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► **To cite this version:**

Diana Nurbakova, Audrey Serna, Abdelbasset Omiri, Antoine Boutet. Adaptive and Privacy-Aware Persuasive Strategies to Promote Healthy Eating Habits: Position Paper. UMAP 2023 - 31st ACM Conference on User Modeling, Adaptation and Personalization, Jun 2023, Limassol, Cyprus. pp.129-131, 10.1145/3563359.3596987 . hal-04142017

HAL Id: hal-04142017

<https://hal.science/hal-04142017v1>

Submitted on 26 Jun 2023

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Adaptive and Privacy-Aware Persuasive Strategies to Promote Healthy Eating Habits: Position Paper

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Food has become a social issue. Developing a healthy relationship with food is a complex process as it implies a behaviour change. At first sight, recent advances in recommender system domain ensure personalised service and assistance of a user in decision-making process. However, traditional recommender systems lack the consideration of health-related factors (e.g., healthy diet guidelines, food allergies, etc.). Moreover, instead of recommending a new item (recipe), an effective system should apply persuasion strategies to accompany a user in a long process, a little step at a time. Furthermore, most of existing recommender models do not take privacy preservation into account. In this position paper, we outline the challenges faced by a persuasive system for promoting eating habits and discuss our vision on the implementation of adaptive and privacy-aware persuasive strategies for healthy food promotion.

CCS Concepts: • **Information systems** → **Collaborative filtering**; • **Human-centered computing** → **Social recommendation**; **User models**; • **Applied computing** → *Consumer health*.

Additional Key Words and Phrases: persuasive system, healthy eating habits, behaviour change

ACM Reference Format:

Diana Nurbakova, Audrey Serna, Abdelbasset Omiri, and Antoine Boutet. 2023. Adaptive and Privacy-Aware Persuasive Strategies to Promote Healthy Eating Habits: Position Paper. In *Adjunct Proceedings of the 31st ACM Conference on User Modeling, Adaptation and Personalization (UMAP '23 Adjunct)*, June 26–29, 2023, Limassol, Cyprus. ACM, New York, NY, USA, 4 pages. <https://doi.org/10.1145/3563359.3596987>

1 INTRODUCTION AND BACKGROUND

Malnutrition (*undernutrition* and *overweight*) threatens human health¹. Thus, according to the World Health Organization (WHO)², in 2016, over 1.9 billion adults (over 39%) were suffering from being overweight, among who 650 million were considered obese (13% of adults)³. Moreover, WHO urges to promote diets that are both healthy and have low environmental impact [17]. But food is much more than calorie intake. It reflects culture, family traditions, rites, taste savouring. For instance, in 2010, the *Gastronomic meal of French* was inscribed on the UNESCO Representative List of the Intangible Cultural Heritage of Humanity⁴. At the same time, it can have comforting and convenient facets and be seen as a punishment or reward. Moreover, socio-economic shifts have contributed to the way we eat and produce food.

*Both authors contributed equally to this research.

¹<https://www.who.int/health-topics/nutrition>

²<https://www.who.int/news-room/fact-sheets/detail/healthy-diet>

³For adults, WHO defines overweight and obesity based on the value of body mass index (BMI) as follows: overweight if $BMI \geq 25$, obesity if $BMI \geq 30$

⁴<https://ich.unesco.org/en/RL/gastronomic-meal-of-the-french-00437>

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Manuscript submitted to ACM

(Re-)establishing a healthy relationship with food is a challenge as it implies to change our eating behaviour for the better. To assist such a change, recommender systems can be used, providing a user with personalised content. However, to achieve the final goal of behaviour change, such a system should go far beyond a traditional recommender system. Indeed, the works on (healthy) food recommendation (e.g., [5, 6, 11]) mainly focus on recommending personalised recipes or diets. As argued in [5], most existing food recommenders ignore crucial health factors (e.g., allergies and nutrition needs), and/or do not consider the rich food knowledge for recommending healthy recipes. Personal and sensitive information is often exchanged without protection for the recommendation process, which poses important privacy concerns [3] and a potential limit for the user adoption. Moreover, and maybe most importantly, existing food recommenders fail at accompanying a user all over the process of behaviour change that usually takes time.

Indeed, to well incorporate behaviour change models / theories, a system should provide a combination of services, pieces of advice, progress tracking and support for individuals, and to be adjusted in time within the user's progress [19]. To address such challenges, persuasive design principles can be adopted [13]. Various recent works have shown that persuasive games and gamified systems can enhance users' motivation and engagement for behaviour change for health [14]. A recent study [20] proposes a taxonomy for behaviour change applications drawn on the Self-Determination Theory (SDT) [16], a well-known theory of human motivation and personality. The authors argue that future research should be focused on tailoring the system interventions to resonate with the constructs of SDT, in particular offering optimal challenges to users. In the same line, [15] point out several design recommendations such as tailoring the content and allowing users to set their own goals, offering suggestions on both how to set effective goals and how to reach the goals. The authors also underline the differences related to users' privacy consciousness, suggesting to adopt either a system-controlled tailoring or a user-controlled tailoring approach.

Yet, recommender systems and behaviour change systems are largely powered by sensitive data related to users and their behaviour. The growing exploitation of personal data considerably erodes the privacy of users and the development of new technologies such as artificial intelligence only reinforces this phenomenon. To reduce privacy risks, different learning approaches preserving the privacy of personal data have emerged such as federated learning [4]. This learning scheme makes it possible to train models in a decentralized way with a very large number of participants by exchanging model information and not personal data. However, risks of inference remain even through these model exchanges [10].

In this project, we are therefore interested in tailoring persuasion strategies and system recommendations to users' profile while providing a comprehensible user-control of their privacy for healthy food promotion. Thus, the **objectives** of the current project are two-fold: (1) To explore the fusion of recommender systems and persuasion and gamified strategies to overcome the individual limits of each domain to better support users in their behaviour change, offering them optimal challenges. (2) To identify different privacy control levels and their impact on the relevance of the system.

2 IMPLEMENTING ADAPTIVE AND PRIVACY-AWARE PERSUASIVE STRATEGIES

Following the framework of [19] mainly inspired by Social Cognitive Theory (SCT) [2] and nourished from other behaviour change theories, including SDT, we identify the key components of our eating behaviour change system (see Figure 1). From our perspective, to achieve our goal three axes should be considered all together: tailored motivational affordances, healthiness-aware food recommender system over a large knowledge base, and privacy preservation.

Tailored Motivational Affordances As mentioned previously, recent studies underlined the importance to rely on motivational theories when designing systems for behaviour changes, also considering users' *individual preferences and factors*. We want to integrate in our system tailored game elements and persuasive strategies promoting the SDT psychological needs (*autonomy, relatedness and competence*). We chose to rely on SDT since it is well adapted to describe

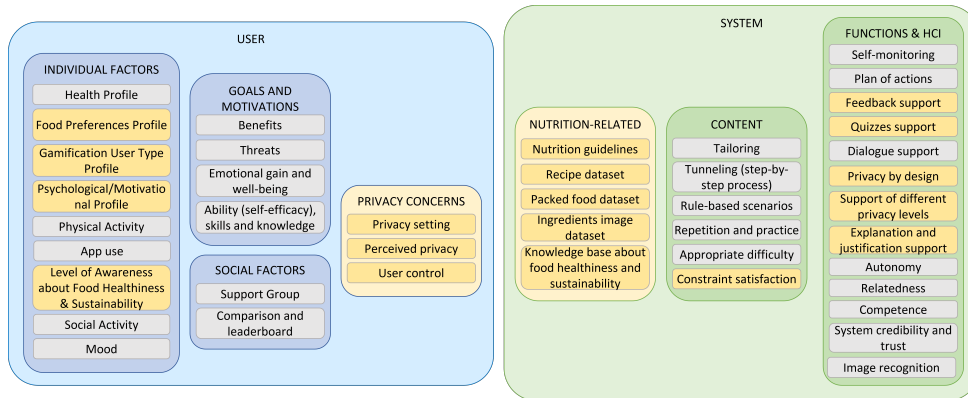


Fig. 1. Key components of a healthy eating behaviour change system. The components given in the yellow boxes are mainly related to Nutrition and Privacy domains and are additional compared to [19].

the development of causal action and self-determined behaviour, with applicability across multiple life domains [20] and it is widely used in the field of gamification, in particular for player profiles. Regarding the adaptation mechanisms, in recent work [7] in the field of Education, the authors developed an algorithm to tailor game elements to learners' profile, combining recommendations for their player profile and their motivation for the task into a unique recommendation. This resulted in an adaptation that was more effective on learners' motivation and engagement than those based on a unique profile. It has also been shown that the analysis of logs can be useful to detect users' engagement and could be a lever for adapting different motivational elements. Following this idea, we want to rely on two different aspects of users profiles: (a) *player profile* (Hexad [18], for instance) and (b), *users' motivational profile* and their *goals* toward healthy food. The content and optimal challenges proposed should also be adapted dynamically according to behavioural patterns that we could track from the real activity of users (*App use*).

Healthiness-Aware Food Recommender System To make use of rich food data, we will use FoodKG [8], recipe data, and all *nutrition-related data*. This will allow to reason over it, as providing *justifications* of recommendation can effectively support users' choices [1, 12]. Chen *et al.* [5] suggest a constraint-based question-answering model allowing to account for nutrient-related constraints and answer user query using FoodKG. A similar approach can be used to incorporate *individual factors and constraints* (e.g. allergies, health condition, etc.). However, the use of user queries is a limitation in our scenario, though we also consider to create recommendations based on the *images of available ingredients*. We will need to *tailor the food recommendations* to the behaviour change stages, *goals and motivations*.

Privacy Preservation Finally, the existing algorithms do not consider privacy aspects, using all kinds of data available. In this project we propose to explore to what extent an adaptation algorithm can integrate *privacy constraints* and how users can *control* this compromise. Considering such a system from the privacy point of view raises several issues. A key aspect in a persuasive behaviour change system is to be able to monitor users' progress, keeping a track of user's activity and behaviours and to quantify their progress. The tracked information can be quite sensitive (e.g., sex, weight, height, eating allergies, physical condition, mood etc.). Moreover, the system may allow comparison of the achievements with other users, another key component of a persuasive system. Therefore, progress monitoring and social comparison should be *privacy-preserving and ethical* by design, and *controllable by the user* themselves. A study of data minimisation schemes (e.g., [9]) and the use of Federated Learning architecture (e.g., [3, 10]) will be conducted.

3 CONCLUSION

In this position paper, we presented our vision of adaptive and privacy-aware persuasive strategies for healthy food promotion. Future work consists in a gradual implementation of such a system combining three domains: behaviour change and persuasion design, recommender systems, and privacy preservation.

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