RESEARCH ARTICLE

Promoting Green Fashion Consumption Through Digital Nudges in Recommender Systems

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ABSTRACT The fashion industry accounts for a relevant portion of the environmental impact of EU consumption. Moreover, the expansion of fast fashion raises further concerns about the well-being of the people and animals involved in its production. Increasing the purchase of green clothes (i.e., sustainable garments that have been produced by brands conforming to good ethical standards) is thus key to the reduction of fashion's environmental and social footprint. In this paper, we investigate digital nudges to promote the selection of green clothes in online catalogs. For this purpose, we propose a recommender system that combines the personalized suggestion of new and second-hand garments with the presentation of sustainability and ethical standards data to favor item comparison and support responsible selection decisions. This is different from standard recommender systems, which suggest homogeneous products, either new or second-hand. Moreover, it is challenged by the tendency to buy new products observed in the literature about clothing consumption. In a user study involving 251 participants, we found that enhancing clothes recommendations with 1) sentences that promote second-hand garments and 2) visual labels that summarize items' sustainability and brands' ethical standards, sensibly reduced this tendency. Moreover, it induced some people to take the sustainability of products into account in their selection decisions. However, participants' interest in brands' ethical standards seemed to be secondary, especially regarding respect for animals. This finding reveals a need to enhance people's awareness and sensitivity on this topic. Even though more work is needed to increase green, and especially ethical fashion consumption, our findings suggest the adoption of nudges in clothes recommender systems to enhance user awareness about items, their sustainability, and their social impact.

INDEX TERMS Digital nudging, recommender systems, sustainable fashion consumption.

I. INTRODUCTION

The environmental and social footprint of the fashion industry has to be dramatically improved to meet desirable standards and comply with the European energy strategy, which targets a 40% reduction in CO_2 emissions compared to 1990 levels, and a 25% energy-saving [1], [2]. The situation is exacerbated by the expansion of fast fashion. This raises further concerns about environmental sustainability, as well as the well-being of the people and animals involved in its production [3],

which is often distributed in countries with lower labor and environmental standards [4]. In this context, it is crucial to push *green consumption*, i.e., a selection of clothes that are environmentally sustainable and have been produced by brands that conform to satisfactory ethical standards. The selection of second-hand clothes sustains the circular economy and meets the EU's goal to favor a second-hand market, thus reducing pollution effects and costs originated by the production cycle [4].

Inducing sustainable fashion consumption is a challenge. People buy many more new clothes than second-hand ones [5], [6]. Moreover, fashion, and especially fast fashion,

seem to induce impulsive consuming habits, regardless of the individual sensitivity to environmental issues [3], [7]. Even the people who adopt sustainable behaviors tend to overlook environmental and ethical issues when buying fashion products. Furthermore, style is key in clothes selection [8], and price negatively affects consumer behavior [9]. Combined with the desire to be trendy, this leads to overlooking green but more expensive garments, in favor of fast-fashion products that mimic designer brands at low costs.

Recommender systems [10], [11] are a promising technology to answer this challenge because they help users select items they like. However, current systems have to be extended to consider sustainability issues and to guide people towards green consumption habits. Moreover, current systems recommend either new or second-hand products. If users are interested in the former, they will hardly explore the catalogs presenting the latter.

The recommender systems research has investigated digital nudging [12] to steer consumer behavior toward goals that are beneficial to the user and thus should be pursued when making a selection decision. In this paper, we investigate the potential of some digital nudges to drive people toward consumption habits that are both ethical and respectful of the environment [13], [14]. For this purpose, we tested three user interfaces for a system that, starting from a standard catalog of garments, suggests new and/or second-hand clothes as alternative products to the user's initial choices. The user interfaces included the following nudges:

1) Messages that promote second-hand items.
2) Visual labels that summarize products' evaluation taking multiple sustainability and ethical standards into account.

The user interfaces presented either new and second-hand clothes, or only second-hand ones, as alternatives to the product initially selected by the user.

We tested these user interfaces in a study involving 251 participants who interacted with a test application developed for this purpose. The system measured user experience and logged people's behavior during the selection of clothes to understand whether and how the nudges influenced their choices. We found that users appreciated the nudges and felt positively influenced by them. Moreover, during the test, they selected second-hand clothes much more frequently than what is observed in previous studies [5], [6]. Furthermore, they frequently chose green garments. However, their interest in brands' ethical standards was secondary, especially concerning respect for animals. Thus, in line with previous analyses of sustainable consuming behavior [7], [15], we conclude that exploiting informative nudges in fashion catalogs is crucial and must be diffused to educate consumers.

To summarize, we make two contributions. The first one is the design of textual and visual informational nudges to induce green fashion consumption, combined with the presentation of carousels to compare new and second-hand clothes. The second one is a user study investigating (i) the impact of such nudges on decision-making, and (ii) the user experience with different user interfaces for the presentation and recommendation of new and second-hand garments.

The remainder of this article is organized as follows: Sections II and III introduce the fashion market and position our work in the related one. Section IV describes the dataset we used. Section V describes the goals and the hypotheses that guided the design of the experiment. Section VI provides the details of the user study and VII presents the findings we collected. Section VIII elaborates how the results of the experiment support our hypotheses. Sections IX and X discuss the limitations of our work and conclude the paper.

II. FASHION AND FAST FASHION

During the last decades, the fashion industry has been an object of international interest because of its environmentally polluting supply chain operations [16]. Its environmental impact has been assessed through indicators related to the use of materials and to supply-chain management [17], [18], [19]. However, ethical issues associated with production practices have received less attention. Noticeably, the Good On You platform [20] covers multiple aspects to assess the impact of fashion brands. It considers issues such as resource use and waste management and the sustainability of business models. About workers' rights, it assesses the policies and practices concerning child labor, forced labor, worker safety, freedom of association, gender equality, diversity, and payment. Finally, it assesses how brands track their animal products, as well as the adoption of controversial practices.

In 2019, the European Parliament reported that clothing accounts for between 2% and 10% of the environmental impact of EU consumption [4]. Thus, improving the environmental and social footprint of this industry is a strategic objective to be achieved. According to WWF (World Wildlife Fund), an eco-sustainable direction involves three areas for the application of transformation [21]. One of these is sustainable (or green) consumption, which Phipps et al. define as "consumption that simultaneously optimizes the environmental, social, and economic consequences of acquisition, use and disposition in order to meet the needs of both current and future generations" [13]. In the fashion domain, sustainable consumption means that people should choose clothing with care (supporting slow fashion), and embrace eco-friendly solutions such as garment sharing and second-hand market (circular fashion) [21].

According to Barnard [22], clothing is a symbol that represents people's internal perceptions through their outer appearance. The findings described in [3] and [7] suggest that the satisfaction of individual preferences is key to driving people towards sustainable consumption because desire tends to be their priority. Those works show that even the people who adhere to good practices (such as waste recycling) and are concerned about the environmental and social impact of their non-fashion purchases, hardly apply the same principles to clothing. Indeed, they are strongly attracted by the updated looks, great variety, and limited editions characterizing fast

fashion. Other researchers confirm the strong preference for buying new clothes. For instance, in a study involving Japanese customers, Moon et al. found that even the most environmentally-conscious and frugal consumers rarely purchase second-hand daily goods for general use, including clothes [5]. Moreover, Persson and Hinton observed that, in 2020, the revenue from the sale of second-hand clothes in Sweden amounted to 7% of the total revenue generated from novel clothes [6]. Finally, according to further analyses of sustainable consuming behavior [15], people's interest in environmental sustainability has grown inducing waste reduction, and other virtuous practices. However, the same kind of sensitivity can hardly be found when thinking about the ethical issues concerning production cycles.

III. RELATED WORK

"Recommender systems are software tools and techniques providing suggestions for items to be of use to a user" [10]. They are largely employed in information sites and online catalogs to support information filtering and the discovery of relevant items through personalized suggestions, such as Amazon's [23] "You might be interested in" feature. While fashion recommender systems [11] focus on individual user preferences, we point out that nudging is key to making them suitable to induce green consumption.

Weinmann et al. defined digital nudging as "the use of user-interface design elements to guide people's behavior in digital choice environments" [24]. Jesse and Jannach [12] defined a taxonomy of techniques that have been applied in recommender systems, building on previous categorizations such as [25]. The presentation of sustainability and ethical issues data, which we propose, falls into the "decision information" category, aimed at changing the information that is shown without changing the options themselves. We present visual cues and data to enhance the user's awareness of items and their decision-making behavior.

Recommender systems employed nudges to steer human behavior in various application domains such as the adoption of energy-saving solutions [26] and the use of sustainable transportation means [27]. However, those works modified the choice architecture using techniques like the choice defaults, e.g., setting printers to double-side modality [28]. These can be hardly applied in the fashion domain because clothes' style and origin (new or second-hand) are important evaluation criteria and the greenest items might not satisfy the user's preferences. Thus, we empower people to freely select the preferred solutions, without prioritizing any options. However, we pursue the enhancement of user awareness about items' characteristics to steer green consumption.

Starke et al. [29] investigated the induction of healthy eating behavior through multi-list user interfaces that visualize food recipes satisfying different eating goals; for example, recipes with fewer calories. Moreover, Majjodi et al. [30] focused on informational nudges. They used nutrition labels to show either an overall, qualitative evaluation of items or their exact nutritional values. However, those values might be difficult to understand for lay users because they are expressed in different scales. In comparison:

1) We challenge users by suggesting both new and second-hand clothes. We expose them to items that look similar to what they are searching for but can be more expensive or, in the case of second-hand clothes, could generate distrust.

2) We introduce visual labels and color coding to simultaneously show, in a normalized scale, (i) an overall score summarizing clothes' environmental sustainability and their brands' ethical standards, and (ii) garments' evaluation according to specific criteria like water conservation and workers' well-being. This is aimed at enabling people to quickly compare items according to multiple criteria, complying with individual priorities. Moreover, it might help critical consumers, who are attentive to virtuous purchasing practices, to find the products that satisfy their ethical values [31].

In [32], we introduced the first version of the visual labels to represent individual evaluation dimensions in a multi-list user interface whose carousels represented different evaluation criteria. Differently, the visual labels described in the present paper support both an overview and a fine-grained comparison of the system suggestions. As such, they are suitable for being used in simple carousels.

Some online e-commerce platforms present data about products' sustainability. For instance, Zalando [33], About You [34], and Amazon [23] offer filters to search for sustainable products and highlight such items with icons and textual explanations. However, they only show that some products are over a sustainability threshold. Thus, they fail to support fine-grained evaluation and comparison of items.

IV. INFORMATION ABOUT CLOTHES
A. DATASET

For our work, we needed data about garments and their photos. We could not find any suitable public dataset because the existing ones (e.g., the H&M dataset [35], and Amazon Review Data [36]) do not report the images of clothes or their materials, which we used to compute water consumption and CO_2 emissions. The only dataset providing the information we needed is [37]. However, it does not deal with second-hand clothes and only includes about 1500 items. We thus scraped the Zalando website from February to March 2022 to download information about both new and second-hand products and we extended such data through further analysis, as follows:

- **Basic data.** For each garment, we retrieved from the Zalando website its product name, price, color, category (e.g., skirt_women), brand, list of materials composing it with percentages (e.g., [[cotton, 80], [polyester, 20]]), and its first available image. We downloaded data about 30,722 clothes produced by a total of 2,730 brands. Henceforth, we will denote this set of items as I.

- **Style.** To specify the clothes' style, we analyzed their images using the pre-trained model based on ResNet50, from the MMFashion library [38]. For each item $i \in I$, we obtained a 1000-dimensional vector $\vec{f_i}$ of binary features like "knit", "print", "striped", and "pocket", describing its appearance.
- **Color.** The Zalando catalog reports some unconventional colors like "taupe", and "driftwood". Thus, we analyzed the images of clothes and inferred their color in a standard RGB scale using a convolutional neural network trained specifically for our dataset, using transfer learning on ResNet50 [39]. The trained model is available here: http://bit.ly/3Y30Ej0.
- **Environmental sustainability.** We decided to describe the environmental sustainability of each garment $i \in I$ in terms of how much the production of its fabric:
  - -- preserves the quality of the air ("air conservation" indicator), by reducing CO_2 emissions, and
  - -- limits water consumption ("water conservation")

  compared to the items of the same category in our dataset. We defined both indicators in [0, 10] to support their presentation as levels on a uniform scale.

  By default, second-hand clothes have maximum environmental sustainability (10) because the production efforts only concern their first sales. Differently, we estimated the water consumption and CO_2 emissions of new garments based on their composition. For this computation, we used [19] to retrieve data about water consumption in the production of materials, per Kilogram, and [17] for emissions. Moreover, as we could not find the weight of items in the Zalando catalog, we estimated it based on their category using [40].

  Given the materials of a new garment i, and their percentages, we computed water consumption and CO_2 emissions by applying the following cost function:

$$Cost_i(d) = w_i \sum_{j=0}^{n} cost_d(material_j) \cdot percent_j \quad (1)$$

where:
  - -- d is either water consumption or CO_2 emissions;
  - -- w_i is the estimated weight of i in Kilograms;
  - -- $material_j$ is the j-th material of i's, and $percent_j$ its percentage in i;
  - -- $cost_d(material_j)$ is the cost (Liters of consumed water, or Kg of emitted CO_2) derived from the production of 1 Kg of $material_j$.

  Given the estimated costs, the scores of "air conservation" and "water conservation" are:

$$Score_i(d) = (1 - \frac{Cost_i(d) - min\_cc_{d,i}}{max\_cc_{d,i} - min\_cc_{d,i}}) \cdot 10 \quad (2)$$

where:
  - -- d is either water consumption or CO_2 emissions;
  - -- $min\_cc_{d,i}$ ($max\_cc_{d,i}$) is the minimum (maximum) cost for d observed in our dataset, considering the items that belong to the same category of i.

In Equation 2, we subtract the minimum cost observed in the clothing category ($min\_cc_{d,i}$) to $Cost_i(d)$. This is done to equate the new clothes produced by very virtuous brands to second-hand garments in their comparison.

- **Brands' ethical standards.** We relied on an external source because their estimation is complex and based on information that we could not directly retrieve. The application supporting the user study retrieves this data from the Good On You platform that provides its evaluation of workers' well-being ("labour rating"), and respect for animals ("animal rating") in the production cycle. Good On You takes in input a brand's name and returns the results in the [1, 5] range [41]. However, the test application normalizes these values in [0, 10] for uniformity with the air and water conservation indicators.

In the dataset we created,[1] each garment $i \in I$ is represented by the following vector:

> $\vec{v_i}$ = [product_id, product_name, image_id, price, Zalando_color_string, category, brand_name, materials, rgb_color, binary_features, water_conservation_score, air_conservation_score]

For instance:

> ["c0k22d04p-k11", "CREW - Jumper", "c0k22d04p-k11.jpg", 109.99, "light blue", "jumpers_cardigans_men", "Club Monaco", [[linen, 88], [nylon, 12]], [0,0,255], [-1,-1,…,-1], 8.62, 7.17]

We assigned the same importance to the four environmental sustainability and ethical standards dimensions we considered (workers' well-being, respect for animals, air and water conservation). Therefore, the overall environmental sustainability and ethical standards score is calculated as the simple average between those four dimensions.

B. ITEM SIMILARITY

To support the recommendation of clothes that the user likes, we compute the similarity of two items $i, j \in I$ focusing on their appearance. We use the following dimensions:

- The *color similarity* ($\sigma_{color_{ij}}$), considering both the color and its lightness.
- The *stylistic similarity* ($\sigma_{features_{ij}}$) based on the features of items like the presence of pockets, stripes, and so forth.

In the following, we describe how we compute $\sigma_{color_{ij}}$ and $\sigma_{features_{ij}}$.

1) COLOR SIMILARITY

Given two items $i, j \in I$, $\sigma_{color_{ij}}$ is the complement of their color difference. Usually, the color difference is estimated using the well-known ΔE CIEDE 2000 formula [42], which

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[1]As we scraped the Zalando website to retrieve the basic metadata of clothes, we cannot share this dataset.

This is a collection of clothes from a catalog selling new products. Please, select an item that you would like to buy from the following list by clicking on it.
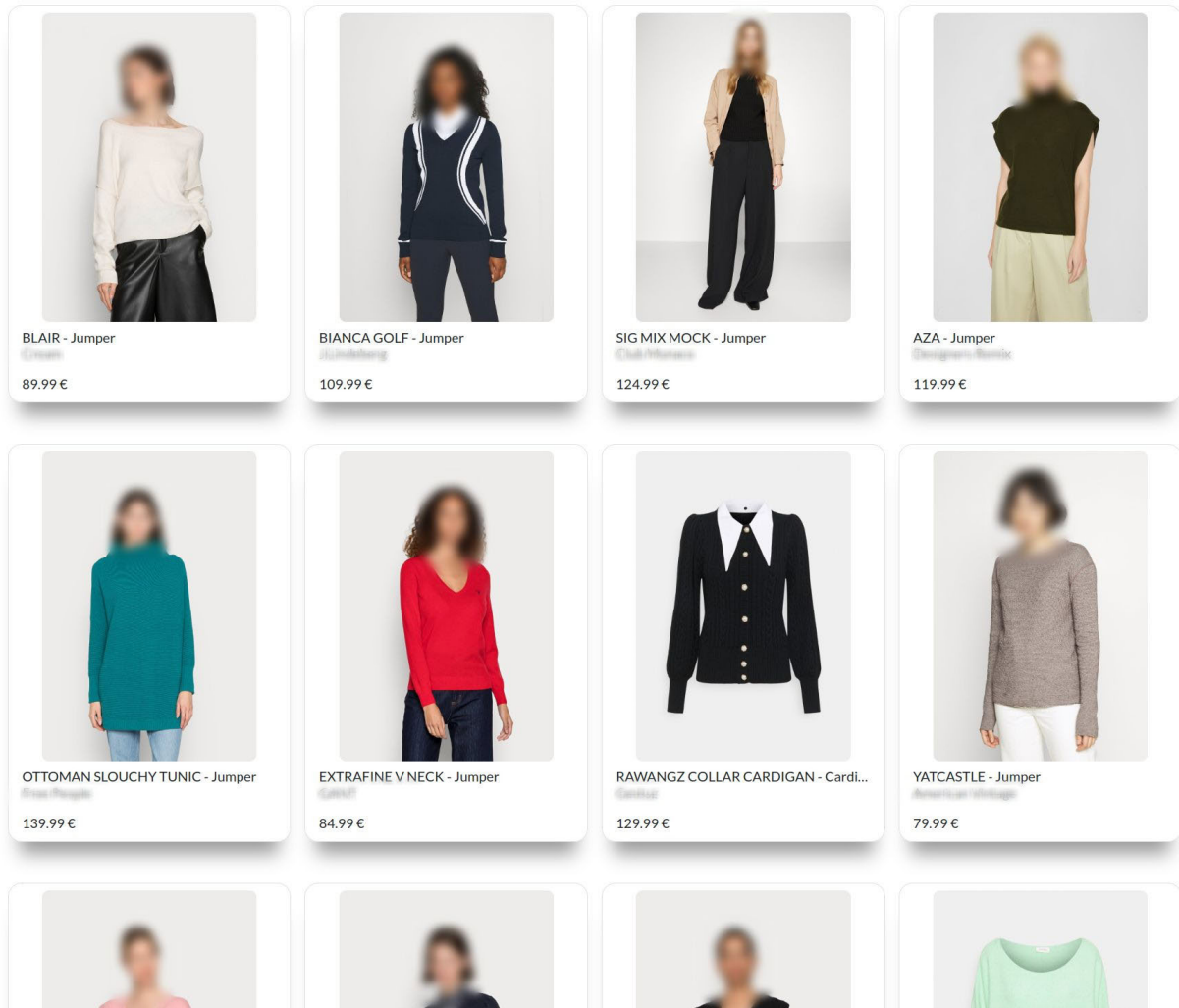

FIGURE 1. Catalog of new clothes. Presentation of a list of clothes that belong to the "jumpers_and_cardigans_for_women" category. The images of this figure and the following ones are blurred for publication purposes.

requires color to be defined in the CIELAB color space that includes the following three dimensions[2]:

- Lightness, denoted as L* in CIELAB color space;
- Red/green continuum (denoted as a*);
- Blue/yellow continuum (b*).

This formula does not fully satisfy our requirements because it considers the lightness of colors as secondary. For instance, it evaluates samples like light blue and blue navy, which we perceive as very different, as similar colors. To address this limitation, we introduced a penalty that enhances the impact of lightness in the computation of color similarity:

$$\sigma_{color_{ij}} = [2 - \frac{\Delta E \; CIEDE2000(\vec{c}_i, \vec{c}_j)}{100} - \frac{(L_i - L_j)^2}{100^2}]/2 \tag{3}$$

where:

²Since our neural network outputs colors encoded in the RGB space, we use a function to translate their representation to the CIELAB color space.

- $\vec{c}_i = \{L_i, a_i, b_i\}$ and $\vec{c}_j = \{L_j, a_j, b_j\}$ are the colors of the two items.
- L_i and L_j are their Lightness values, i.e., the values of the first dimension in their representation in the CIELAB color space.

Notice that Lightness values are in [0, 100]. Thus, in Equation 3, their squared difference is divided by 100^2, resulting in a penalty of 1 if two colors have opposite Lightness. Moreover, we divide $\Delta E \; CIEDE2000(\vec{c}_i, \vec{c}_j)$ by 100 to normalize its value in [0, 1], and the entire formula by 2 to normalize σ_color_{ij} in [0,1].

2) FEATURE-BASED SIMILARITY

Given a clothes category C, we compute the stylistic similarity $\sigma_{features_{ij}}$ of two items $i, j \in C$ as the Jaccard similarity of their feature vectors $(\vec{f}_i, \vec{f}_j$, see bullet "Style" in Section IV):

$$Jaccard\_similarity(\vec{f}_i, \vec{f}_j) = \frac{n_{11}}{n_{01} + n_{10} + n_{11}} \tag{4}$$
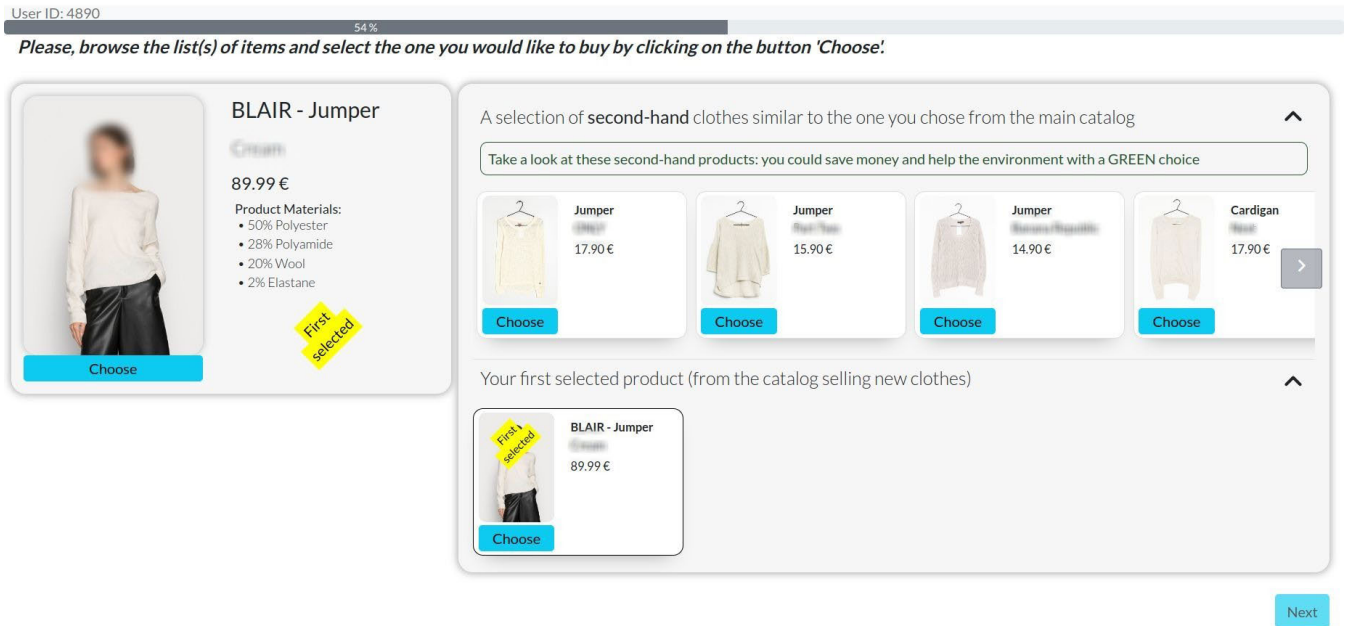
FIGURE 2. Recommendations page of the `SH` user interface.

where:

- n_{11} is the number of attributes with value = 1 in both $\vec{f_i}$ and $\vec{f_j}$;
- n_{01} is the number of attributes that are 0 in $\vec{f_i}$ and 1 in $\vec{f_j}$;
- n_{10} is the number of attributes whose value is 1 in $\vec{f_i}$ and 0 in $\vec{f_j}$.

As the Jaccard similarity does not account for attributes having a value of 0 in both vectors, it is suitable for use cases where vectors are sparse, like ours.

V. METHOD

We carried out a user study to understand whether, by enriching a clothing catalog with digital nudges and sustainability information, we could induce people into green item selections while preserving a good user experience with the system. To promote sustainable consumption, we selected a set of nudges that are suitable for a clothes catalog. Then, we developed a test application that applies them in three different user interfaces to evaluate their impact on users' experience and their influence on decision-making.

We considered the following types of nudges, which support user awareness about items:

- More or less detailed sentences promoting the selection of second-hand clothes.
- Visual labels summarizing the level of sustainability and ethical standards of each new/second-hand garment. The labels also support item comparison.

We excluded other types of nudges, such as the choice defaults because, as pointed out in Section III, they might challenge the user preferences for products' style and new/second-hand origin.

As few people buy second-hand clothes [5], [6], we could not assume that the participants we involved were spontaneously interested in those products. Thus, we decided to elicit their preferences for new clothes. The test application works in two steps (see Section VI for the details of the interaction flow):

- First, it shows a catalog of new clothes and asks the user to choose the item (s)he would like to buy. Henceforth, we will denote this item as the "pivot".
- Then, it recommends alternative second-hand/new garments that look similar to the pivot. The application visualizes the suggestions in the user interfaces we designed.

Given the pivot i, the application generates the recommendation list as follows:

1) First, it extracts the 30 items $j \in C$ whose color is most similar to that of i by evaluating $\sigma_{color_{ij}}$.
2) Then, it sorts these items based on $\sigma_{features_{ij}}$ and retains the 15 most stylistically similar ones.

In the generation of the recommendation list, we might have used items' prices to propose garments whose costs did not sensibly exceed the pivot. However, we did not do this because new garments produced by brands that offer good sustainability and ethical standards might be more expensive than fast-fashion products. Thus, even though suggesting them was a priority, they would have been filtered out, limiting the presentation of green products.

A. HYPOTHESES

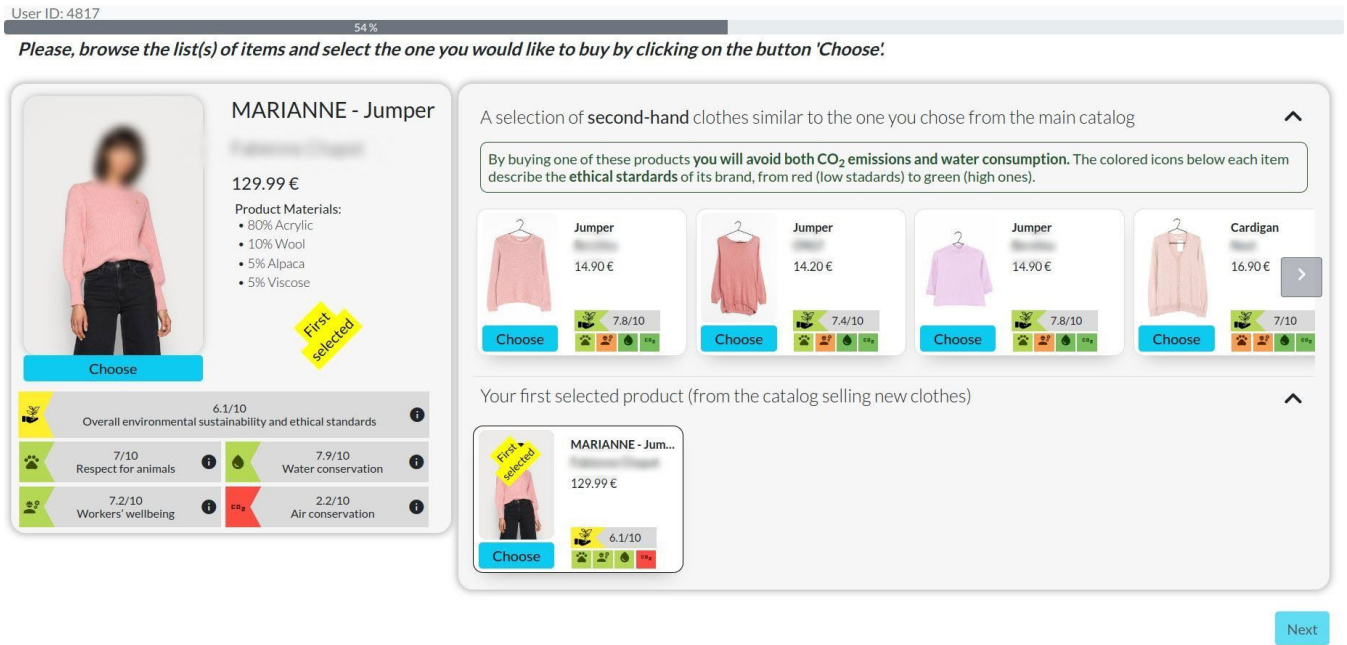We formulated the following hypotheses to be tested:

FIGURE 3. Recommendations page of the `LABELSH` user interface.

H1 *Our digital nudges positively influence the user experience with the user interface.*

We expect to confirm this hypothesis because our digital nudges provide information useful to evaluate items from a broader viewpoint rather than only considering their basic properties.

H2 *Users' curiosity (CEI-II level [43]) positively impacts the user experience with the user interface.*

We expect to confirm this hypothesis. We suppose that people having high CEI-II values give higher scores to the user interfaces that show sustainability and ethical standards data than people with lower curiosity levels.

H3 *Users' interests in environmental sustainability and brands' ethical standards impact the experience with the user interface.*

We expect to confirm this hypothesis because we assume that people who care about green consumption are interested in receiving this type of information about products.

H4 *Users' interests in environmental sustainability and brands' ethical standards influence decision-making towards green consumption.*

We expect to confirm this hypothesis because we assume that people who care about sustainability and ethical standards are interested in buying green products.

H5 *Showing information about environmental sustainability and ethical standards of items' brands induces green consumption.*

Based on previous analyses about sustainable consuming behavior [15] and consumers' awareness of the sustainability of fashion brands [7], we expect to confirm this
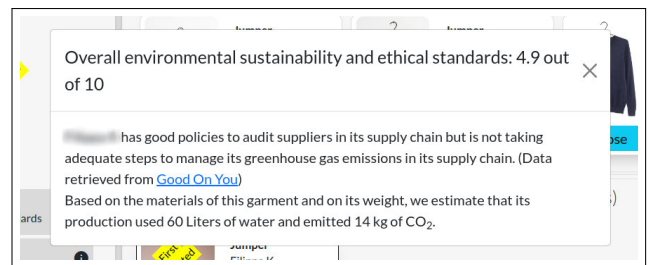

FIGURE 4. Popup showing details about a garment's sustainability and about its brand's ethical standards.

hypothesis. The reason is that we assume that presenting this information provides a broader viewpoint to evaluate products than only considering their basic properties.

H6 *Informing users that buying second-hand clothes preserves the environment increases the conversion rate to this type of product.*

Given the growing interest in sustainability [15], we expect to confirm this hypothesis.

H7 *Enriching the presentation of clothes with information about products' sustainability mitigates people's tendency to buy new garments.*

Given the growing interest in sustainability [15], we expect to confirm this hypothesis because our visual labels show that second-hand clothes excel in this aspect.

The user study was a within-subject one, inspired by Bilgic and Mooney's analysis of the effects of explanation in recommender systems. Those authors investigated whether users change their minds about items before and after having been exposed to an explanation of the recommendations [44]. Similarly, we investigated the impact of three different
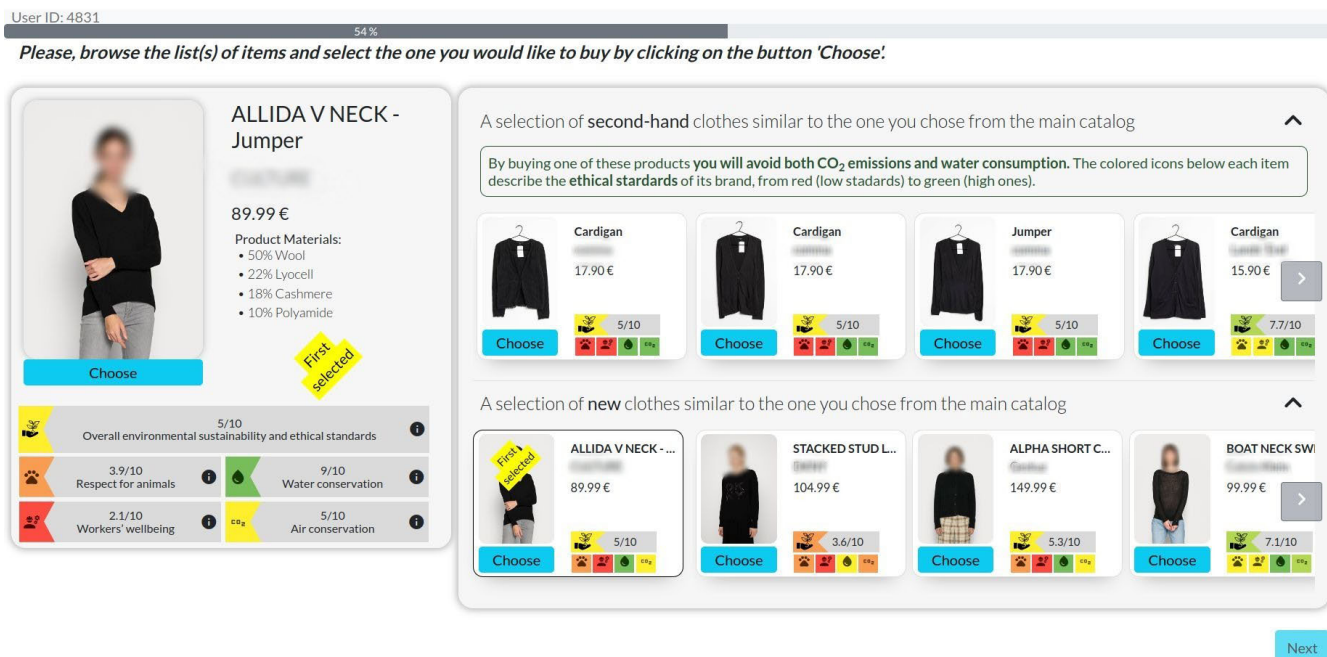
FIGURE 5. Recommendations page of the `LABELSHNEW` user interface.

user interfaces providing digital nudges, by analyzing user experience and decision-making before and after being aware of items' sustainability and their brands' ethical standards. The idea is to assess whether users appreciate the presence of this extra information and change their selections accordingly. We evaluated user experience considering Tintarev and Masthoff's explanatory aims of effectiveness (help users make good decisions), and satisfaction (increase the ease of use or enjoyment) [45].

In the study, we tested our hypotheses by administering different questionnaires to participants, and by analyzing their interaction with the test application, which we logged. In planning the study, we complied with literature guidelines on controlled experiments [46], [47].

B. USER INTERFACES

This section describes the user interfaces (`SH`, `LABELSH`, and `LABELSHNEW`) that we developed to test the hypotheses defined in Section V-A.

All the user interfaces include a left widget to present items' details and a right one to browse the suggestion list; for instance, see Figure 2. However, they differ in the nudges they apply and/or in the origin of the products they recommend:

- **SH** (Figure 2) is aimed at testing the impact of textually summarizing the advantages brought by second-hand clothes on:
  - - the user experience;
  - - the conversion rate to second-hand garments.

  The challenge is that of convincing the user to abandon the pivot in favor of a second-hand product.

  The application **recommends a list of second-hand clothes** and nudges the user into choosing one of them

through the sentence "Take a look at these second-hand products: you could save money and help the environment with a GREEN choice". Below the list, the system shows a reminder of the pivot $i \in C$ that the user has previously selected. See the yellow "First selected" label.

- **LABELSH.** Also this user interface (Figure 3) attempts to convince the user to abandon the pivot in favor of a second-hand product. However, it applies more informative nudges than `SH` to investigate their impact on:
  - - the user experience;
  - - the conversion rate to second-hand garments;
  - - the selection of items that score better than the pivot in terms of sustainability and/or brands' ethical standards.

  The application nudges the user towards the selection of second-hand clothes with a sentence that explicitly mentions saving CO_2 emissions and water consumption: "By buying one of these products you will avoid both CO_2 emissions and water consumption." Moreover, it enriches the presentation of each item with a **visual label** to summarize its sustainability and ethical standards levels. The colors of the label range from red (very bad evaluations) to green (very good ones).

  - - The smaller icons of the visual label show the evaluation of the item regarding (i) respect for animals, (ii) workers' well-being, (iii) water conservation, and (iv) air conservation. The first two aspects are the normalized "animal rating" and "labour rating" values provided by Good On You.

-- The top segment is the item's overall evaluation (arithmetic mean of the scores of the four aspects).

The visual label of the product on the left portion of the page shows a "more information" icon. The user can click it to view the detailed data about water consumption, CO_2 emissions, and Good On You's textual explanation of the ethical standards level; see Figure 4.

Even though second-hand clothes are equivalent to each other from the viewpoint of water and air conservation, they might differ in their brands' ethical standards. As discussed in Section III, clothing is a symbol that represents people's internal perceptions through outer appearance [22]. Moreover, brands' ethical standards are strictly related to the self-image of users [15] because they reflect brands' personalities [48]. LABELSH is aimed to assess the impact of this information on users' selection decisions.

- **LABELSHNEW** (Figure 5) shows the same nudges as LABELSH but presents two lists of products. The upper one suggests **second-hand clothes** and the lower one recommends **new ones**. This user interface is aimed at understanding whether user experience and decision-making change when people are exposed to both types of products, considering the observed tendency to select new clothes [5], [6]. Specifically, we separated the recommendation lists into two carousels to support item comparisons between these heterogeneous types of products. Specifically, in LABELSHNEW we investigate the following aspects:
  -- Whether the user experience differs from LABELSH when the same digital nudges are applied to recommend both new and second-hand garments.
  -- The conversion rates to new and second-hand products in the presence of both types of options.
  -- The selection of new and second-hand clothes that are greener than the pivot.

VI. USER STUDY

We recruited adult participants by using the Amazon Mechanical Turk platform. We carried out the study by exploiting our test application, linked to the experiment that we published on the platform. The system guided participants in all the steps of the study. To guarantee users' privacy, it did not collect their names or any other identifying data; at the beginning of the test, it generated a numerical identifier to tag the anonymous data acquired during the interaction session.

We managed each treatment condition (catalog of new clothes plus user interface showing recommendations) as an independent variable and each participant received all the treatments in counterbalanced order to reduce the effects of practice and fatigue. The interaction between the test application and the user is summarized in Figure 6:

1) First, the application prompted users to read the **informed consent**[3] and asked them to declare that they were 18 years old or over. Moreover, it asked them to give their **explicit agreement to participate in the study.** Only those who positively answered both questions could continue the interaction.

2) Then, the application showed an **instruction page** (the same for all users) to make participants familiar with the tasks to be performed.

3) To guarantee that users explored a uniform set of clothes, the application only presented **jumpers and cardigans**. However, it asked them whether they wanted to inspect **clothes for women or men** to comply with their interests. Depending on the answer, the category C to be used during the experiment was either "jumpers_cardigans_women" or "jumpers_cardigans_men".

4) Next, the application administered a **first questionnaire** to elicit demographic information, cultural background, and familiarity with booking and e-commerce platforms, based on the ResQue recommender system questionnaire [49]; see Appendix.

5) After these preliminary steps, each participant explored **three clothing catalogs** to choose the products to buy. These catalogs have no intersection to avoid memory effects. They are the same for all users and only depend on the selected category C of clothes.[4] For each catalog:

   a) The application displayed 20 new garments belonging to C; see Figure 1. Then, it asked the user to choose the item i that (s)he would have liked to buy (pivot item). As the catalog page did not present any sustainability or ethical standards data, we assume that each user identified an item satisfying her/his preferences, without being influenced by any other factors.

   b) Then, the application **recommended either one or two lists of clothes** belonging to C **which were similar to the selected pivot in color and style.** The items were **second-hand, and/or new ones,** as in Figures 2, 3, and 5, depending on the user interface. The users might keep the pivot as their final choice or replace it with any of these garments.

   c) After users confirmed the selection of the preferred item, the application prompted them with the following question:
      "Which aspects of the product you chose positively affected your decision? You can select more than one aspect:
      - environmental sustainability;

---

[3]The consent text can be found at this link: https://bit.ly/3J9XinU. Our experiment has been approved by the Ethics Committee of the University of Torino (Protocol Number: 0244699).

[4]At set-up time, we generated 6 distinct sets of items (3 for "jumpers_cardigans_women", and 3 for "jumpers_cardigans_men") by including random items from the respective product categories.
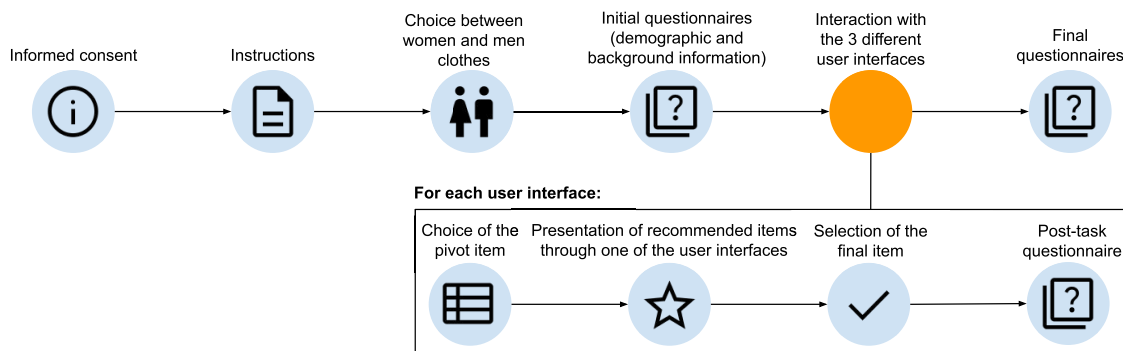
FIGURE 6. Diagram representing the interaction with the test application.

- ethical standards;
- color;
- materials;
- style;
- price."

This is aimed to test hypotheses H4, and H5. With SH, the system did not show the first two options because the user did not receive this information.

d) Then, the application asked users to declare their level of agreement with the statements of the **post-task questionnaire** shown in Table 1, which measures the **user experience (UX)** with the interface they just interacted with (H1, H2, H3). The statements are taken from [49], [50], and [51].

6) At the end of the test, the application administered the last questionnaires to elicit deeper information about participants and their decision criteria. Specifically, it asked them to answer:

- The **Curiosity and Exploration Inventory-II (CEI-II) questionnaire** [43] to measure their curiosity; see H2.
- A **post-test questionnaire** aimed at building users' "environmental sustainability and ethical standards profiles" (EE). In this questionnaire, we elicited the importance that participants attributed to the following item properties after having been exposed to the visual labels of items:
  -- air conservation;
  -- water conservation;
  -- workers' well-being;
  -- respect for animals.

All the statements had the same format and users answered them in the {Strongly disagree, ..., Strongly agree} scale, mapped to [1, 5]. We report the text of the first one (the others are similar):

> "Air conservation is important to me in choosing clothes to buy".

We did not investigate participants' personalities in terms of the Big-5 traits, which cover different aspects including emotions, because past work obtained mixed results about their influence on sustainable behavior [15].

VII. RESULTS

For the user study, we aimed to collect a sample of 226 participants that, according to Power Analysis, supports $\alpha = 0.05$ (Type I error rate), Power = 0.90 (Type II error rate), and Effect size = 0.20. 347 people joined the user study in April 2023 but we excluded 2 of them because they completed the test too quickly, 3 because they did not reach its end, and 91 because they failed to pass the attention checks. We considered the remaining 251 users for our analysis. The mean duration of the experiment was about 23 minutes.

A. USER DATA (FIRST QUESTIONNAIRE, AND PC)

We report the distributions of answers to the questionnaires given by the 251 participants we retained for the analysis:

- *Gender:* 112 female, 139 male, 0 not-binary, 0 not-declared.
- *Age:* ≤ 20 (0), 21-30 (123), 31-40 (91), 41-50 (23), 51-60 (13), > 60 (1).
- *Education level:* 0 primary school, 4 middle school, 61 high school, 182 bachelor's or master's graduates, and 4 Ph.D. graduates.
- *Background:* 119 technical, 43 humanities, 37 economics, 29 languages, 14 scientific, and 9 other backgrounds.
- *Familiarity with IT:* 88 people advanced, 131 average, 32 beginners.
- *Familiarity with online booking or e-commerce platforms:* 111 people declared that they used those platforms a few times in a month, 135 a few times in a year, 2 a few times overall and 3 people never used one before.

B. USER EXPERIENCE (UX) RESULTS (POST-TASK QUESTIONNAIRE)

1) UX ANALYSIS ON THE WHOLE PARTICIPANTS' SAMPLE

Table 1 shows the results of the post-task questionnaire administered after having interacted with each user interface. We describe them grouped by user experience constructs, all of which are statistically significant with $p < 0.01$, or $p < 0.05$ according to a Kruskall-Wallis test. See the "Average" rows in the table:

TABLE 1. Post-task questionnaire results describing participants' experience with the three user interfaces. Results are grouped by user experience construct. The "Average" row reports the mean value of the factors. The highest values are in boldface. Stars denote the statistical significance of the difference between the best-performing model and the other ones (Kruskall-Wallis test). Significance levels: (***)$p < 0.01$, (**)$p < 0.05$, (*)$p < 0.1$.

Construct	Statement	User Interface			p-value
		SH	LABELSH	LABELSHNEW	
		M(SD)	M(SD)	M(SD)	
Decision Making (D)	D1: The labels showing ratings about environmental sustainability and ethical standards below item's photos were useful.		**3.96(0.95)**	3.75(0.89)	0.006***
	D2: The information about environmental sustainability and ethical standards impacted my selection decisions.		**3.99(0.88)**	3.94(0.87)	0.462
	D3: Being informed that buying second-hand clothes preserves the environment impacted my choices.		**3.94(0.88)**	3.80(1.01)	0.163
	Average (value of the construct)		**3.96(0.67)**	3.83(0.73)	0.031**
Interface Adequacy (I)	I1: The user interface of the system was not particularly cluttered.	3.84(1.02)	3.70(0.83)	**3.89(0.93)**	0.019**
	I2: I found the user interface very intuitive.	3.85(0.94)	3.75(0.93)	**3.95(0.89)**	0.045**
	I3: The user interface of the system was sufficiently informative.	3.91(0.98)	3.78(0.94)	**3.99(0.89)**	0.040**
	Average (value of the construct)	3.87(0.74)	3.74(0.66)	**3.94(0.67)**	0.001***
Satisfaction (S)	S1: I thought this system to explore clothes was easy to use.	**3.94(1.06)**	3.81(0.99)	**3.94(0.92)**	0.242
	S2: I felt very confident using this system to explore clothes.	**3.86(0.93)**	3.70(0.93)	3.84(0.97)	0.058*
	S3: This system made me confident about my decision.	3.87(0.92)	3.83(0.78)	**3.92(0.95)**	0.233
	Average (value of the construct)	3.89(0.76)	3.78(0.68)	**3.90(0.73)**	0.038**

TABLE 2. Post-task questionnaire results grouped by CEI-II value. The last column (Overall) shows the results concerning the overall sample of participants. The highest values for each user group are in boldface. Stars denote the statistical significance of the difference between the best-performing model and the other ones. Significance levels: (****)$p < 0.001$, (***)$p < 0.01$, (**)$p < 0.05$, (*)$p < 0.1$.

		Low CEI-II (< 4, 122 people)	High CEI-II (≥ 4, 129 people)	Overall
Decision Making (D)	SH			
	LABELSH	**3.60(0.70)****	**4.31(0.42)**	**3.96(0.67)****
	LABELSHNEW	3.40(0.70)	4.24(0.46)	3.83(0.73)
Interface Adequacy (I)	SH	3.45(0.74)	4.26(0.47)	3.87(0.74)
	LABELSH	3.31(0.61)	4.15(0.41)	3.74(0.66)
	LABELSHNEW	**3.54(0.63)****	**4.33(0.45)*****	**3.94(0.67)*****
Satisfaction (S)	SH	3.42(0.72)	**4.34(0.49)*******	3.89(0.76)
	LABELSH	3.42(0.68)	4.13(0.48)	3.78(0.68)
	LABELSHNEW	**3.48(0.75)**	4.31(0.43)	**3.90(0.73)****

- *Decision-making (D).*
  We analyze this construct to understand whether, based on participants' declarations, the three user interfaces impact decision-making. This analysis is aimed to verify hypotheses H4, H5 and H6.
  LABELSH is better than LABELSHNEW on this construct with a statistically significant difference in statement D1 (M = 3.96, $p < 0.01$). This means that people found the visual labels more useful when they compared clothes using LABELSH than LABELSHNEW. Moreover, participants' answers provide weak evidence that the visual labels, as well as the sentence promoting second-hand clothes, impacted their selection decisions

more when using LABELSH (D2: M = 0.99; D3: M = 3.94) than with LABELSHNEW (D2: M = 3.94; D3: M = 3.80).
The superiority of LABELSH over LABELSHNEW is interesting because these user interfaces employ the same digital nudges but the former only suggests second-hand items while LABELSHNEW exposes the user to new items, as well.

- *Interface Adequacy (I).*
  We analyze this construct to understand whether our digital nudges impact users' evaluation of the comprehension and informativeness of the user interface. This analysis is aimed to verify hypotheses H1, H2, and H3.

TABLE 3. Post-task questionnaire results grouped by Environmental Sustainability and Ethical Standards profile (EE). Same notation as in Table 2.

		Low EE ($<$ 4, 127 people)	High EE ($\geq$ 4, 124 people)	Overall
Decision Making (D)	SH	**3.70(0.73)***	**4.22(0.50)**	**3.96(0.67)****
	LABELSH	3.47(0.77)	4.18(0.47)	3.83(0.73)
	LABELSHNEW			
Interface Adequacy (I)	SH	3.59(0.77)	4.14(0.59)	3.87(0.74)
	LABELSH	3.45(0.65)	4.03(0.54)	3.74(0.66)
	LABELSHNEW	**3.65(0.69)***	**4.24(0.51)***	**3.94(0.67)****
Satisfaction (S)	SH	3.53(0.81)	**4.24(0.52)***	3.89(0.76)
	LABELSH	3.49(0.72)	4.07(0.50)	3.78(0.68)
	LABELSHNEW	**3.58(0.78)**	4.22(0.52)	**3.90(0.73)****

Participants perceived LABELSHNEW as the best user interface for all the statements of this construct with statistically significant differences. They said it was the less cluttered (I1: M = 3.89) and most intuitive user interface (I2: M = 3.95), and the strongest one as far as informativeness is concerned (I3: M = 3.99).

- *Satisfaction (S).*
  The analysis of this construct is aimed at understanding whether the user is satisfied with the user interface, in terms of ease of use and confidence in decision-making. This analysis contributes to hypotheses H1, H2, and H3.
  LABELSHNEW is the best user interface on this construct (M=3.90) but the detailed results are mixed.
  Participants considered both SH and LABELSHNEW as the easiest-to-use solutions (S1: M = 3.94). They stated that, when exploring clothes, they felt more confident when using SH (S2: M=3.86) than the other user interfaces. However, LABELSHNEW made them more confident in their decisions (S3: M=3.92).

2) UX ANALYSIS BASED ON PARTICIPANTS' CURIOSITY
To further understand user experience and test H2, we analyzed the three user experience constructs by splitting the sample of participants according to their curiosity level. We grouped people depending on the values they obtained when they answered the Curiosity and Exploration Inventory-II (CEI-II) questionnaire. This supports the understanding of their motivation to seek out knowledge and new experiences (Stretching) and their willingness to embrace the novel, uncertain, and unpredictable nature of everyday life (Embracing). Participants with a low (or high) CEI-II value have low (high) Stretching and Embracing levels. Table 2 shows the user experience results.

- The findings concerning the group with low CEI-II levels are similar to those of the overall sample. LABELSH is the best-performing model on the *Decision Making* construct. LABELSHNEW is the best one in *Interface Adequacy* and *Satisfaction*. These results are statistically significant except for *Satisfaction*.

- The user experience of participants with high CEI-II values is higher than that of the overall sample. This indicates that these people particularly appreciated the three user interfaces. Their preferences are coherent with those of the low CEI-II group regarding the *Decision Making* and *Interface Adequacy* constructs. However, they felt slightly more satisfied when using SH (M = 4.34) than LABELSHNEW (M = 4.31). These differences are statistically significant except for *Decision Making*.

3) UX ANALYSIS BASED ON EE PROFILES
We grouped participants based on the data regarding environmental sustainability and ethical standards elicited in the post-test questionnaire to test H3. For each user, we computed the **EE profile** as the arithmetic mean of the importance (s)he gave to air conservation, water conservation, workers' well-being, and respect for animals in buying clothes. Table 3 shows the user experience results:

- The participants having a low EE value felt more satisfied when using LABELSHNEW, similar to the overall sample. However, the *Satisfaction* construct didn't achieve statistically significant results.

- Those having a high EE score were more satisfied when interacting with SH. Moreover, the average values they provided are higher than those of the low EE group and the complete participants' sample.

4) SUMMARY
The user experience results concerning the overall participants' sample, and those regarding the subgroups identified by the level of curiosity, and by EE profiles show that:

- LABELSH is the preferred user interface for *Decision Making* on the overall sample and on all its splits.

- LABELSHNEW received the highest evaluations of the *Interface Adequacy* on the overall sample and its splits.

- Regarding *Satisfaction*, the overall sample of participants, and those having low curiosity or a low EE profile preferred LABELSHNEW. The other people preferred the SH user interface. These results are unexpected. We discuss them in Section VIII, which combines the various types of information collected in the user study.

TABLE 4. Declared influence of item aspects on participants' selection decisions for each user interface we tested. The results concern the overall participants' sample and the subgroups identified by the Environmental Sustainability and Ethical Standards profile (EE).

	User Interface	Low EE	High EE	Overall
Environmental Sustainability	SH			
	LABELSH	0.27	0.38	0.33
	LABELSHNEW	0.33	0.43	0.38
Ethical Standards	SH			
	LABELSH	0.33	0.43	0.38
	LABELSHNEW	0.39	0.42	0.40
Color	SH	0.60	0.67	0.64
	LABELSH	0.52	0.68	0.60
	LABELSHNEW	0.55	0.66	0.61
Materials	SH	0.47	0.60	0.53
	LABELSH	0.38	0.52	0.45
	LABELSHNEW	0.43	0.44	0.43
Style	SH	0.40	0.58	0.49
	LABELSH	0.32	0.45	0.39
	LABELSHNEW	0.34	0.45	0.39
Price	SH	0.51	0.66	0.59
	LABELSH	0.53	0.57	0.55
	LABELSHNEW	0.52	0.61	0.56

Overall, these findings suggest that the visual labels we designed (LABELSH and LABELSHNEW) enhanced user experience. Moreover, the fairly high evaluations provided by participants show that they appreciated the user interfaces, with different degrees of preference depending on the considered aspect of user experience.

C. DECISION-MAKING

1) DECLARATIONS ABOUT THE INFLUENCE OF ASPECTS ON THE SELECTION OF CLOTHES

Table 4 reports the fractions of participants' answers to the question "Which aspects of the product you chose positively affected your decision?" that the test application posed immediately after participants confirmed their final choices. By analyzing the fractions of choices in the overall participants' sample, and those in the low/high EE groups, we notice that:

- Color is the strongest factor in clothes selection. The majority of users declared that it positively impacted their decisions, regardless of the applied user interface, both in the overall sample and in the splits.
- Price is very important as well. However, considering the overall sample and the high EE group, a larger number of participants stated that it positively influenced their choices when interacting with SH than with LABELSH or LABELSHNEW.
- The materials positively influenced more than 50% of the overall sample, and 60% of the high EE group when using the SH user interface. However, the rates are lower when using LABELSH, and LABELSHNEW. For all the user interfaces, the fraction of the high EE group declaring that the materials positively impacted their choices is larger than the one of the other group.

TABLE 5. Log analysis. Distribution of final choices among pivots, new and second-hand clothes. In the third row, the value for SH and LABELSH is 0 because these user interfaces only recommend second-hand clothes.

	SH	LABELSH	LABELSHNEW
Percentage of final choices which were pivot	0.36	0.33	0.29
Percentage of final choices which were second-hand clothes	0.64	0.67	0.50
Percentage of final choices which were new clothes	0	0	0.21

- The style of clothes is considered influential but the rate of participants is higher when using SH than with the other user interfaces, regardless of the split.
- Ethical standards are slightly more influential than environmental sustainability, but they are less influential than the previous aspects. Specifically, the rate of participants who declared that environmental sustainability influenced their choices is 33% for LABELSH and 38% for LABELSHNEW. As far as ethical standards are concerned, these rates are 38% and 40%, respectively. Consistently with the previous aspects, we observe higher rates for the high EE group than for the other one.

These findings suggest that the visual labels displayed by LABELSH and LABELSHNEW weaken users' perception of the influence of the other item properties and, possibly, their evaluation criteria. Only color and, partially, price, are considered as influential across user interfaces.

2) LOG ANALYSIS

We logged participants' final choices and we analyzed the properties of the selected items. To understand whether the presence of our digital nudges impacted decision-making, we made two different analyses:

- The former investigates the selection of **new clothes vs. second-hand ones**. Table 5 shows the rates of final choices in which participants (i) confirmed the pivot item selected from the catalog of new clothes, (ii) selected a second-hand product or (ii) selected a product from the list of new garments:
  - By comparing the user interfaces that only present second-hand clothes, we notice that people maintained the pivot as the final choice a bit more frequently with SH (36%) than with LABELSH (33%).
  - When interacting with SH and LABELSH, more than 64% of participants preferred to select a second-hand garment as their final choice (the others confirmed the pivot). With LABELSHNEW, 50% of the people selected a second-hand product, and 50% either confirmed the pivot (29%) or chose a new garment (21%).

  The conversion rates to second-hand clothes shown in Table 5 are very encouraging if compared to previous analyses of consuming behavior. As described

in Section II, Persson and Hinton reported that, in 2020, the revenue from the sale of second-hand clothes in Sweden amounted to 7% of the total revenue generated from new clothes [6]. From this data, we estimated the distribution of new and second-hand garments by exploiting the mean prices of clothes in our dataset (real prices extracted from Zalando's catalog). The result is that the sales of second-hand clothes corresponding to Persson and Hilton's report amounted to about 35% of the total number of transactions, against the 50% we observed in our user study.

On the other hand, the comparison of the conversion rates when participants used SH and LABELSH suggests that the visual labels of items have a relatively minor impact on decision-making w.r.t the promotional sentences presented in both user interfaces.

- To better understand the characteristics of the final choices, we focus on LABELSHNEW, which proposes both new and second-hand clothes. We investigate the fraction of selections involving garments whose sustainability/ethical standards evaluation is better than the pivot; see Table 6. Unfortunately, we could not find any reports about ethical consumption in the clothing domain to be used as a benchmark.

As far as the selection of new clothes is concerned (21% of the total number of final choices), 57% of products have a higher overall score than the pivot. In detail, more than half of the new clothes selected by participants are greener than the pivot but sustainability prevails over ethical standards:

- - 57% of these items have a higher air conservation score and 52% have a higher water conservation score.
- - 48% have a higher workers' well-being score and 38% a higher score concerning respect for animals.

In the selection of second-hand clothes (50% of the total number of selections), 86% of the products have a higher overall score than the pivot:

- - A large majority of second-hand clothes have higher sustainability than the pivot. In detail, 90% have a higher ($>$) air conservation score and 78% a higher ($>$) water conservation score.
- - Fewer have a higher score regarding workers' well-being (34%) or respect for animals (22%).

The same trend can be observed in the third column of Table 6, which covers the whole set of items selected by participants to replace the pivots (71% of all the choices).

To conclude, participants' choices might have been mediated by item properties such as price, and materials that might sensibly differ from those of the pivot item. However, these findings suggest that people paid relatively more attention to environmental sustainability than to brands' ethical standards. Moreover, as far as

TABLE 6. Log analysis relative to LABELSHNEW. Percentage of choices of items having higher sustainability/ethical standards scores than the pivots selected by participants.

LABELSHNEW	New clothes (21% of choices)	Second-hand clothes (50%)	Second-hand and new (71%)
Overall rating	0.57	0.86	0.77
Air conservation	0.57	0.90	0.80
Water conservation	0.52	0.78	0.70
Workers' well-being	0.48	0.34	0.38
Respect for animals	0.38	0.22	0.27

ethical standards are concerned, participants cared more about workers' well-being than respect for animals.

VIII. DISCUSSION

The results of the user study enable us to confirm almost all the hypotheses listed in Section V-A; see Table 7.

H1 *Our digital nudges positively influence the user experience with the user interface.*

As discussed at the end of Section VII-B, this is supported by the fairly high evaluations of the three user interfaces reported in Tables 1, 2, and 3. These tables also show that most participants preferred LABELSH and LABELSHNEW (that present detailed information about water consumption, CO_2 emissions, and brands' ethical standards) to SH which promotes second-hand garments through a sentence.

H2 *Users' curiosity (CEI-II level) positively impacts the user experience with the user interfaces.*

We partially accept this hypothesis.

Table 2 shows that, concerning the *Decision Making (D)* and *Interface Adequacy (I)*, participants' preferences were the same regardless of their CEI-II values. In contrast, the high CEI-II group was unexpectedly more satisfied (*Satisfaction (S)*) with SH, which is the less informative user interface, while the other group preferred the other two.

We can explain the preference for SH with the expected openness of highly curious people to new experiences, combined with the low interest in brands' ethical standards; see Table 6. Specifically, SH recommends garments having maximum sustainability; therefore, it is sufficient to choose the product to buy. Differently, people having low CEI-II values are less willing to embrace new experiences. Thus, they might have preferred to receive more information about items through the visual labels displayed by LABELSH and LABELSHNEW.

H3 *Users' interests in environmental sustainability and brands' ethical standards impact the experience with the user interface.*

Table 3 supports this hypothesis by showing that the high EE group gave higher UX scores to the user interfaces than the other participants.

The two groups disagreed on the *Satisfaction (S)* construct but the people with lower interest in sustainability

TABLE 7. Evaluation of the hypotheses defined in Section V-A.

Hypothesis	Evidence	Outcome
H1: *Our digital nudges positively influence the user experience with the user interface.*	Post-task questionnaire (Tables 1, 2, and 3).	Accepted
H2: *Users' curiosity (CEI-II level [43]) positively impacts the user experience with the user interface.*	Post-task questionnaire (Table 2), Log analysis (Table 6).	Partially accepted
H3: *Users' interests in environmental sustainability and brands' ethical standards impacts the experience with the user interface.*	Post-task questionnaire (Table 3), Post-test questionnaire to build the EE profiles.	Accepted
H4: *Users' interests in environmental sustainability and brands' ethical standards influence decision-making towards green consumption.*	Post-task questionnaire (statement D2 of Table 1) and Table 3, Post-test questionnaire to build the EE profiles, Question "Which aspects of the products you chose positively affected your decision?" (Table 4). Log analysis (Table 6) to estimate users' interests in brands' ethical standards.	Accepted
H5: *Showing information about environmental sustainability and ethical standards of items' brands induces green consumption.*	Question "Which aspects of the product you chose positively affected your decision?..." (Table 4), Post-test questionnaire to build the EE profiles, Log analysis (Table 6).	Partially accepted
H6: *Informing users that buying second-hand clothes preserves the environment increases the conversion rate to this type of product.*	Post-task questionnaire (Table 1, statement D3), Log analysis (Table 5).	Accepted
H7: *Enriching the presentation of clothes with information about products' sustainability mitigates people's tendency to buy new garments.*	Log analysis (Tables 5 and 6).	Accepted

and ethical standards preferred `LABELSHNEW` while the other group preferred `SH`. In principle, people having a high EE profile should be interested in receiving sustainability and ethical standards data but the results were the opposite. However, the partitions by curiosity and by EE profiles have a large overlap that might have influenced this finding: out of the 129 people with high CEI-II values, 93 (72%) also had a high EE value. This fact might have biased the results.

H4 *Users' interests in environmental sustainability and brands' ethical standards influence decision-making towards green consumption.*

Participants' answers to the questionnaires confirm this hypothesis. People exhibited a high level of agreement with statement D2 of Table 1, where the mean evaluation is 3.99 for `LABELSH` and 3.94 for `LABELSHNEW`. Moreover, in Table 3, the high EE group gave a higher decision-making score to the user interfaces than the low EE group. Furthermore, Table 4 shows that, in the high EE group, a larger fraction of people declared that environmental sustainability and ethical standards information positively affected selection choices than in the low EE group.

H5 *Showing information about environmental sustainability and ethical standards of items' brands induces green consumption.*

We partially accept this hypothesis by analyzing user behavior with `LABELSHNEW`.

Table 6 shows that 71% of final choices differed from the pivot. Within that set of items, 77% had a better overall rating than it. Moreover, when

users chose a new garment, this was greener than the pivot in more than half of the time. However, the rates of final choices whose brands guarantee good ethical standards are lower for both new and second-hand clothes. Thus, it seems that sustainability data influences consumption fairly strongly while the impact of information about ethical standards is weaker.

H6 *Informing users that buying second-hand clothes preserves the environment increases the conversion rate to this type of product.*

This is supported both by participants' selection behavior and their answers to the questionnaires. As reported in Table 5, when users interacted with `SH` (which promotes second-hand clothes through a sentence but does not show the visual labels), 64% of final choices were second-hand garments. This value is much higher than the 35% we estimated by analyzing the results reported in [6]. Moreover, users agreed with the statement D3 of Table 1 both for `LABELSH` (with an average of 3.96) and `LABELSHNEW` (3.83).

H7 *Enriching the presentation of clothes with information about products' sustainability mitigates people's tendency to buy new garments.*

We confirm this hypothesis thanks to the results of Tables 5, and 6. Table 5 shows that participants selected a second-hand garment 67% of the time with `LABELSH` (that shows the visual labels), and 64% with `SH`. Moreover, when our application suggested both new and second-hand clothes (`LABELSHNEW`), people chose 50% second-hand products. Both values are much higher than the 35% we estimated by analyzing the results of [6].

TABLE 8. First questionnaire about demographic information, cultural background, and familiarity with booking and e-commerce platforms.

Question	Options
Please, select your gender:	Male, Female, Non-binary, Prefer not to answer
Please, indicate your age:	<= 20, 21 - 30, 31 - 40, 41 - 50, 51 - 60, >= 60
Please, select your education level:	Primary School, Middle School, High School, University, Doctorate
Please, select your background:	Humanities, Scientific, Language Studies, Technical, Economics, Other
How would you rate yourself as a computer user?	No experience, Beginner, Average, Advanced
How frequently have you used booking and e-commerce sites (e.g.: Amazon, Zalando, etc.)?	Never, Infrequently (just a few times overall), Moderately (a few times a year), Regularly (a few times a month)

IX. LIMITATIONS AND FUTURE WORK

Online fashion retailers recently started to enrich the presentation of products with sustainability information. However, they adopt minimalist nudges that provide poor data about items and brands. To our knowledge, the present work is the first attempt to nudge users by considering multiple criteria on environmental sustainability and ethical standards.

Despite the effort we put into this work, it has some limitations that we discuss in the following:

- Environmental sustainability includes different facets such as data about chemical dispersion, and the impact of clothing manufacturing and distribution. We could not find any datasets reporting this information by product category. Thus, we approximated environmental sustainability using air and water conservation as indicators related to the production of the material. We plan to extend our work with further indicators.
- We investigated informational nudges to enrich product presentation. However, it would be interesting to use and test the impact of other nudges [12], such as incentives in the form of discounts if a person buys a green product. Another relevant technique is the decoy effect [52] that occurs when the preference for one of two options changes dramatically when a third, similar but less attractive option is added to the set.
- In the user study, a relevant group of people was simultaneously classified as highly curious and having a high interest in sustainability and brands' ethical standards. Having used a crowdsourcing platform to recruit participants, we could not foresee this coincidence, which limited the analysis of results. To address this issue, we plan to organize another user study, hoping to involve a more diverse set of people.

In our future work, we also plan to assess the applicability of the digital nudges we designed in other application domains such as food recommendations or the sales of different types of products.

X. CONCLUSION

This paper investigated digital nudges to promote green fashion consumption in online catalogs using recommender systems. We aimed to induce users to choose sustainable items from brands with good ethical standards through preference satisfaction and awareness support.

In a user study involving 251 participants, we enriched clothes recommendations with (i) sentences that promote second-hand garments and (ii) visual labels that summarize sustainability and ethical standards information about items. In this way, we induced a relevant fraction of our participants to choose green products. Moreover, we obtained a conversion rate to second-hand garments that was much higher than what previous consumer behavior studies observed. However, participants' interest in brands' ethical standards seemed to be secondary to sustainability.

According to previous analyses of sustainable consumption behavior, people's interest in environmental sustainability has grown. However, the same kind of sensitivity can be hardly found when thinking about the ethical issues concerning the production cycle. Our findings confirm these observations and enforce the need to enhance user awareness about ethical issues regarding workers' well-being and respect for animals. Specifically, the results we obtained in our user study suggest increasing the adoption of nudges in clothes recommender systems to enhance user awareness about items, their sustainability, and their social impact.

APPENDIX
FIRST QUESTIONNAIRE ADMINISTERED BY THE TEST APPLICATION

See the Table 8.

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