I-Know my Users: User-Centric Profiling Based on the Perceptual Preference Questionnaire (PPQ)

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ABSTRACT
A substantial proportion of user modeling research deals with detection, classification and use of as well as adaptation to the users' preferences. In this paper, we develop a questionnaire to assess aspects of perceptual preferences in regard to information processing, knowledge gain and learning, named Perceptual Preferences Questionnaire (PPQ). The PPQ is validated based on the results of an online survey with forum users (n=76). Given the perceptual preferences of a user, we explore first implications on how to present information to that specific user in order to ease understanding, which can be achieved by matching his/her perceptual preferences. Further research aims to combine the PPQ with implicit testing based on the users' textual utterances and the users' interests.

Categories and Subject Descriptors
H.1.2. User/Machine Systems; H.5.m. User Modeling: Miscellaneous.

General Terms
Measurement, Experimentation, Design, Human Factors.

Keywords
Preferences, Perception, Cognitive Style, User Modeling.

1. INTRODUCTION
Digital media permits to present information in manifold ways. An adequate mode of information presentation helps the user with information processing and knowledge gain, e.g. user A prefers to read new information whereas user B definitely prefers listening to it. Research shows that information can be more easily understood if its presentation is adapted to the cognitive preference of the user that needs to be reached [5, 17]. One aspect of cognitive preference consists in the preferred mode of perception. However, there exists no empirically validated questionnaire focusing only on perceptual preference, which is focus of our ongoing research. To this end, we developed a questionnaire to assess aspects of perceptual preferences in regard to information processing and learning, the Perceptual Preferences Questionnaire (PPQ). Even though a valid instrument (see Section 2.2), we are aware that knowledge discovery research is rather looking for methods that require less intense interaction with the user than extensive questionnaires in order to design personalized applications. The PPQ is thus thought to be an interim step, which might be replaced with knowledge about the users' textual utterances or interests as implicit indicators to perceptual preference. Such knowledge about the users' perceptual preferences might be of interest for every user model used in a setting where the user's interest needs to be captured and/or the user's process of information perception and organization shall be supported. It might hence be an interesting extension for adaptive hypermedia, especially for the field of flexible content and interface design. Such personalization could be useful for a wide range of applications including, but not limited to, e-commerce and e-learning.

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2. RELATED RESEARCH
In the field of user modeling, two sorts of variables are modeled in order to describe a user: rather permanent and rather transitory attributes. Permanent attributes stay the same over a long time and can concern user personality, preferences, or fields of interest. Transitory attributes are state-dependent, may change after a short period of time, and represent moods, plans and goals. The choice and number of variables used in such a model are strongly dependent on the field of application and the purpose of the user model. User models are usually designed for a specific goal, e.g., to make people learn more easily or buy more. One method to evoke such effects is to personalize the choice, amount and presentation mode of information.

Two subfields of user modeling should be considered within this context: The subfield of cognitive user modeling combines psychological theories and representations about aspects of human cognition. Different applications for this field are described in [8]. The subfield focusing on educational application seeks to collect information about learner characteristics like knowledge, skills, and personality traits in order to select the best learning environment for a particular student to optimize learning outcome [16]. In this paper, we suggest to combines aspects of cognitive user modeling and user modeling in e-learning environments. We think that this combination could be a useful extension for the subfields of cognitive user modeling and e-learning.

In education, cognitive or learning styles describe different preferences in how learners perceive and retain information. Cognitive style "may be defined as an individual's consistent approach to organising and processing information during thinking" [15]. Several models have attributes that express sensory preferences: Several learning style models describe dimensions of information representation that can be classified as sensory preference for visual input as opposed to verbal input (which might be considered as preference for auditory input if one assumes content is communicated orally): e.g., the dimension "imager vs. verbalizer" as proposed by Riding [3; 15], or the

dimension "visual vs. verbal" as proposed by Felder and Silverman [6]. Dunn and Dunn's model includes the "modality preferences" visual, auditory, kinesthetic and tactile preference [3; 5]. An application of this concept to the field of language learning was published by Reid [13]. In her model on learning styles she differentiates between four basic perceptual learning channels, visual, auditory, kinesthetic and tactile modalities, and presents a questionnaire focusing on the learner's perceptual preference and his or her preference for individual vs. group learning.

Learning strategies can be categorized as rather permanent attributes. They are developed according to conscious or unconscious interventions by the learner. Furthermore, interventions might be formed by some other external agent like teachers, tutors or learning systems [14]. Learning strategies might change after a longer period of time or after intense training, but not from one day to the other [13].

3. TESTING THE USER'S PERCEPTUAL PREFERENCES

For statistical analyses, we used IBM SPSS, Version 19.0. If not explicitly mentioned, statistical requirements for inference statistical analyses and procedures were fulfilled. For all analyses, alpha level was $\alpha = .05$.

3.1 Procedure

We used the Unipark[1] survey system to set up an online survey combining the PPQ with some questions on demographic data. The link was distributed to four different forums.

We only used completely filled-in questionnaires for further analyses, which leads to a number of n=76 participants, whereof 52 male and 24 female, with a mean age of 37.24 years (*SD* = 13.28). The educational background of the sample was allocated by 2 without school-leaving qualifications, 15 with a secondary school degree, 5 with apprenticeship, 28 with high-school diploma, 22 with university degree, and 4 with a post gradual degree. The distribution of forum membership in the test sample is as follows: cooking forums (13), photography forums (23), and music forums (37). Data that could not be linked to a forum was not counted in for analyses in regard to forum membership.

3.2 The Perceptual Preferences Questionnaire (PPQ)

The PPQ is a newly developed questionnaire to assess aspects of perceptual preferences in regard to information processing, knowledge gain, and learning. Even though there are some tests on cognitive style mentioned in Section 2 that partially test sensory preferences, to the best of our knowledge there is none that meets our needs, which are (a) a focus on perceptual preference only, (b) a relation to individual information processing and learning without testing other aspects of learning styles, and (c) to be in German language so that it can be understood by our survey participants. The PPQ is designed to meet those requirements.

The PPQ is composed of four scales, one for each sensory system: visual, auditory, kinesthetic, and olfactory+gustatory (widely addressed as "the five senses"). Olfactory and gustatory are treated as one scale because of the high overlap within those two fields. This overlap might be explained by the similar body regions that are active when perceiving odor and taste, wherefore they are often referred jointly as "chemical senses" [7].

The PPQ's test items are inspired by related work as well as by the test items of *Reid*'s Perceptual Learning Style Preference Questionnaire (PLSPQ) [13] and some non-validated online self-assessment tools such as *Chislet/Chapman*'s VAK test, *Fleming*'s VARK test, and its German equivalent, *Stangl*'s HALB test.[2] On a 5-point-Likert scale, participants can indicate their agreement with each test item on answer options ranging from "strongly disagree" to "strongly agree". With regard to item validation, we developed 46 items in order to choose the most relevant items per category based on validity tests. Therefore, we checked all specific values considering test difficulty, test reliability and structural validity by factor analysis [2], and identified the items that provide best values regarding test construction without losing information. With a total of 20 remaining items, the PPQ provides sufficient information and is more economic in regard to survey length. A three step validity analysis is applied to the selected 20 items. The PPQ's items and validation results can be found in Table 1.

In a first step, descriptive statistics and item difficulty (p_i) [3] were analyzed (see Table 1). The 20 relevant items provide acceptable means (*M*) and standard deviations (*SD*) and lie between the critical p_i limits of .20 to .80 defined in [1]. Means of the PPQ per scale are: visual (3.49; *SD* = .65) auditory (*M* = 3.18, *SD* = .68), kinesthetic (*M* = 3.52, *SD* = .80) and olfactory (*M* = 2.93, *SD* = .83).

In a second step, factor analysis was performed. Extraction of the number of factors was done by the *Kaiser*'s eigenvalue-greater-than-one-rule and the scree-test [4], which identified six factors. However, the *Kaiser* criterion overestimates the number of factors in most of the cases [18]. Four factors seem to fit the data, which is confirmed by the major drop in the scree plot. An additional parallel analysis, as proposed by *Horn* [9], also suggests four factors, which account for 50.49 % of the total variance. After a Varimax rotation, factor 1 (olfactory+gustatory) accounts for 16.32%, factor 2 (kinesthetic) for 15.29%, factor 3 (visual) for 10.20% and factor 4 (auditory) accounts for 8.68% of the variance. An orthogonal Varimax rotation was applied in order to obtain the factor structure of the PPQ, which shows that each item loads highest for the according factor with smaller or negative secondary loadings for other factors (see Table 1). Item *Aud2* is an exception with a higher loading on factor 1, but from context it fits much better for factor 4, which is why it has been assigned to factor 4.

In a third step, reliability was analyzed based on *Cronbach*'s alpha (α_C) for each scale. α_C represents the internal consistency of the items within a scale; additionally, α_Cs are reported if a specific item would be deleted (see Table 1). *Vis3* is the only item that would increase α_C if item is deleted, but the rise would not change alpha dramatically. For reasons of well-balanced scales, *Vis3* is included in further analyses. The scales of visual and auditory perception show rather low α_C and might need revision.

[1] http://www.unipark.com/

[2] More information on those online assessment tools can be found at the respective sites, VAK Test http://www.businessballs.com/vaklearningstylestest.htm, VARK Test http://www.vark-learn.com, and HALB Test http://arbeitsblaetter.stangl-taller.at/TEST/HALB/Test.shtml.

[3] Note: $n = 76$; *Min* =1 and *Max* =5 for all 20 items; k is the number of answer options on the rating scale, in this case k=5. p_i index was calculated by the following formula for rating scales that start the rating by 1: $p_i = \frac{x-1}{k-1}$

Table 1. The 20 items of the Perceptual Preferences Questionnaire (PPQ), translated to English[4], and results for the three validity test steps, including (1) mean (*M*), standard deviation (*SD*), and item difficulty (p_i), (2) factor analysis for the four factors F1-F4, and (3) reliability testing based on *Cronbach*'s alpha (α_C) and *Cronbach*'s alpha if item deleted (α_C iid).

				Step 1: Descriptive Data			*Step 2: Factor Analysis*				*Step 3: Reliability*	
Nr.	Item Text (Original)	Item Text (English Translation[4])	Scale	*M*	*SD*	p_i	F1	F2	F3	F4	α_C	α_C iid
Vis1	Ich kann mir Fakten besser merken, wenn ich sie lese.	I retain facts better if I read them.	Visual	3.83	1.01	0.71			0.38	-0.53	.58	0.56
Vis2	Ich verstehe Anleitungen nur, wenn ich sie selber lese.	I only understand instructions if I read them myself.		3.37	1.20	0.59			0.71			0.46
Vis3	Zur Orientierung in einer fremden Stadt verwende ich am liebsten einen Stadtplan.	For orientation in a foreign city, I prefer to use a city map.		3.92	0.96	0.73	-0.36		0.36			0.66
Vis4	Ich kann mir die meisten Sachen nur merken, wenn ich sie auch gelesen habe.	I usually remember content only if I read it.		3.00	1.07	0.50	0.29		0.66			0.42
Vis5	Namen kann ich mir viel besser merken, wenn ich sie lese, als wenn ich sie höre.	I retain names much better if I read them than if I hear them.		3.33	1.05	0.58	0.39		0.65			0.45
Aud1	Erklärungen reichen mir meistens nicht aus, ich benötige etwas Schriftliches, um etwas gut zu verstehen.	Reading a text is not enough for me to retain content.	Auditory	2.89	1.27	0.47		0.38		0.67	.33	0.19
Aud2	Beim Lernen spreche ich mir die Lerninhalte selbst vor, damit ich auch höre, was ich lese.	I usually talk the learning content through to hear what I am reading.		2.59	1.31	0.40	0.44			0.36		0.29
Aud3	Hörspiele finde ich besser als Stummfilme.	I like radio plays better than silent movies.		3.78	1.17	0.70				0.62		0.22
Aud4	Ich lasse gern nebenbei Musik bzw. den Fernseher laufen, um ein Hintergrundgeräusch zu haben.	I like to have the radio or TV turned on to have some sound in the background.		3.17	1.54	0.54			0.35	0.41		0.25
Aud5	Ich gehe lieber zu einem klassischen oder Jazzkonzert als in eine Kunstausstellung.	I prefer going to a classical or jazz concert rather than going to an art exhibition.		3.51	1.23	0.63		-0.42		0.25		0.42
Kin1	Ich bevorzuge es, mit meinen Händen zu arbeiten.	I prefer to work with my hands.	Kinesthetic	3.43	1.01	0.61	0.28	0.78			.79	0.72
Kin2	Lernen kann ich am besten, wenn ich auch Gegenstände in die Hand nehmen kann.	I learn best if I can touch objects with my hands.		3.41	1.10	0.60		0.63	0.28			0.76
Kin3	Handwerkliche Tätigkeiten sind für mich sehr wichtig.	Craft activities are really important for me.		3.43	1.17	0.61		0.77				0.75
Kin4	Ich bevorzuge "learning by doing" und probiere alles lieber selbst gleich, statt erst aus Büchern zu lernen.	I prefer "learning by doing" instead of learning from books.		3.75	1.11	0.69		0.69		0.28		0.75
Kin5	Wenn ich selbst ein Modell baue, kann ich mir die Sachen leichter merken.	I retain content easier if I build models.		3.58	1.04	0.65	-0.28	0.65				0.75
Olg1	Durch bestimmte Gerüche erinnere ich mich sofort an Ereignisse oder Orte aus meiner Vergangenheit.	Certain odors immediately remind me of special events or places from my past.	Olfactory + Gustatory	3.99	1.09	0.75	0.53				.78	0.77
Olg2	Mein Geruchssinn ist mir sehr wichtig.	My sense of smell is really important for me.		3.50	1.23	0.63	0.64			-0.24		0.76
Olg3	Beim Lernen verknüpfe ich gern Inhalte mit verschiedenen Gerüchen.	When studying, I like to connect content to different odors.		2.09	1.07	0.27	0.84					0.69
Olg4	Rezepte kann ich mir gut merken, wenn ich den Geschmack der Zutaten dazu kenne.	I retain recipes well if I know the taste of the ingredients.		3.00	1.25	0.50	0.66					0.75
Olg5	Mit Gerüchen verbinde ich verschiedene Lerninhalte.	For me, different odors are related to different learning content.		2.07	1.08	0.27	0.78					0.70

[4] Our results presented in this paper are based on the German version of the PPQ. However, for better traceability, the items are presented with an English translation (which is not validated yet and would require additional testing before use).

3.3 Perceptual Preference and Forums

In regard to perceptual preference and membership in certain forums, results show that membership of a music forum correlates with auditory preferences ($r_{\phi 76}$ = .342, p = .00), stating that music forum members prefer auditory input. At the same time, membership in a photography forum correlates negatively with auditory preferences ($r_{\phi 76}$ = -.441, p = .00), indicating that members of photography forums prefer other than auditory input. Membership in cooking forums correlates positively with olfactory/gustatory preference ($r_{\phi 76}$ = .245, p = .03). This means members of cooking forums tend to have a preference for olfactory/gustatory perception.

4. DISCUSSION

The discussion is organized around two questions and a paragraph on the paper's limitations.

How can perceptual preference be tested? This paper provides a new method to elicit perceptual preference, the Perceptual Preferences Questionnaire (PPQ). The test was validated with statistical methods as outlined in this paper. Even though direct measurement of sensation is quite challenging [12], it might be interesting to compare results from the PPQ with testing of information processing.

How can such knowledge be used? We suggest adapting presentation of information to the user's perceptual preference, which has been proven to support understanding and learning respectively [5, 17]. This can be done by choosing different forms of content presentation (like visual versus auditory content), but, following the findings of [10], also by reformulating verbal information in regard to the perceptual preference of a user by using perceptually stimulating vocabulary. However, the degree of adaption should be chosen according to the specific goals of an application: if an application only aims to attract the user's attention, one should apply a higher degree of adaptation to the user's perceptual preference, than in an educational tool that does not only seek to ease understanding as a short-term effect, but also tries to reach long-term effects by training the user's less preferred perceptual systems instead of presenting each content in the same way and thus creating "perceptual filter bubbles".

Limitations Our experiment provides with 76 participants already a sufficient sample size to allow psycho-pedagogical sound interpretation of data. Our sample varies quite well concerning age, but in our study male participants are slightly over-represented. A repetition of our study with a higher number of participants might give further insights, and might aim towards a scale revision of visual and auditory scales.

5. CONCLUSIONS AND OUTLOOK

Based on findings from cognitive information processing and learning styles, we developed the Perceptual Preferences Questionnaire (PPQ), which was validated with statistical methods based on the results of an online survey with 76 participants. Furthermore, we examined co-occurrence patterns of perceptual preferences and forum membership. The obtained results are quite encouraging: Our next steps are thus to repeat the study with a larger number of users and, if necessary, to revise the PPQ to assure high reliability of scales. In addition, it is envisioned to investigate implicit preference elicitation on a textual basis as proposed in [11] and by co-occurrence analysis with the users' interests, to examine interrelations between perceptual preference and other user-modeling related factors, and to design and test content adaptation to perceptual preferences as elicited in this paper.

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