An Approach to Controlling User Models and Personalization Effects in Recommender Systems

Fedor Bakalov[1], **Marie-Jean Meurs**[2,3], **Birgitta König-Ries**[1],
Bahar Sateli[2], **René Witte**[2], **Greg Butler**[2,3], **and Adrian Tsang**[3,4]
[1]Institute for Computer Science, Friedrich Schiller University of Jena, Germany
[2]Department of Computer Science and Software Engineering, Concordia University, Montréal, QC, Canada
[3]Centre for Structural and Functional Genomics, Concordia University, Montréal, QC, Canada
[4]Department of Biology, Concordia University, Montréal, QC, Canada

ABSTRACT
Personalization nowadays is a commodity in a broad spectrum of computer systems. Examples range from online shops recommending products identified based on the user's previous purchases to web search engines sorting search hits based on the user's browsing history. The aim of such adaptive behavior is to help users to find relevant content easier and faster. However, there are a number of negative aspects of this behavior. Adaptive systems have been criticized for violating the usability principles of direct manipulation systems, namely controllability, predictability, transparency, and unobtrusiveness. In this paper, we propose an approach to controlling adaptive behavior in recommender systems. It allows users to get an overview of personalization effects, view the user profile that is used for personalization, and adjust the profile and personalization effects to their needs and preferences. We present this approach using an example of a personalized portal for biochemical literature, whose users are biochemists, biologists and genomicists. Also, we report on a user study evaluating the impact of controllable personalization on the usefulness, usability, user satisfaction, transparency, and trustworthiness of personalized systems.

ACM Classification Keywords
H.5.2 User Interfaces: Natural language, User-centered design; H.5.4 Hypertext/Hypermedia: Architectures, Navigation, User issues

Author Keywords
adaptive hypermedia, personalization, user modeling, usability

INTRODUCTION

Personalized information systems emerged as an answer to the problem of steadily growing amounts of information and constantly increasing complexity of navigation in the information space that overwhelms the user. These systems are able to learn about the needs of individual users and to tailor the content, appearance, and behavior to the user needs. Examples of personalization range from online shops recommending products identified based on the user's previous purchases to web search engines sorting search hits based on the user's browsing history. The aim of such adaptive behavior is to help users to find relevant content easier and faster. To achieve such behavior, the system needs a user model providing information about users, e.g., about their interests, expertise, background, or traits. It also needs metadata of information resources and some logic or rules that govern how the resources must be delivered to users given their user model.

In most personalized systems, the user model and the process of adaptation are hidden from users. Users see only the resulting personalization effects. But they do not have direct access to the information the system collects about them and do not have control over the personalization behavior. This results in a number of grave usability and privacy problems. It violates two of Nielson's ten usability principles [15]: hiding user models *occludes the system status* and *hinders control over the system*. Jameson in [8] identifies further problems of personalized systems. Preventing users from accessing their user models and controlling personalization has a negative impact on the predictability and transparency of the system. It may also limit the user experience, i.e., due to incompleteness of the user model, the system may filter out relevant and important information. Finally, hindering users from accessing the user model violates privacy legislation of many countries [11, 17]. For instance, according to the German Act on the Protection of Personal Data Used in Teleservices (Gesetz über den Datenschutz bei Telediensten),

> "§7 User's right to information
> The user shall be entitled at any time to inspect, free of charge, stored data concerning his person or his pseudonym at the provider's. The information shall be given electronically if so requested by the user." [1]

To mitigate the usability and privacy problems, personalized systems must provide users full control over the user model and the personalization. However, introducing controllability into a personalized system brings a number of challenges: (1)

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Since controllability of personalization has not yet become an integral feature of all personalized systems, an average user might not have developed the mental model of how to control the user model and personalization effects [6]; (2) Controlling adaptation is certainly not the main task the user wants to accomplish in an adaptive system. Therefore, the user might not have sufficient motivation to do it, especially if it requires training or specific skills; (3) In the case of systems applying complex adaptation rules, it might be difficult for users to understand the adaptation process and adjust it to their personal needs.

In this paper, we propose an approach to controlling user models and personalization effects in recommender systems. This approach leverages IntrospectiveViews, a visualization of semantic user models proposed by Bakalov et al. in [4]. It uses the visualization as a means to explain the adaptive behavior to users and to allow them to adjust this behavior to their preferences in an efficient and easy-to-use way. The approach allows users to directly see how a change in the user model affects the personalization. It also includes a method allowing users to apply personalization effects they like or to deactivate them. We present this approach using an example of a portal for biochemical literature, which provides a personalized single point of access to bibliography harvested from multiple scientific databases. Furthermore, we evaluate the impact of our approach on the perception of personalized systems by users, namely on the usefulness, ease of use, ease of learning, satisfaction, and trustworthiness.

The main contributions of this paper are twofold. First, it presents a method that can be applied in various recommender systems for empowering users to adjust user models and personalization effects to their needs and preferences. Second, it provides insights into how users perceive this control.

This paper is organized as follows. Section provides a short overview of the previous research related to controllable personalization and scrutable user models. Section outlines the system components required for controllable personalization in a content aggregating portal. Section presents a graphical user interface and interaction patterns for viewing and editing user models and adjusting personalization effects. In Section , we report on a user study evaluating the impact of giving users control over personalization. Finally, Section summarizes the paper and outlines the directions for our future work.

RELATED WORK

The usability and privacy problems of personalized systems have received much attention in the research areas of adaptive hypermedia and user modeling. A number of approaches have been proposed for scrutable user modeling. For instance, the um_view interface [5] allows traversing through a user model by expanding the tree of leaves and viewing detailed information about the items in the model. VlUM [20] and its successor SIV [9] are capable of visualizing large user models and enable users to get an overview of the whole model, view a subset of related beliefs, filter items by relevance, and obtain detailed information about the displayed items. STyLE-OLM [7] and ViSMod [22] visualize learner models using concept graphs and Bayesian Networks, respectively. However, most approaches to scrutable user modeling are primarily focused on allowing users to view information stored in the model. Little research has been conducted with respect to providing users full control over the user model, including edit operations on the model.

Even less research has been conducted with respect to bridging the changes on the user model initiated by users and the end effects these changes have on the personalization. Czarkowski [6] proposes a system for scrutable adaptive hypertext, in which personalized fragments of web pages are supplemented with textual messages showing what information from the user model was used for personalization. It also allows users to change user models, and hence influence the personalization in the system. More visual approaches to explaining the implication of changes in the user model are proposed by Kliger [10] and Tsandilas and Schraefel [19]. Kliger's PeerGlass architecture, next to personalized content, displays 3D visualizations of the parts of the user model that were used for personalizing the content. Additionally, it allows users to open the user model directly from the personalized page, make necessary changes in it, and see the effect on personalization. Similarly, the system proposed by Tsandilas and Schraefel displays the user model next to the personalized text. A change in the model is projected on the personalized text, so that the user can see the direct link between the user model and the personalization.

The three aforementioned approaches for explaining personalization effects leverage simple and relatively small user models. In contrast, our approach is suitable for the visualization of very large ontology-based user models. It empowers users to obtain an overview of the entire model, filter items, and zoom in and out. It shows semantic relations between items and provides additional information about selected items. It also allows users to edit the status of items, add new items, and delete items from the model in an intuitive and easy-to-use way. In addition, our approach supports multiple personalization effects for a single resource. It allows users to select effects they like for each resource individually. Finally, it allows user to switch personalization on and off.

SYSTEM ARCHITECTURE

In this section, we present the system architecture of a web portal that enables users to view and edit their user models and fine tune personalization effects. We describe the proposed architecture using the example of a portal providing personalized access to bibliography harvested from multiple scientific databases, such as PubMed[1]. The ultimate goal of this portal is to assist scientists in keeping track of relevant literature. To accomplish this goal, users must be able to search publications using keywords and other metadata attributes, e.g., author, title, or publication date. However, the number of returned search hits can be extremely large, e.g., for the search query "bacterial cellulose", the PubMed database returns more than five thousand hits. Therefore, the portal must

[1] http://www.ncbi.nlm.nih.gov/pubmed

provide a method for helping users to identify the most relevant hits. This can be achieved in a number of ways. For instance, the entire set of search hits can be sorted according to the relevance of the interests of individual users. Alternatively, the portal can foreground the most relevant of the user hits. It can also highlight the parts of retrieved content that is likely to be interesting for the user.

Below we describe a system architecture that provides components required for such adaptive behavior. It consists of four units displayed in Figure 1.

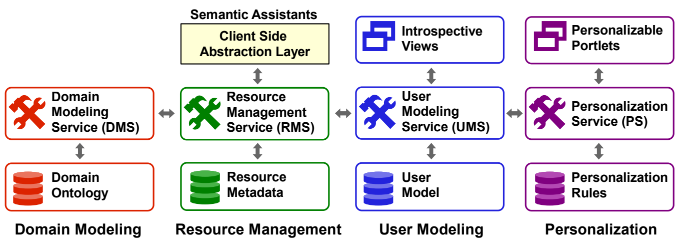

Figure 1. Portal system architecture

Domain Modeling Unit encapsulates the components responsible for storing, accessing, and managing the domain model representing the machine-processable description of the domain knowledge. The domain model is represented as an ontology, formalized in the Web Ontology Language (OWL)[2].

Resource Management Unit is responsible for harvesting and annotating literature from multiple scientific databases. For literature harvesting, we leverage the approach proposed by Schimratzki et al. in [16], whereas the semantic annotation of literature is achieved by processing the retrieved content with named entity extractors provided by the Semantic Assistants framework, an open source framework described in [21].

User Modeling Unit provides the models, mechanisms, and interfaces for managing information about users that are required for adaptation, namely, interests of individual scientists. It is designed as an overlay model: user interests are represented as an overlay of domain concepts defined in the domain ontology. For each concept, the user model stores information about the exact *degree* to which the user is interested in it. The user model is updated following a hybrid approach to user modeling proposed by Bakalov et al. in [3]. This approach supports automatic updates of the model based on a user's browsing history and the semantic structure of the domain knowledge model. Also, it enables users to update their profiles through the user model visualization presented in Section .

Personalization Unit stores personalization rules and provides mechanisms for performing personalization in the portal. As described in detail in Section , the portal content is delivered to users through personalizable portlets[3]. Users can view portlets in standard or personalized states. In a personalized state, users can choose between several personalization effects. For example, they can choose whether publications must be sorted by interest or chronologically. If a portlet is requested in a personalized view, the portlet invokes the personalization service. The service retrieves user personalization preferences to determine what personalization effects must be generated for the given portlet and user. It also retrieves metadata of the requested content and interests of the given user. Based on the metadata, user interests, and personalization preferences, it personalizes the content and passes it to the requesting portlet.

USER INTERFACE

The proposed framework was implemented and deployed on an IBM WebSphere Portal Server[4]. Figure 2 displays a personalized page that users see after they have logged in to the portal. This page consists of a number of portlets providing different types of content and functions. The *Query* portlet on the left displays a list of user search queries, which are used by the portal to retrieve publications from scientific databases. This portlet allows users to add, edit, and delete queries and organize them hierarchically. Upon a mouse click on a query, the portal will display a list of matching publications in the *Listing* portlet.

The *Listing* portlet allows users to request various types of semantic assistance on the content displayed. Users can view a list of named entities extracted from the publications or summaries of the publications. All types of assistance supported by the portlet can be seen in the *Semantic Assistants* menu, in which they can choose an assistant they want and set desired view options for the assistant results. Depending on the type of assistant, its results can be displayed in the source text, as an index, a map, or a text in a side portlet. For instance, Figure 2 displays results of the mycoMINE assistant [14], which extracts entities and facts related to fungal enzymes, such as enzymes, assays, genes, substrates and pH, temperature or activity assay conditions. The entities extracted by the assistant are underlined in the text of publications listed in the origin portlet. They are also displayed as an index in a side portlet. The index portlet lists all entities grouped by entity type. By hovering the mouse pointer over an entity in the index, all mentions of this entity will be highlighted in the text of publications. Users can also obtain some additional information about the extracted entities. By clicking an entity in the index, they can get all features of the entity, e.g., alias, abbreviations, and links to scientific databases.

Portal content and results of semantic assistants can be personalized by users. For most portlets, users can select whether they want to see the content in a personalized or a standard view. Users can switch between personalized and standard views using a personalization drop-down menu. This menu can be opened by clicking the heart icon on the portlet title bar. By selecting the *Turn personalization off* command, the portlet will be turned into standard view, i.e., no personalization will be applied on the content of the portlet. By selecting the *Turn personalization on*, the portlet will be displayed in a personalized view.

[2]http://www.w3.org/TR/owl-features/

[3]A portlet is a pluggable user interface component of web portals that provides a specific piece of content or an application

[4]`http://www.ibm.com/software/websphere/portal/`

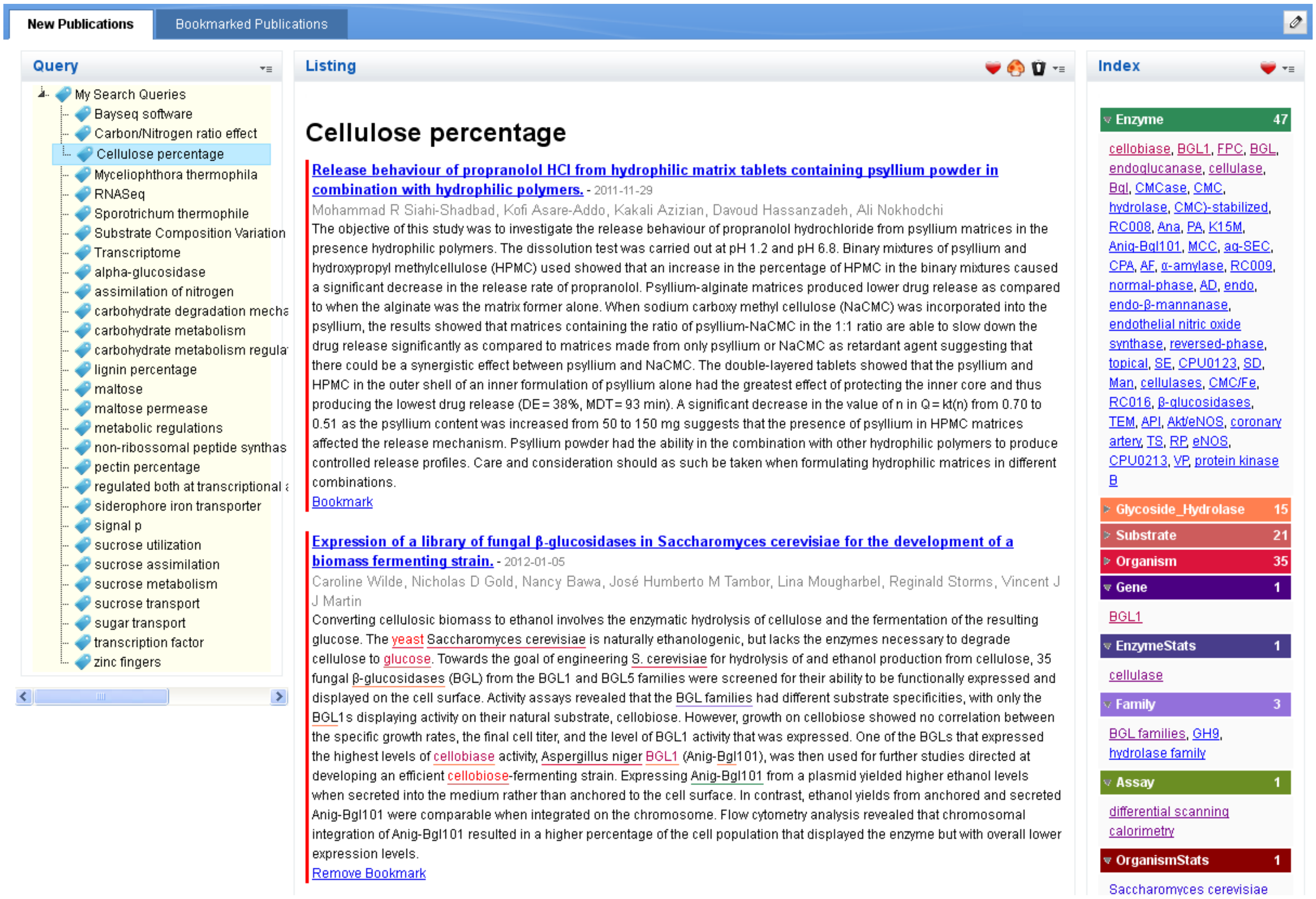

Figure 2. A portal page personalized to an individual user. The *Listing* portlet displays a list of publications sorted and color-coded according to interests of the user. The color codes match the color scheme of the user profile: red colored items represent interesting information. The *Index* portlet provides a personalized list of entities extracted from the publications. Likewise, the entities are sorted and highlighted using the user's interest profile.

In the personalized view, users can view and edit their interest profile, as well as define how the portlet content should be personalized. This can be done in a personalization options window, which can be opened by selecting the *Personalization options & interest profile* command from the portlet personalization menu. The personalization options window (Figure 3) is displayed as an overlay over the portlet. In the upper part, it displays the options for personalization supported by the portlet. The personalization options vary from portlet to portlet. For example, the *Listing* portlet, displaying a list of new publications, supports three personalization effects: (1) publications can be sorted according to the user interest profile; (2) the most interesting of the user publications can be highlighted by a color marker; (3) mentions of items from the user interest profile can be highlighted in the publications list. By selecting corresponding checkboxes, users can achieve the desired personalization effects in the portlet. User changes on the personalization options are immediately projected onto the portlet content.

For visualization of user profiles, we leverage the IntrospectiveViews interface proposed by Bakalov et al. in [4]. The interface (Figure 3) visualizes user interests using a metaphor of circular zones partitioned into slices, where each zone represents items of a certain interest degree and each slice represents items of a specific type, i.e., ontology class. The hot zone in the center displays items that users are strongly interested in. The cold zone at the circle edge displays items that users are not interested in. Items are grouped into circular sectors by type. The profile shown in Figure 3 displays items of such types as enzyme, gene, organism, strain, and some others. In addition to viewing, the visualization allows editing information in the model. It allows adding and deleting items, changing the interest degree, organizing items by type, defining user-specific types, and creating semantic relations among items.

Similarly to changes of personalization options, all changes in the interest profile made through the visualization are immediately projected onto the personalized content. For example, upon a change in the interest profile, the publications in the *Listing* portlet (Figure 2) will be resorted and the color markers of the most relevant publications will be updated. This helps users understand the connection between the user model and the end personalization effects. In turn, this should make the adaptive behavior more transparent and comprehen-

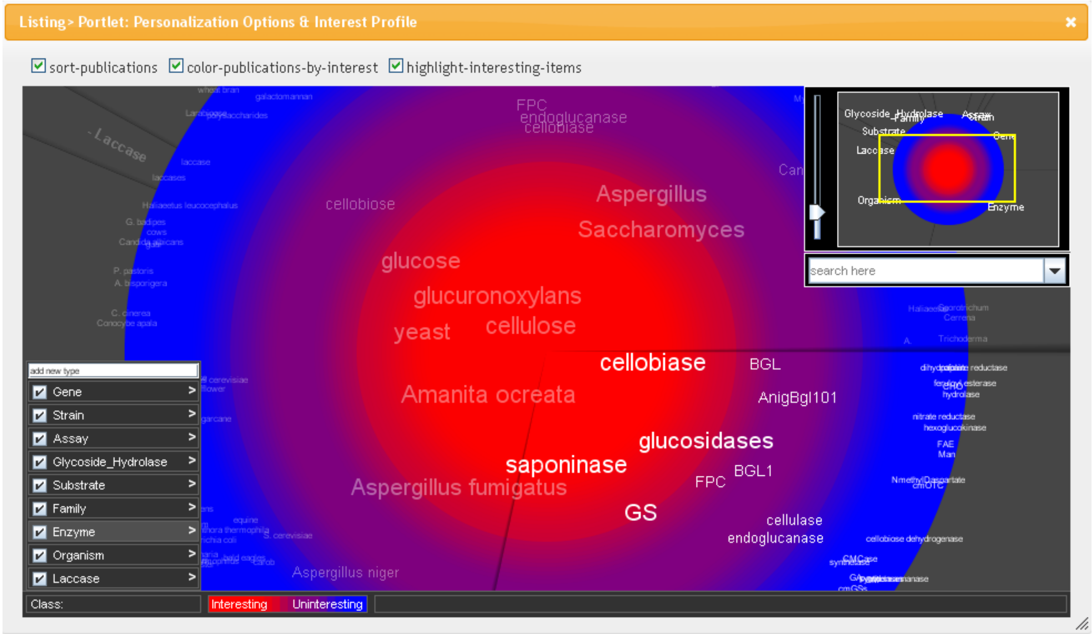

Figure 3. Personalization options and user interest profile

sible for users. This should also help users develop a mental model of affordance to control the adaptive behavior. In the next section, we evaluate whether these goals are achieved by our approach.

EVALUATION

We conducted a user study to evaluate the impact of our approach to controllable personalization on the subjective perception of a personalized system by users. More precisely, we aimed to assess how it affects the usefulness, usability, user satisfaction, and trustworthiness. Also, we aimed to collect user feedback with respect to possible improvements and enhancements of the approach.

The user study was conducted at the Concordia Centre for Structural and Functional Genomics (CSFG)[5]. The subjects of this study were seven employees of the center working in the Genozymes project[6], where the goal is to find novel ways of creating bioproducts and biofuels from green waste. Part of their work is the curation of characterized glycoside hydrolases[7] of fungal origin from the domain literature. The main background of the subjects is biology, chemistry, and genomics.

Study Design

For this user study, we used the personalized portal for biochemical literature presented in Section . The study was conducted in two phases. In the first phase, the subjects were provided with a version of the portal in which the control over personalization was blocked. The subjects knew that the portal collects information about their interests and personalizes its content. More precisely, publications in the portal were automatically sorted according to interests of individual users. Also, the text fragments of publications matching to items in the user model were highlighted by color. However, the subjects did not have access to the user model. They were also not able to switch personalization off or change personalization effects. The subjects were using this version of the portal for the entire duration of the first phase, which lasted two weeks.

At the end of the first phase, we asked the subjects to fill out a questionnaire. The questionnaire was designed based on the USE question set of Arnold Lund [13]. It includes questions regarding to the usefulness, ease of use, ease of learning, and satisfaction. Additionally, we added questions on the novelty and trust. In total, the questionnaire consists of 36 questions grouped into five categories. Figure 4 displays the complete lists of questions. For each question, the subjects were asked to cast a vote on a six-point Likert scale. The questionnaire was available online in the portal. The subjects were able to fill it out on their own computer at any convenient time. After all subjects had completed the questionnaire, we started the second phase of this study. In the second phase, the subjects were provided with a version of the portal that gives the user full control over personalization. In this version, they were able to access the user model, edit it and see the effects on personalization. They were also able to switch personalization on and off and fine tune personalization effects for individual portlets. The subjects were using this version for a period of two weeks. Table 1 provides the system usage statistics on selected interactions that subjects made during the study.

At the end of the second phase, they were asked again to respond to the same questionnaire that they filled out in the first phase. Additionally, we interviewed them. In the interview,

[5] `http://genomics.concordia.ca/`
[6] `http://fungalgenomics.ca`
[7] family of enzymes used to break down plant cell walls

Table 1. System usage statistics

Action	Total	⌀ User
Portlet content request	1369	195,57
Semantic assistant request	76	10,86
Personalization on/off	11	1,57
Personalization interface request	74	10,57
User model change	44	6,29
Personalization effects change	16	2,29

we requested subjects to speak out on the positive and negative aspects of the portal. We also asked them about additional functions and content they would like to have in the portal. The rest of this section presents the results of the two surveys and the interviews.

Results

The results of the two surveys are shown in Figure 4, with respect to individual questions of the survey questionnaire. As can be seen from the figure, providing users control over personalization has a considerable impact on the usefulness, usability, and user satisfaction of the personalized system. On average, the second version of the portal, in which users had control over personalization, received a 23% better rating than the version without the control. In the rest of this section, we discuss the results of the surveys and interviews with respect to the five categories of the questionnaire. We also present our findings with respect to the user modeling and user-driven changes on domain knowledge models of personalized systems.

Usefulness

The first version of the portal received relatively low rating in the *Usefulness* category. We attribute this to the prototypical state of the system and insufficient coverage of literature. In the interviews, most respondents said that they need the portal to be able to harvest publications from all the major scientific databases and to have at least two years of retrospective coverage. They also need a number of additional features, such as advanced search, functions for sharing publications, commenting, and rating.

However, the second version of the portal, which allows fine tuning of personalization, received a 24% better rating of the usefulness than the first version. Despite the prototypical state and low coverage of literature, the respondents rated the second version as a very useful tool that helps them to be more effective and productive. From the interviews, we found out that users like very much to be able to view and edit their interest profiles. They like the functions for applying different personalization effects to the portal content. Users especially like to be able to sort content according to the interest profile. The function for highlighting items from the user model in the text of portal pages was deemed useful as well. To avoid clutter on portal pages, users need to be able to select entity types they are mostly interested in. Only entities of the selected types must be highlighted in the portal.

Also, some respondents requested a function for rating portal content with respect to the relevance to their interest profile. Some said that they like to be able to flag uninteresting and

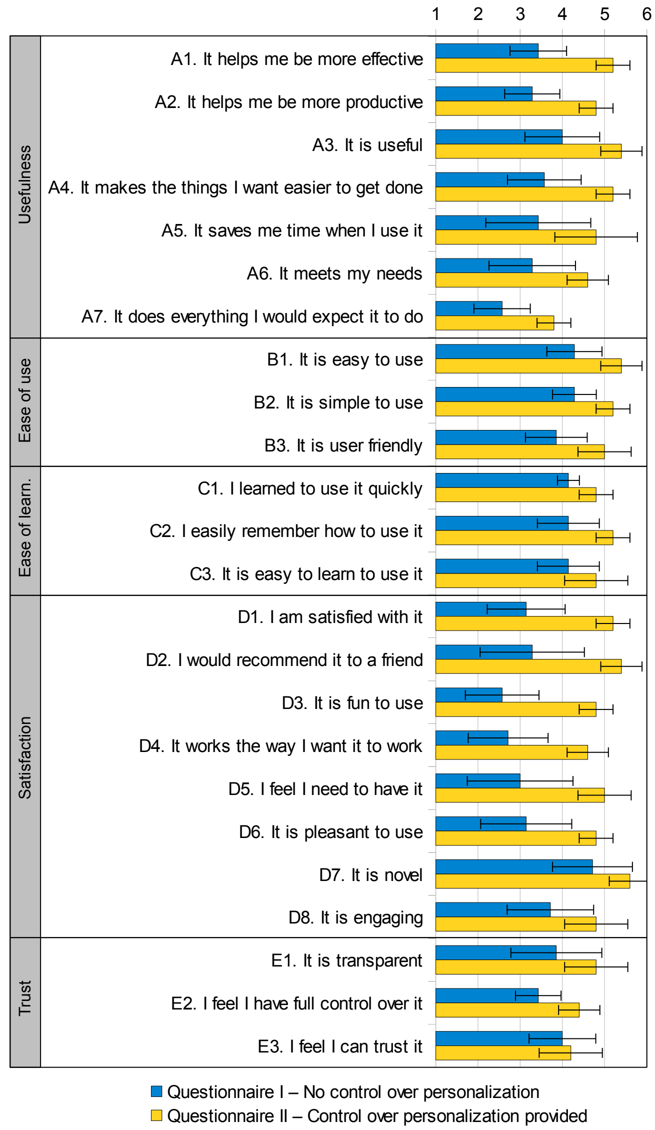

Figure 4. Questionnaire responses

irrelevant content and they want the portal to use this information for updating their interest profiles and improving the retrieval mechanisms. Additionally, we received a number interesting suggestions to further enhance the usefulness of controllable personalization in the portal. For example, several respondents said that they would like to have a function for setting alerts on certain parts of the user model in order to receive a notification when new relevant content becomes available.

Ease of Use and Learning

The version with controllable personalization received better ratings of the ease of use (18% increase) and the ease of learning (13% increase). The better rating in these categories is a surprising observation since the second version had a higher complexity than the first version, i.e., a higher number of control elements and functions. We attribute the improvement of the perceived usability of the second version to the gain of its outward attractiveness. A very strong correlation between the perceived ease of use and the subjective attractiveness of computer systems was first detected by Kurosu and Kashimura [12] and then confirmed in a number of replicated experiments by Tractinsky [18]. These studies reveal that users deem a visually attractive system more usable than its analog with a less attractive appearance.

In the case of the second version of the portal, the improvement of attractiveness is likely to be caused by the interactive visualization of user interests through IntrospectiveViews. The results of the previous study of the usability and hedonic aspects of this visualization [2] show that users deem the visualization visually attractive, engaging, pleasant, and fun to use. Hence, we argue that the integration of this visualization into a personalized system can improve not only its attractiveness, but also the perceived usability.

Satisfaction

In this category, we observed the highest increase of the rating in comparison with the other four categories. The respondents were 29% more satisfied with the portal in which they had control over personalization than with the portal where they did not have such control. All respondents were either satisfied or very satisfied with the second version.

We also observed a strong impact of the interface for controllable personalization on the emotional perception of the portal by users. The results show that the second version is deemed to be 37% more fun-to-use, 28% more pleasant, and 18% more engaging. Also, the willingness to recommend the system to a friend is 35% higher and the user's need to have the system is 33% stronger. This is an important observation because the emotional aspects influence the users' motivation to use their interest profiles for adjusting personalization. Hence, users are more likely to keep the information in the profile up-to-date and accurate. The accurate and complete information in user profiles, in turn, ensures the quality of personalization effects and the precision and recall of content recommendation.

Trust

We observed a 16% increase of the transparency of the second portal version in comparison to the first one. The user's feeling of having control over the system is increased too at the same rate as the transparency. During the interviews, all respondents said that they like to be able to know whether the content is personalized or not and what adaptations have been made. They also appreciated the access to their interest profiles and the ability to choose what personalization effects have to be applied to the content.

However, the results show only a marginal 3% increase of the trustworthiness. From the interviews, we found that some users do not care whether the portal collects information about their interests as long as it uses it for recommending relevant content, whereas others have significant concerns about their privacy. The difference of user attitude to the collection and usage of personal information can also be seen from a relatively high deviation in responses on questions E1 and E3. From these results we can conclude that different users have different concerns about privacy, hence they need different levels of control over their personal data. Those users who wish the highest degree of control should be able to delegate the management of their personal data to some trusted authority or to manage it locally on their desktops. They should be able to control what applications use their personal data and for what purpose.

User and Domain Modeling

The overall feedback with respect to user modeling is very positive. Users liked the function of using interest profiles for personalizing portal content. They liked that these profiles can be updated in both ways: unobtrusively based on the user interaction with the portal and explicitly by users. They also liked very much the visual interface for displaying and editing their profiles.

During the interviews, the subjects made a number of interesting suggestions with respect to a further enhancement of user modeling. Many subjects suggested allowing users to have multiple interest profiles. A user may work for several projects at one time. In different projects users may be responsible for different tasks. Therefore, the portal should allow users to create multiple profiles and to be able to select a profile for personalization effects in a given portal session. Also, respondents suggested having a group profile that reflects interests of a project team or a group of friends. Similar to personal profiles, the portal should allow users to select group profiles for generating personalization effects. In addition to that, some users are willing to share their interest profiles with their colleagues or friends. This function can be especially useful in corporate portals for senior staff and experts willing to share their knowledge with less experienced staff members, e.g., new employees or interns.

Also, one of the factors that had a negative impact on the user satisfaction with the portal is the incorrect classification of certain entities in the user profile. Users found it irritating. However, some of them said that they would be willing to correct the occasional misclassification by rearranging items in their interest profiles, i.e., by moving entities to the corresponding sectors on the interface for user model visualization. These corrections can be used by the portal to update the ontology representing machine-processable semantics of the domain knowledge. This information can be further used to improve the search and personalization in the portal.

It is important to mention the limitations of this study. Due to the small number of participants, it was not possible to conduct it with a control group. It also lacks counterbalancing of the system versions. Hence, we admit that the improved rating of the second version might be partially caused by the gain of the user experience with the system. Nevertheless, the study provides valuable insights into how users perceive the control over personalization. It also provides insights into how this control could be further enhanced.

CONCLUSIONS AND FUTURE WORK

In this paper, we have presented an approach to controlling user models and personalization effects in recommender systems. This approach enables users to access their user models that the system builds and uses for adaptation. It permits users to request a justification about the beliefs the system makes about their traits and override them if necessary. Also, it empowers users to get an explanation about personalization effects the system makes, based on the user profile. In addition, the approach allows users to set the desired degree of adaptivity: users can fine tune personalization effects or deactivate them at the level of individual content fragments.

We have reported the results of a user study, in which we evaluated the impact of our approach on the usefulness, usability, user satisfaction, transparency, and trustworthiness. The results show that the approach improves the usefulness of personalized systems. Users deem the mechanisms for controlling personalization provided by our approach easy, fun, and pleasant to use. This is an important result since the subjective attractiveness of these mechanisms is an essential requirement for motivating users to work with their user profiles and keep them up-to-date and accurate. This, in its turn, can improve the quality of personalization.

Also, the results of the user study show that our approach helps to solve the transparency and controllability problems that personalized systems have been criticized for. However, our findings with respect to the trustworthiness reveal that giving users full control over their user models alone is not enough to establish a sufficient level of trust between the user and a personalized system. Our results show that some users have significant concerns about their privacy, even though they have control over the user model and personalization effects.

The limitations of this user study are the small number of participants, the short duration of the study, and the lack of counterbalancing of the system versions. In our future work, we plan to evaluate the impact of this approach in a controlled experiment lasting a longer period of time and involving a larger number of subjects. Also, we plan to investigate methods for privacy management in order to improve the trustworthiness of personalized systems. In addition, we will further enhance our approach by incorporating the suggestions that we collected in this study.

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