Behaviour for Green and Healthy Dietary Choices Among University Students

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ABSTRACT

The global escalation in animal-source food consumption presents significant challenges to human health and environmental sustainability. This study addresses the pressing need for healthier and more sustainable dietary practices among university students who face unique challenges in maintaining a balanced diet. Leveraging insights from the Theory of Planned Behaviour and Nudging Theory, our research aims to study a food recommender interface tailored to the needs of university students and accompany them to a healthier and greener diet habit. Specifically, we investigate strategies to influence attitudes, subjective norms, and perceived behavioural control using nudging mechanisms, as well as the impact of different nudges embedded within the app interface on students' choices between meat-based and plant-based meals. Through literature review, conceptual mapping, and an empirical study using a structured interview, we aim to bridge the gap between technology and human behaviour, ultimately promoting healthier and more sustainable eating habits among university students.

Additional Key Words and Phrases: food recommender, university student, The Theory of Planned Behaviour, Nudge theory, human-centric, sustainable food consumption.

1 INTRODUCTION

The escalation of global animal-source food consumption, driven by industrialization, improved welfare, and population growth, poses significant challenges for human health and environmental sustainability. Despite their nutritional value, overconsumption of red and processed meat is linked to various health risks, including mortality, cancer, cardiovascular diseases, and type 2 diabetes [1][34]. Additionally, the production of animal-source foods contributes substantially to environmental degradation, including greenhouse gas emissions, water depletion, and biodiversity loss [34]. The Netherlands is not an exception. Therefore, the Dutch Health Council advocates shifting towards a plant-based diet with fewer animal-source foods to address health and environmental concerns [20]. In the context of Dutch university students, maintaining a healthy diet is particularly challenging. Emerging adulthood, marked by significant transitions in lifestyle and circumstances, is associated with an increased risk of weight gain and obesity, attributed to various barriers [28][31]. These obstacles include limited knowledge and information, a perceived lack of time for cooking and planning, and a lack of support systems to facilitate informed dietary choices [13]. However, with adequate knowledge and instruction, this transition period also presents an opportunity for changing eating habits [8] that can persist into adulthood.

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Life transitions, such as moving house, offer a window of opportunity for reducing meat consumption among young adults, with changes in social environments and increased independence playing pivotal roles [31]. Moreover, interventions focused on nutrition education and self-regulation strategies show promise in improving university students' dietary habits [9].

To address these challenges and opportunities, developing a food recommender system tailored to the needs of university students is imperative. However, existing technology often fails to engage users effectively due to a lack of human-centric design. In the era of Industry 5.0, technology should not only be advanced but also considerate of human needs and behaviours. Leveraging psychological insights can be instrumental in driving behaviour change and facilitating the adoption of healthier and more sustainable eating habits among university students [26].

University students, who often live alone, perceived eating alone as a chore instead of a joy [13] underscores the importance of personalized interventions tailored to individual needs, which are essential for promoting healthier eating habits in this demographic. The Theory of Planned Behaviour [2] provides a strong base on dietary behaviour and sustainable consumption [7][18], giving valuable insights into designing behaviour modification interventions.

Besides, Nudge Theory [4] offers a promising framework for designing choice architectures that steer individuals towards better decisions without imposing a specific outcome on the user [30], which aligns with the nature of a personalized system. However, despite the potential of these theories, interdisciplinary research in this area is lacking. Therefore, a new path for research is unveiled where behaviour can be the foundation of recommendation systems, and nudging strategies can be leveraged to guide the user based on such understanding of the behavioural model.

1.1 Objective and Research question

This research aims to bridge the gap between technology and human behaviour by exploring the Theory of Planned Behaviour and Nudge theory in the context of food recommender systems for university students. Therefore, it is important to first understand the baseline Theory of Planned Behaviour's components' potential associations with different nudging mechanisms in the realm of healthy and sustainable food recommender systems for university students.

This leads to the following research questions:

- **RQ:** Which nudging strategies can influence university students' attitudes, subjective norms, and perceived behavioural control regarding meat consumption?

2 METHODOLOGY

This research employs several methods to explore digital nudging strategies that can influence university students' dietary behaviour.

2.1 Literature review

A literature review will be conducted to evaluate the applicability and navigate potential applications of the Theory of Planned Behaviour (TPB) and Digital Nudging.

2.2 Conceptual Map

A conceptual map exercise will be undertaken to organize and synthesize the findings from Literature Review. This mapping will assist in sketching the relationships between different nudging strategies and their effects on attitudes, subjective norms, and perceived behavioural control, providing a structured framework for further analysis.

2.3 Evaluation Methodology: Structured Interview

2.3.1 Participant. The study involved 22 university students (n=22) in the Netherlands, aged between 18 and 25, who cook and eat alone. We specifically chose non-vegan participants since they have not adopted the desired dietary practices.

2.3.2 Procedure. Using an interview invitation poster, participants were recruited through online messages and onsite. The interviews were conducted both online and offline, with each session lasting between 30 and 45 minutes. The structured interview comprised open-ended questions divided into four main sections: preliminary questions, attitudes, subjective norms, and perceived behavioural control towards a sustainable diet. Preliminary questions focused on the frequency of meat and plant-based meal consumption, opinions on (1) plant-based and meat-based diets, (2) the influence of social and cultural factors on their dietary choices, and (3) challenges in preparing healthy and sustainable meals.

The main section of the interview presented scenario-based questions involving digital nudges. The imagined scenario gave the participant a canvas of detailed and relatable contexts, aiming to elicit insights into how specific digital nudging mechanisms could affect their dietary choices in realistic settings. Participants were asked to reflect on these scenarios and consider how the presented nudging feature might influence the corresponding TPB's component regarding meat consumption and plant-based diets. For example, Question 1 provides a scenario: "*You are browsing a recipe-recommending app and come across two recipes: one for a beef burger and one for a soy-based burger. The app shows a side-by-side comparison of the environmental impacts of both protein options (Figure 1).*". Then, the question follows: "*Looking at this comparison of the environmental impacts, how does this information influence your interest in the environmental impact of the food you choose? And how does this influence your attitude towards choosing the chickpea burger over the beef burger? Why?*".

2.4 Analysis

The qualitative data was analyzed using thematic analysis, following the 6-phase framework by Braun and Clarke [5]. This method provided a reliable framework to evaluate the nudging mechanisms that impacted participants' attitudes, subjective norms, and perceived behavioural control regarding their dietary choices. Moreover, it reveals the underlying themes that determine the result, allowing

for a deeper understanding of the effectiveness of specific nudging strategies on TPB components.

3 LITERATURE REVIEW

The literature review employed a strategic search combining various keywords with fixed strings as "(university OR college OR higher education)", "(student OR young adult OR emerging adult)", "(diet* OR eat*) AND (behaviour* OR habit*)", "Netherlands", "meat" and explicit strings like "(The Theory of Planned Behaviour OR TPB)", "(Digital OR mobile) nudg*". From Google Scholar and Science Direct, papers that met the inclusion criteria were selected. Although the research aimed to focus on the Netherlands demographic, studies from other European countries with similar settings were also accepted. Similarly, while the primary focus was on university students, sources that mentioned young adults were included to provide a comprehensive understanding of the subject.

3.1 The Theory of Planned Behaviour

Our investigation began with an in-depth examination of the Theory of Planned Behaviour to validate its relevance and applicability in the context of sustainable and healthy food consumption. We then identified potential factors that hinder or accelerate interventions aimed at reducing meat consumption, focusing on those that impact attitudes, subjective norms, and perceived behavioural control regarding animal-based intake.

3.1.1 Theoretical Framework: The Theory of Planned Behaviour. The Theory of Planned Behaviour (TPB), formulated by Icek Ajzen[2], is a widely recognized model for predicting and understanding human behaviour in various contexts. TPB posits that an individual's intention to perform a behaviour is the most significant predictor of that behaviour. This intention is influenced by three components: (1) attitudes, (2) subjective norms, and (3) perceived behavioural control (PBC). Attitudes play a crucial role in dictating the individual's perception of the outcome of their action. A positive attitude towards healthy eating or sustainable consumption will likely lead to the desired behaviour. Besides, subjective norms refer to the social pressure individuals feel to engage in or avoid a behaviour influenced by the expectations of significant others like family and friends. If an individual's social circle values sustainable consumption, this pressure can increase their intention to adopt such behaviours. Perceived behavioural control (PBC) involves the individual's perception of their ability to perform the behaviour. High PBC, driven by knowledge, resources, and confidence, enhances the likelihood of the individual carrying out the behaviour, as they feel capable of overcoming potential barriers.

3.1.2 The Theory of Planned Behaviour in Predicting Food Choices and Sustainable Consumption. Several studies have proven that TPB could be an effective predictor of predicting food choices [16][18][24]. Notably, van't Riet et al.[32] found that reducing meat consumption is more effective during disruptions of eating habits.

The TPB framework has also been recognized as a useful model for understanding sustainable consumption patterns. For instance,

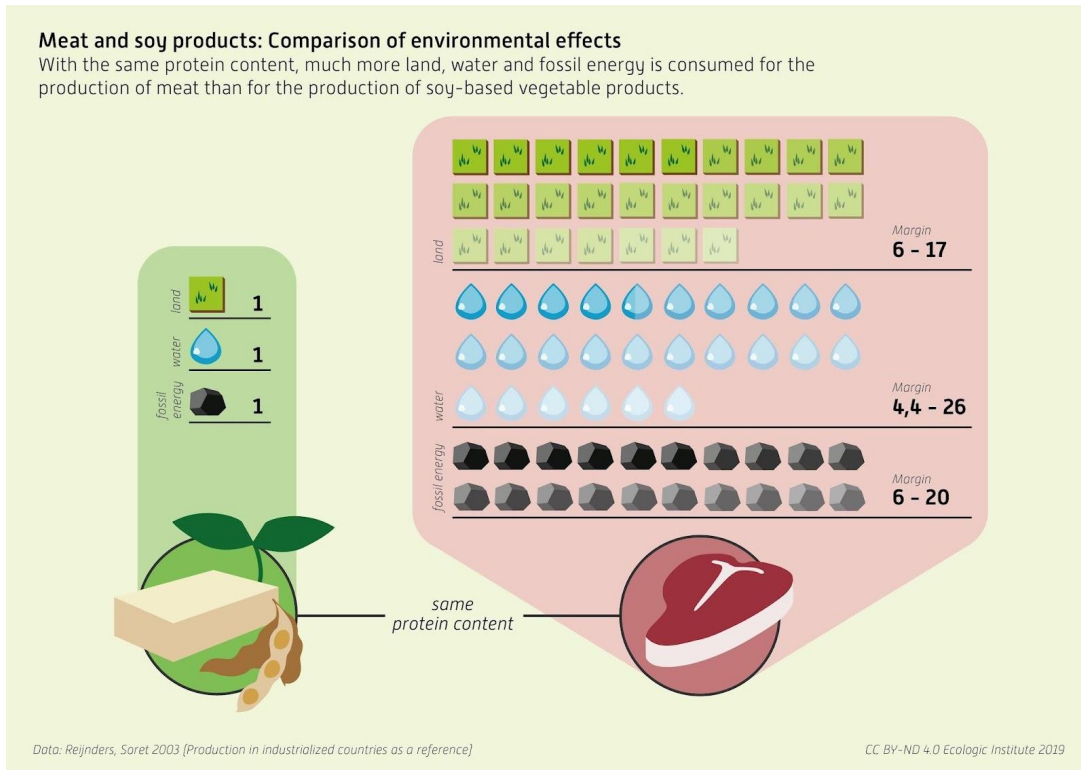


Fig. 1. Example infographic for interview. Source: Ecologic Institute 2019: Meat and Soy Products: Comparison of environmental effects. Infographic. [36]

research by Iris Vermeir and Wim Verbeke [33] highlighted the robustness of TPB in predicting sustainable food consumption among young adults in Belgium. This finding is consistent with Coker and Linden’s [7] study on pro-environmental behaviours by reducing meat intake.

3.1.3 The Theory of Planned Behaviour and University Students Dietary Behaviour: Barriers, Enablers, and Strategies. University students, most of whom are fresh out of the comfort of their homes, face challenges in maintaining sustainable and balanced diets. The papers by van Den Berg et al. [31], Kolb and Diehl [13], and Dutch National Institute for Public Health and the Environment (RIVM) [12] identify the blockades and facilitators to reduce animal-derived consumption and suggest strategies to achieve a healthier and greener diet in the Netherlands or the nearby country, Germany. Here, factors which fit into the characteristics of one of the TPB components are identified and discussed.

Interest in the environment, animal welfare, and health highlighted by the first paper [31], influences the attitude to explore a plant-based diet. Young adults with an increased awareness of environmental and animal welfare or health acknowledge the benefits of reducing meat consumption and tend to be open to plant-based recipes [3][37], implying the need for intervention strategies to promote awareness of such factors to the users.

Simultaneously, social influence occurs as a recurrent theme in determining food choice, aligning with the subjective norms component. Perceived cultural and social norms around meat consumption reinforce culinary decisions [12][31]. The belief that meat consumption is natural or lacks social acceptance are barriers that prevent lower meat intake. Contrarily, close circle’s (e.g. friends and family) interest in health and/or ecological well-being and dynamic norms could steer individuals in better dietary habits [31]. Scalco et al. [25] targeted subjective norms for reducing meat intake and found that norm-based messages about healthful and sustainable consumption within the social networks positively influence meat consumption behaviours in the workplace. Additionally, Sparkman and Walton [27] and Lindsey [15] studies indicate that dynamic norm related to meat consumption significantly influence subjective social norms regarding meatless meals or fruit and vegetable consumption.

Additionally, Perceived behavioural control (PBC) encompasses factors like knowledge to identify meat-derived alternatives or healthy eating, time management, and financial constraints that significantly impact students’ ability to make healthy and ecologically friendly dietary choices. Limited knowledge about plant-based alternatives to prepare such meals is a common barrier [13][31], emphasizing the need to lower the perceived difficulty in these aspects. Increased awareness of plant-based meat alternatives and their benefits can improve individuals’ confidence in adopting a plant-based

diet [3]. Moreover, Wyker et al. [37] addresses the concerns surrounding nutrient insufficiency in plant-based diets. It underscores the need to enhance knowledge about maintaining a nutritious plant-based diet, boosting users' belief in dietary choices. Neufingerl & Eilander [19] suggest that informed dietary choices regarding health are essential to guide and facilitate behaviour change, aiding the population's transition to a nutritionally balanced plant-based diet. Time perception is also a hindrance. Most emerging adults perceive time constraints as an obstacle leading to unhealthy food consumption behaviour. Nevertheless, many appear to be able to maintain a balanced diet despite a low time budget. Interventions focused on time management strategies to achieve time demands are important [23]. Financial constraints also pose a challenge in adopting a more sustainable diet [13]. Feher et al. [11] articulated that cost savings of plant-based diets compared to meat-based diets can positively influence perceived behavioural control regarding dietary choices.

Understanding TPB's core components and validating its predictive power in food choices and sustainable consumption behaviour is essential for identifying key factors influencing food choices. By focusing on attitudes, subjective norms, and perceived behavioural control, this research can pinpoint the niche psychological and social factors that affect university students' dietary behaviours, reducing the heuristic for nudging targets and providing a robust framework for designing effective nudging interventions.

3.2 Digital Nudging in Food Behaviour Domain and Recommender Systems

Nudge theory, particularly digital nudging, is reviewed to explore its relevance in promoting healthy and sustainable diets. This included an overview of digital nudging applications within food recommendation systems, through which we identified specific nudging categories and potential mechanisms that could effectively influence dietary behaviour.

3.2.1 Nudge Theory, Digital Nudging, and Food Behaviour Domain. Nudge theory [29] presented that there exists a "choice architecture" in which all the external forces may subtly guide the users' decision while maintaining the freedom of choice [30]. In the field of dietary behaviour, Nudge theory has demonstrated its potential in promoting healthy food choices. The study on *The efficacy of nudge theory strategies in influencing adult dietary behaviour* [4] in developed countries found that nudging strategies increased healthier dietary choices. Similarly, nudging interventions that aim to increase fruit and/or vegetable consumption are proven effective [6]. Meske and Potthoff defined digital nudging as a "*subtle form of using design, information and interaction elements to guide user behaviour in digital environments, without restricting the individual's freedom of choice.*".

3.2.2 Digital Nudging and Food Recommender Systems. In the context of food recommendation systems, digital nudging can be employed to promote healthier eating habits. A typical food recommender system might learn a user's preference for certain types of unhealthy food. To nudge the user towards healthier choices, the

system can instead highlight healthier options within the recommendation list, even if these are not the top-ranked items based on past preferences [14]. This approach leverages nudging mechanisms such as increasing the salience of healthier options and positioning them prominently to guide user choices [14]. The paper by Jesse and Jannach [14] also formulated a taxonomy of nudging mechanisms, in which, the Decision Information and Social Decision Appeal categories will be discussed in this paper.

The Decision Information category involves changing the information shown to the decision-maker without altering the options. Such changes can include increasing the salience of the provided information or reframing the description of the options. For example, providing nutritional benefits ensures that users are more aware of the healthier choices available, subtly guiding their decisions towards better eating habits without limiting their freedom of choice. Similarly, the Social Decision Appeal category changes the information presented to users, however, focusing on the emotional and social implications of the change. This category of nudging mechanisms leverages the power of social proof, aligning with the values of Subjective Norms.

Moreover, other research investigated the use of different nudging mechanisms in the realm of recommender systems. For instance, the Cora conversational recipes recommender system revealed that explanations generally enhance the user experience, indicating that explain justifications in recommender systems can positively influence users' perceptions. [22]. It has also been found that employing nutrition labels, such as Multiple Traffic Light labels (e.g. Nutri-Score), did not significantly moderate the unhealthiness of choices in personalised contexts. However, these labels reduced choice difficulty in personalised recipes, making decision-making easier [10]. Furthermore, the effectiveness of digital nudges is moderated by perceived choice difficulty, indicating that a non-confusing, unambiguous decision environment is more effective at facilitating healthy eating goals [10].

Digital nudging is crucial for health and sustainability promotions in recommender systems. This part aims to pinpoint and harness effective digital strategies to influence and improve dietary behaviours among university students by integrating specific nudging categories and mechanisms into food recommendation systems.

3.3 Contribution

Despite these insights, the application of TPB and digital nudging in food recommender systems remains limited. Most studies have focused on algorithmic aspects rather than interface features applications of food recommendations, or they do not target the college students/young adult population. Also, many nudge strategies have not been examined in the recommendation system [14].

TPB and digital nudging each have their advantages and setbacks. TPB provides a robust theoretical framework to understand and predict behaviour changes by examining attitudes, subjective norms, and perceived behavioural control. Digital nudging leverages subtle design and interface cues to influence user behaviour in digital environments. By merging these fields, the research harnesses the

predictive power of TPB to design targeted nudges that can effectively alter user intentions and behaviours. This interdisciplinary strategy not only enhances the theoretical understanding of behaviour change mechanisms but also offers practical solutions for improving the effectiveness of food recommender systems in promoting healthier and more sustainable eating habits.

Therefore, the research aims to address this discrepancy by integrating digital nudging techniques into personalized food recommender systems to encourage healthier eating behaviours based on the TPB model. By evaluating various mechanisms and their impact on user choices, this study seeks to develop effective strategies for promoting healthy/sustainable food choices in a personalized and user-friendly manner.

4 CONCEPTUAL MAPPING: DIGITAL NUDGING STRATEGIES AND TPB COMPONENTS

This study aims to identify and evaluate effective nudging mechanisms to influence students' dietary choices towards healthier and more sustainable options. To achieve this, specific questions were first formed to identify the appropriate nudging mechanisms outlined in Jesse and Jannach's paper [14]. These questions were designed to align with the factors shaping students' behaviours and the corresponding components of the Theory of Planned Behavior (TPB). For example, "*Which nudging mechanisms are suitable to increase interest in the environment and animal welfare to give the user a more positive attitude toward changing to a more sustainable diet?*"

Next, the nudging mechanisms stated in Jesse and Jannach's paper [14] were evaluated and mapped with the appropriate factors and TPB components. This evaluation involved consulting the mechanisms in the section on digital nudging in the food behaviour domain and recommender systems. By systematically aligning each nudging mechanism with specific TPB components, the chosen interventions were designed to address the identified behavioural factors effectively.

The proposed strategies are based on several assumptions. Firstly, it is assumed that the social norm is shifting towards reducing meat consumption. Findings from *Natuur & Milieu* support this [17], which indicates that the majority of Dutch adults believe eating less meat will become the norm. Secondly, it is assumed that the trend of plant-based products becoming cheaper than conventional meat-based ingredients will positively influence perceptions of plant-based meal costs. This is supported by data indicating a decrease in the price of plant-based products compared to meat [35]. Communicating this trend is expected to enhance the perceived affordability of plant-based meals.

4.1 Conceptual mapping

4.1.1 Nudging mechanisms categories. The nature of Decision Information strategies allows them to shape users' attitudes and perceived behaviour control by making information more prominent and making informed choices more straightforward. This approach leverages the power of salience and clarity, presenting users with insights about the impacts of their choices. Decision Information

interventions can also reduce the cognitive load on users, making the decision-making process more manageable. This is particularly relevant in contexts where users need to balance health, environmental concerns, and practical constraints such as time and cost.

The use of the Social Decision Appeal category is highly relevant for promoting healthy and sustainable choices within the TPB framework. Mechanisms in this category utilize social proof and emotional engagement to shift perceptions of acceptable behaviour. By making these choices appear more common and socially endorsed, these mechanisms can effectively inspire and motivate individuals to adopt similar behaviours, thereby aligning with and reinforcing subjective norms within their social groups.

4.1.2 Nudging mechanisms and Factors mapping. The conceptual mapping between nudging mechanisms and the TPB components is critical for understanding how different interventions influence behaviour. For Attitude, nudging mechanisms such as "Give Comparative" and "Providing Explanations" can significantly shape attitudes towards interest in the environment and animal welfare. "Give Comparative" helps users see the relative benefits of plant-based options compared to meat, thereby enhancing their interest in environmental and animal welfare issues. "Providing Explanations" can reinforce this by educating users about the positive impacts of their dietary choices on the environment and animal welfare, similar to Cora's exemplary [22]. Likewise, providing comparative information and detailed explanations can foster a greater interest in health. When users are presented with clear comparisons between the health benefits of plant-based diets versus meat-based diets, along with explanations of these benefits, their attitudes towards healthier eating are positively influenced.

For Subjective Norms, the "Social Reference Points" mechanism plays a crucial role. By highlighting what peers and social groups are doing and sharing stories using norm-based messages [25][27] that evoke empathy, individuals are more likely to perceive these behaviours as normative and feel social pressure to conform. "Social Influence" through comparison can instigate empathy and shift subjective norms regarding health. When individuals see their peers making healthier choices and emotionally engaging through empathy-driven narratives, these healthy behaviours become more socially endorsed. Additionally, social influence through comparisons can alter perceptions of cultural and social norms about meat consumption. By showing trends and behaviours in social groups, individuals can begin to perceive plant-based eating as more culturally acceptable and normative.

For Perceived Behavioral Control, providing comparative information and explanations can enhance perceived control by increasing knowledge about plant-based meat alternatives [22]. When users are informed about the benefits and options available for plant-based alternatives, they feel more capable of making these choices. The distinction between simplified and detailed also facilitates different forms of communication that complement each other. The "Simplification" mechanism (e.g. using labels) will reduce the difficulty of decision-making. Meanwhile, detailed insights help deepen the user's understanding. Similarly, giving comparative information

and detailed explanations about healthy eating options can increase users' perceived control over their dietary choices (e.g. address nutrient concerns and dietary choices) [37][19]. Perceived control over preparing healthy meals can be improved by increasing the salience of time-saving attributes. Highlighting quick and easy time-related attributes in recipes assures users of their ability to prepare healthy meals despite time constraints with low heuristics. Additionally, increasing the salience of cost-effective attributes and providing comparative cost information can alleviate financial concerns [11]. These nudges display cost-effective, healthy options that the users might not know about, enhancing perceived control over cooking healthy dietary choices without financial strain.

Moreover, comparative cost information can alleviate financial concerns [11]. Therefore, increasing the salience of cost-effective attributes of favourable options can enhance perceived control over cooking healthy dietary choices without financial strain. Table 1 summarizes the mapped Nudging Mechanisms corresponding to TPB components and Factors.

5 RESULT

5.1 Attitudes

5.1.1 Interest in the environment and animal welfare. Overall, the nudging mechanisms "Give Comparative" and "Providing Explanations" influenced students' attitudes towards meat consumption by heightening awareness of environmental and animal welfare impacts, although with some uncertainties. These mechanisms evoked emotional responses such as guilt and motivation. There were also indications of change in attitudes. For example, some participants indicated, "*Making a plant-based burger seems more ecologically efficient. It changes my attitude towards my meat consumption.*" or "*My attitude towards the veggie burger becomes a bit more positive.*". However, the influence of these mechanisms is moderated greatly by scepticism, taste preferences, health priorities, and initial level of interest. While "Give Comparative" raises ecological awareness in the participants who do not have prior knowledge regarding their food's environmental consequences or reinforce the knowledge, its lack of depth creates scepticism. One interviewee expressed suspicion towards the measurement validation of the information, saying that if the source is credible and open for validation, it will lower the doubt. In the "Providing Explanations" case, the absence of source references raises credibility concerns as it contains unverified textual and long-form information. Furthermore, the initial level of interest also has a big impact. Participants who reported that environmental and animal welfare is unimportant to them have minimal to no change in interest and attitude, placing higher importance on taste and health. This kind of nudge could also provoke resistance, as implied in one student's sentiment, "*I would still choose the beef burger, even if it damages the environment significantly more.*".

5.1.2 Interest in health. Similarly, "Give Comparative" and "Providing Explanations" provoked health consciousness. Both mechanisms highlighted the health benefits of plant-based meals compared to meat-based ones, nudging students to consider healthier options. Participant 19, for example, expressed feeling more confident in choosing a chickpea burger after learning about its cardiovascular

benefits. Moreover, the comparative information led to a notable change in attitude towards plant-based diets, with a more positive attitude towards choosing plant-based options. However, they suffer from the same problems, such as a lack of trust and taste preferences.

5.2 Subjective Norms

5.2.1 Social group's interest in the environment and animal welfare. The "Social Reference Point" mechanism is effective regarding subjective norms. Knowing that peers or family members had chosen plant-based diets positively influenced students' perceptions of meat consumption relating to ecological reasons. However, the degree of influence fluctuates, with some participants stating little to no change due to doubt about the actual generalization of the norm based on a small sample.

5.2.2 Social group's interest in health. The "Social Influence (Comparison)" nudge also impacted subjective norms regarding health. Close-circle influences were profound, encouraging students to heighten awareness of healthier eating habits. For instance, a person remarked, "*I would probably become more aware of what I eat because everyone around me also is becoming more aware.*". Participants reported the feeling of "*inspiration*", "*curiosity*", "*feeling behind*", or even "*a slight sense of competition*". Moreover, a participant remarked that this could be a good medium to start discussions regarding health among friends and family. However, the effectiveness of this approach is contingent on a certain magnitude, as one interviewee noted, "*quantity matters*". Also, this mechanism might face resistance due to other mediating priorities or skepticism. For example, "*I don't think this would affect me; not everything everybody says online is true about themselves.*".

5.2.3 Perceived cultural and social norms about meat consumption. The analysis reveals that social influence through comparison had minimal effect on subjective norms around meat consumption. The scenario provided the interviewee with a graph of decreasing meat consumption trends in all age and gender groups in the Netherlands, giving an overview of the broader social dynamic. Nearly half of the participants expressed that knowing the general trend in the Netherlands would not change their opinion, whether on norm or behaviour. A student, for instance, acknowledged the changing social dynamic towards meat consumption but indicated that "*Statistics does not really make up my opinion. The people around me have way more influence than numbers.*".

5.3 Perceived Behaviour Control (PBC)

5.3.1 Knowledge about plant-based alternatives. The "Simplification" and "Providing Explanations" strategies were positively received, with participants commenting that the described features would help them in their decision-making process. For "Simplification", students were presented with a set of simple and easy-to-grasp informational cues inspired by Open Food Fact [21] representation, such as Multiple Traffic Light labels and a short nutritional/ecological level summary. This type of display was helpful in briefly educating and increasing self-efficacy perception over knowledge about plant-based alternatives. Nevertheless, the labels

TPB Components	Factor	Nudging Mechanism
Attitude	Interest in the environment and animal welfare	Give Comparative Providing Explanations
	Interest in health	Give Comparative Providing Explanations
Subjective Norms	Social group’s interest in the environment and animal welfare	Social reference point
	Social group’s interest in health	Social Influence (Comparison)
	Perceived cultural and social norms about meat consumption	Social Influence (Comparison)
Perceived Behavioural Control	Knowledge about plant-based alternatives of meat	Give Comparative
		Simplification
		Providing Explanations
	Knowledge about healthy eating	Give Comparative Providing Explanations
	Time-wise perceived control	Increase Saliency of Attribute
	Financial-wise perceived control	Increase Saliency of Attribute
Give Comparative		

Table 1. Nudging Mechanisms Corresponding to TPB Components and Relevant Factors

received mixed responses, in which health/ecological conscious participants expressed less regard for this component than the other. Detailed explanations about the benefits and usage of various plant-based alternatives positively impacted participants’ perceived behavioural control and confidence towards sustainable eating. They found the in-depth knowledge educational and motivating, although a minority indicated an insignificant influence over perceived knowledge due to information overload.

On the other hand, the "Give Comparative" strategy did not significantly enhance perceived behavioural control. While some participants found nutritional and ecological comparisons compelling, others felt overwhelmed by the volume of information. Furthermore, these strategies could not address the concern over perceived control to perform the desired behaviour. Therefore, the assessment of the strategies reported minimal impact on PBC.

5.3.2 Knowledge about healthy eating. In the context of improving knowledge about healthy eating, "Give Comparative" and "Providing Explanations" received mixed responses. While students valued nutritional education and informed dietary choices, many reported information fatigue. This led to resistance to using such features, especially for the "Providing Explanations" mechanism. Some also mentioned other factors, like initial interest in health, taste preference, and availability. Similar to the previous factor, these interventions did not show signs of addressing PBC.

5.3.3 Time-wise perceived control. In this context, the "Increase Saliency of Attribute" mechanism aimed to improve perceived control over preparing healthy meals within time constraints. Many students reported facing barriers due to limited time. By highlighting recipes based on preparation time, this approach effectively addressed time-related barriers. Students particularly appreciated the convenience of quick recipe recommendations, finding them

helpful in managing their time while maintaining a healthy diet.

5.3.4 Financial-wise perceived control. Underscoring the saving costs associated with plant-based meals/ingredients options through the "Increase Saliency of Attribute" and "Give Comparative" mechanisms positively influenced the students’ perception of plant-based affordability. By emphasising the financial benefits or comparing the costs of meat-based meals with plant-based alternatives, these methods positively influenced respondents’ perceptions, especially those who initially thought plant-based options were more expensive. These approaches made plant-based diets seem more accessible and affordable. However, the effectiveness of these mechanisms varied due to mediating factors such as health priorities, source credibility, and initial perceptions.

6 DISCUSSION & FUTURE WORK

The findings suggest that the "Give Comparative" and "Providing Explanations" mechanisms positively influence university students’ attitudes towards meat consumption. These strategies successfully heightened awareness about environmental and animal welfare impacts, evoking emotional responses like guilt and motivation. However, they faced resistance due to scepticism about the information’s credibility, taste and health preferences. Moreover, forceful displays could also lead to resistance. Therefore, such informational features should be able to communicate its credibility. Additionally, awareness-driven interventions should be highly sensitive to users’ state of mind and preferences to mitigate resistance and enhance their effectiveness.

Engaging close social circles proved to be a powerful strategy in shaping Subjective Norms. The "Social Reference Point" and "Social Influence (Comparison)" mechanisms effectively influenced students’ perceptions by highlighting the dietary choices of peers and family members. However, the latter nudge showed little impact

when based solely on statistical data, as participants valued immediate social circles' opinions more. Implementation should focus on personal connections rather than broad societal tendencies to affect subjective norms to maximize influence. Nonetheless, considerations of the feelings being provoked should be carefully examined to mitigate stressful situations for users.

The "Simplification" and "Providing Explanations" strategies were well-received for enhancing knowledge about plant-based alternatives. Simplified informational cues and detailed explanations boosted confidence in making sustainable dietary choices. "Simplification" also confirms that labels ease decision-making, but the effectiveness differs from case to case, requiring further personalized strategies. Moreover, neither mechanism can boost perceived behavioural control because they do not sufficiently tackle the practical aspects of executing the behaviour. To effectively enhance PBC, strategies must also consider and mitigate external barriers and internal limitations that hinder the actual performance of the desired behaviour. In addition, excessive comparisons and information overload hindered decision-making. Balancing detailed and simplified information is essential to promote sustainable eating habits effectively.

Nudging mechanisms that increase PBC over cooking healthy meals, such as "Give Comparative" and "Providing Explanations", aiming at addressing nutrient concerns and notifying appropriate dietary choices, prompted students to consider healthier options. However, information fatigue was a common issue, leading to low adoption rates. Other factors, like taste and availability, are also barriers. Interventions should sophisticatedly integrate external factors like availability, price, and time to be more effective without overwhelming users with too much information.

The "Increase Salience of Attribute" mechanism significantly improved perceived control over meal preparation time. Highlighting quick and easy recipes aids in effectively addressing time-related barriers, enabling students to manage their schedules while maintaining a healthy diet. Likewise, highlighting the cost savings of plant-based meals through the "Increase Salience of Attribute" and "Give Comparative" mechanisms positively influenced students' perceptions of affordability. Emphasizing financial benefits made plant-based diets seem more accessible and affordable, especially to those who originally perceived them as expensive.

Overall, the interventions mentioned in 3.1.3 are crucial in changing the users' attitudes, subjective norms, and PBC. However, finding the right mechanisms to approach such goals is challenging. The "Providing Explanations" and "Give Comparative" strategies can influence users' perceptions, but their impacts depend significantly on the format and complexity of the information presented. Simplified, concise explanations and comparisons are more likely to engage students and positively influence their attitudes and behaviours. "Simplification" and "Increase Salience of Attribute" interventions also effectively influence the users' initial perception and reduce decision-making heuristics.

The success of social mechanisms presents an opportunity to further explore social features, with close-circle interactions being the upfront prospects. On the other hand, the factors provided are incomplete, and future research should address aspects such as skills,

taste, and other personal preferences. Group-based recommendations can further enhance the impact of nudging by personalizing suggestions based on meat consumption patterns, sociodemographic factors, and other relevant components. Decision Structure nudges should also be examined to optimize decision-making by reducing the overall heuristics of the platform. Furthermore, further investigations are needed to unlock TPB's full potential to understand other components, such as intentions and behaviour or the interrelation between the components. Finally, ethical considerations are crucial to ensure that nudges respect user autonomy and do not manipulate decisions unethically.

Developing an effective recommendation system requires simultaneously addressing multiple factors, different components of TPB, and incorporating a comprehensive, user-centered approach. This involves a sophisticated and integrated ethical approach that combines credibility, personalization, and social factors while considering practical barriers such as time and cost.

7 LIMITATIONS

This study has several limitations. Firstly, the TPB components need to be observed over time; the reliance on immediate responses by simple scenarios insufficiently captures the complexity of human behaviour and mind, embedding biases. Secondly, the sample size limits generalizability. Therefore, conducting quantitative research would be beneficial for more accurate evaluations. Finally, socio-demographic differences were not addressed, affecting the applicability of the findings.

8 CONCLUSION

This research investigated the integration of the Theory of Planned Behaviour (TPB) and Nudging Theory into food recommender systems aimed at promoting healthier and more sustainable dietary choices among university students. The conceptual map developed through this study offers a framework for creating targeted interventions that address the specific challenges faced by this demographic. The empirical findings confirm that many of the proposed nudging strategies effectively influence attitudes, subjective norms, and sometimes perceived behavioral control towards reducing meat consumption. These results highlight the potential for personalized digital interventions to foster positive changes in dietary habits. Despite limitations, such as the need for long-term studies and consideration of socio-demographic differences, this research provides valuable insights for designing effective, human-centric food recommendation systems aimed at promoting sustainable eating practices.

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