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Contents

Psychology-informed Recommender Systems

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ABSTRACT

Personalized recommender systems have become indispensable in today's online world. Most of today's recommendation algorithms are data-driven and based on behavioral data. While such systems can produce useful recommendations, they are often uninterpretable, black-box models, which do not incorporate the underlying cognitive reasons for user behavior in the algorithms' design. The aim of this survey is to present a thorough review of the state of the art of recommender systems that leverage psychological constructs and theories to model and predict user behavior and improve the recommendation process. We call such systems *psychology-informed recommender systems*. The survey identifies three categories of psychology-informed recommender systems: *cognition-inspired*, *personality-aware*, and *affect-aware* recommender systems. Moreover, for each category,

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we highlight domains, in which psychological theory plays a key role and is therefore considered in the recommendation process. As recommender systems are fundamental tools to support human decision making, we also discuss selected phenomena related to human decision making that impact the interaction between a user and a recommender. Besides, we discuss related work that investigates the evaluation of recommender systems from the user perspective and highlight user-centric evaluation frameworks. We discuss potential research tasks for future work at the end of this survey.

1

Introduction

1.1 Motivation

In the past twenty years, research on recommender systems has emerged as a growing field within computer science (Ricci *et al.*, 2011). The emergence of online marketplaces, online social networks, online collaboration platforms, and online social information systems (Caverlee *et al.*, 2010) has created a need to support users with recommendations to help them cope with the increase of information and items online (Liu *et al.*, 2014).

A large amount of work exists that has tackled recommender systems research from a broad range of perspectives. Resources like the *Recommender Systems Handbook* (Ricci *et al.*, 2015) or *Recommender systems: An Introduction* (Jannach *et al.*, 2010) give a comprehensive overview of the field. So do review articles such as the one by (Jannach *et al.*, 2012). Recent surveys provide a concise overview of explainable recommendations (Zhang, Chen, *et al.*, 2020), deep learning in recommender systems (Xu *et al.*, 2020), adversarial recommender systems (Deldjoo *et al.*, 2021b) or conversational recommender systems Jannach *et al.* (2012).

Early work on recommender systems was motivated by the observation that humans tend to base their decisions on the recommendations provided by their social surrounding (Ricci *et al.*, 2011). Correspondingly, the first algorithms developed as recommender systems aimed to mimic this behavior (Resnick and Varian, 1997; Ricci *et al.*, 2011). In the early 2000s, the use of psychological models in recommender systems research has gained traction. Pioneering work was carried out by Gustavo Gonzalez, Timo Saari, and Judith Masthoff, which exploited the psychological characteristics of users to improve the recommendation process. To that end, Gonzales et al. (González *et al.*, 2002; González *et al.*, 2004) considered emotional aspects of the user to generate personalized recommendations. Saari et al. (Saari *et al.*, 2004b; Turpeinen and Saari, 2004; Saari *et al.*, 2004a; Saari *et al.*, 2004a; Saari *et al.*, 2005) designed recommender systems that incorporate a user's emotion and attention, as well as other related constructs, to deliver recommendations (Nunes, 2008). Masthoff et al. (Masthoff, 2004b; Masthoff, 2004a; Masthoff, 2005; Masthoff and Gatt, 2006), assessed the user satisfaction of individual users and predicted group satisfaction when recommending sequences of items to user groups. Their intuition was that the first few recommendations in a list of recommendations influence the mood of the user. That mood, in turn, can impact the views the user has about the next items in the recommendation list (Nunes, 2008). Felfernig *et al.* (2007) used insights from decision psychology to gain a deeper understanding of online buyer behavior and to improve knowledge-based recommender systems.

In the present survey article, we provide a review of research strands in the recommender systems community that enrich data-driven recommendation techniques with psychological constructs to design or improve recommender systems. We call such systems *psychology-informed recommender systems*.

This survey is organized as follows. We first give an introduction into common recommender systems methods in Section 1.2, and then, in Section 1.4, briefly describe our survey method and research scope. Next, in Section 2, we review related work on psychology-informed recommender systems, which we categorize into *cognition-inspired*, *personality-aware*, and *affect-aware* recommender systems. Also, in Section 3, we review

works that investigate various decision-psychological phenomena that come into play when users interact with a recommender system. Besides, in Section 4, we discuss works that investigate recommender systems' evaluation from the user perspective. We conclude in Section 5 with key findings and possible directions for future work.

1.2 Main Approaches to Recommender Systems

The most prominent recommendation approaches are collaborative filtering (CF), content-based filtering (CBF), hybrid combinations of both (Ricci *et al.*, 2015), as well as knowledge-based recommmender systems (Burke, 2000b). CF (Schafer *et al.*, 2007) exploits interactions between users and items such as ratings and creates a user–item matrix that is then used to predict missing ratings for pairs of users and items. CF then recommends the items with the highest predicted ratings, with which the target user has not yet interacted. One can distinguish between *model-based CF* and *memory-based CF* (Koren and Bell, 2015). In the case of *model-based CF* (Aggarwal, 2016), the algorithm first projects users and items into a low-dimensional space and then, finds similar users/items in this space. In the case of *memory-based CF* (Sarwar *et al.*, 2001), CF computes similarities between users/items directly from the user–item matrix. *Memory-based CF* can be further divided into *user-based CF* and *item-based CF*, depending on whether recommendations are produced based on user or item similarity.

CBF exploits characteristic properties of items (e.g., movie genres) to recommend items with similar attributes as items the target user has liked in the past (Ricci *et al.*, 2015). For a recent overview of new trends in CBF, please refer to Lops *et al.*, 2019. Correspondingly, hybrid recommender systems (Burke, 2002) are, most commonly, a combination of collaborative and content-based methods. For example, when using CF in a cold-start scenario, a hybrid approach can incorporate CBF to predict items based on their features (Cremonesi *et al.*, 2011b; Ricci *et al.*, 2011).

In contrast to CF and CBF, knowledge-based recommender systems (Burke, 2000b) do not require a user history. Instead, they make use of pre-existing knowledge about the user and the application domain to reason about potentially relevant items. One can distinguish between

two main types of knowledge-based recommender systems, namely, constraint-based recommender systems (Felfernig and Burke, 2008; Atas *et al.*, 2019) and case-based recommender systems (Lorenzi and Ricci, 2003; Burke, 2000a). In constraint-based recommender systems, explicitly defined constraints govern which items should be recommended to a user in a given context, whereas the constraints refer to the user and/or the item domain. Case-based recommender systems are early examples of psychology-informed recommender systems, which model reasoning as primarily memory-based (Leake, 2015). In this paper, they are, therefore, reviewed in more detail (see Section 2.1.4).

1.3 Selected Recommender Systems Software and Datasets

To facilitate getting started with recommender systems experiments, we provide an overview of relevant resources. Tables 1.1 and 1.2 give a non-exhaustive list of software[1] (libraries and open-source code repositories) and datasets, respectively.[2] We focus on the most popular resources as well as on those that provide code and data relevant to psychology-informed recommendation.

1.4 Survey Method and Research Scope

For this survey, we investigated research articles that appeared in relevant publication outlets in the fields of computer science, psychology, and human-computer-interaction. Regarding the scope of our review, we focus on papers that describe algorithms, techniques, and systems that exploit psychological features of the user for improving the recommendation process (see Table 1.5, Table 1.6, Table 1.7, Table 1.8, and Table 1.9). Also, we visualize the reviewed papers as a timeline in Table 1.3, and Table 1.4 to show the evolution of techniques over time. Please note that we split the timeline visualization into periods from 1885 to 2010 and 2011 to 2021 due to space constraints.

[1] See also https://github.com/grahamjenson/list_of_recommender_systems & https://recommender-systems.com/resources/

[2] GroupLens' list of datasets: https://grouplens.org/datasets/, Julian McAuley's list: https://cseweb.ucsd.edu/~jmcauley/datasets.html

Table 1.1: Overview of selected software for recommender systems.

Name	URL	Comments
LKPy	https://github.com/lenskit/lkpy	Python; classical models
Surprise	https://github.com/NicolasHug/Surprise	Python; classical models
pyRecLab	https://github.com/gasevi/pyreclab	Python; classical models
LibRec	https://github.com/guoguibing/librec	Java; classical models
Elliot	https://github.com/sisinflab/elliot	Python; classical and deep models
NeuRec	https://github.com/wubinzzu/NeuRec	Python; deep models
Spotlight	https://github.com/maciejkula/spotlight	Python; classical and deep models
Implicit	https://github.com/benfred/implicit	Python; for implicit-feedback datasets
TagRec	https://github.com/learning-layers/TagRec	Java; cognition-inspired and classical models

Table 1.2: Overview of selected datasets for recommender systems.

Name	URL	Domain	Comments
MovieLens	https://grouplens.org/datasets/movielens	movie	ratings, tags
FilmTrust	https://guoguibing.github.io/librec/datasets.html	movie	ratings, trust scores
Epinions, Ciao	https://www.cse.msu.edu/~tangjili/datasetcode/truststudy.htm	movie	movie ratings, reviews, review ratings, trust scores
Personality 2018	https://grouplens.org/datasets/personality-2018	movie	movie preferences, personality information, ratings (with timestamps)
Serendipity 2018	https://grouplens.org/datasets/serendipity-2018	movie	movie ratings (with timestamps), survey responses related to serendipity preferences
Million Song Dataset	http://millionsongdataset.com	music	listening events, tags, genres, lyrics
LFM-1b	http://www.cp.jku.at/datasets/LFM-1b	music	music listening events (with time stamps), tags, user demographics
Million Playlist Dataset	https://www.aicrowd.com/challenges/spotify-million-playlist-dataset-challenge	music	public user-generated playlists from Spotify
HetRec 2011	https://grouplens.org/datasets/hetrec-2011	social networking, social tagging systems	tag assignments, bookmarks, movie genres, movie genre assignments

The identification of papers for our survey was done according to the following strategy. We first considered the proceedings and volumes of a set of relevant conference series (e.g., *User Modelling, Adaptation and Personalization*, *ACM Recommender Systems Conference*, *The Web Conference*, *ACM SIGIR Conference on Research and Development in Information Retrieval*, *ACM CHI Conference on Human Factors in Computing Systems*, *ACM Hypertext*, *IEEE/WIC/ACM International Conference on Web Intelligence*) and journals (e.g., *User Modeling and User-Adapted Interaction*, *Transaction on Intelligent Information Systems*, *Cognitive Science*, *Journal of Consumer Research*, *IEEE Transactions on Affective Computing*, *Computers in Human Behavior*, *Journal of Personality and Social Psychology*, *ACM Transactions on Intelligent Information Systems*) for articles that fall into the above-described scope. Additionally, we used the keywords "psychology recommender systems", "psychology informed recommender", "cognition recommender", "stereotypes recommender", "case-based recommender", "affective recommender", "emotion recommender", "personality recommender", "decision making recommender", "user-centric recommender", "user evaluation recommender", "user experience recommender", "nudging recommender systems", "persuasion recommender", "cognitive dissonance recommender", "interaction recommender", and "interfaces recommender" to search for papers in Google Scholar. Using the resulting set of articles as a starting point, we followed the references of the retrieved articles to find additional papers.

A few survey works on the topic of psychological models in the context of recommendations already exist. When looking at these existing works, we find that some works on psychology-informed recommender systems are also summarized by Tkalcic and Chen (2015a) with respect to personality-based recommender systems, personality and learning styles (Graus and Ferwerda, 2019), and in (Tkalcic *et al.*, 2011) in terms of affective-based systems. Additionally, Buder and Schwind (2012) discuss personalized recommender systems as well as psychological theories and models that describe learning processes and mechanisms in educational contexts. They, however, focus only on learning as a domain. Yoo *et al.* (2012), and in earlier work, Gretzel and Fesenmaier (2006), discuss recommender systems and their persuasive role in decision-making

processes; Felfernig *et al.* (2008b) outline persuasion in knowledge-based recommendation. These works also shed light on psychological constructs that play a role in persuasion, which corresponds to a mechanism that can be used in recommender systems to influence choices. For a detailed overview of persuasive recommender systems, please refer to Yoo *et al.* (2012). Jesse and Jannach (2021) review related work on nudging with recommender systems. They also discuss 58 psychological mechanisms that are described in the reviewed works. Pu *et al.* (2012) present a survey on evaluating recommender systems from the user perspective, including preference elicitation and refinement, presentation of recommendations, and user-centric evaluation frameworks. Also, the authors summarize the most important results in the form of design guidelines for effective recommender systems.

Explanations of algorithmic decisions made by artificial intelligence help making algorithms more transparent. The recent survey on explainable recommendations by Zhang, Chen, *et al.* (2020) discusses related work on explainable recommendation models. For an overview of the body of research on explanations in artificial intelligence in light of the social sciences, please refer to Miller (2019).

In Zhang, Chen, *et al.* (2020) explanations in recommender systems are related to cognitive science and human decision making. As the authors describe, humans sometimes decide using rational and careful reasoning, while in other cases, they first decide and find explanations for their decisions later. This is in line with the typical approaches to designing explainable recommendation models: either, such models are already designed with transparency and explainability in mind, or post-hoc explanations are used to explain decisions made by black box models (Lipton, 2018; Miller, 2019). Tran *et al.* (2019a) and Tran *et al.* (2020) take into account findings from social choice theory, i.e., the study of collective choices that impact groups (Sen, 1986), to introduce explanations to increase fairness, consensus, and satisfaction of users with group recommendations.

Given the rich body of work on explainability in recommender systems, which is already presented in the survey by Zhang, Chen, *et al.* (2020), we do not focus on this topic in the paper at hand, instead refer the reader to Zhang, Chen, *et al.* (2020) as well as to the

respective chapter in the recommender systems handbook by Tintarev and Masthoff (2015).

The field of group recommender systems also uses social psychology constructs to produce recommendations that are helpful for groups. In this paper, we touch upon them when we discuss relevant work on personality in group recommender systems. For an overview of group recommender systems and mechanisms to model group behavior, please also refer to Felfernig *et al.* (2018c) and Masthoff (2015).

Summing up, with this article, we aim to close the gap between a computer science perspective (in particular, a technical recommendation systems point of view) and a psychological perspective. We hope to appeal to researchers in the information retrieval and recommendation systems communities who want to delve deeper into the psychological foundations of recommendation systems research. In addition, we also address an audience with psychological background who strives to deepen their knowledge on how psychological constructs and models can be incorporated into recommendation systems. Please note that basic knowledge of recommendation systems and psychology is sufficient to understand the article.

Table 1.3: Part I of a timeline visualization of the reviewed publications to depict the evolution of techniques (from 1885 to 2010); note that the earliest works are psychological papers that describe relevant effects).

	Cognition-inspired	Personality-aware	Affect-aware	Decision Making	User-centric Eval.
1885	Ebbinghaus (1885)				
1954					Festinger (1954)
1957				Deese and Kaufman (1957)	
1966				Glanzer and Cunitz (1966)	
1967	Neisser (1967)				
1974	Anderson (1974)			Tversky and Kahneman (1974)	
1978	Matlin and Stang (1978)				
1979	Elaine Rich (1979)				
1980			Russell (1980) and Mehrabian (1980)		
1981				Tversky and Kahneman (1981)	
1982				Huber *et al.* (1982)	
1984	Ingwersen (1984)				McCroskey *et al.* (1984)
1990	Ormerod (1990)				
1992	Bellandi *et al.* (2012)			Tversky and Kahneman (1992)	
1993	Fehling (1993)			Payne *et al.* (1993)	
1994	Lamming and Flynn (1994)				Resnick *et al.* (1994)
1995		Costa and McCrae (1995)			
1997	Anderson *et al.* (1997)				
1999	Burke (1999)		Shiv and Fedorikhin (1999)		Berdichevsky and Neuenschwander (1999)
2000					Herlocker *et al.* (2000)
2001	Ricci and Werthner (2001)			Mandl *et al.* (2011)	Allen and Yen (2001)
2002	Ricci *et al.* (2002), Aguzzoli *et al.* (2002), and Gemmell *et al.* (2002)	Charness and Rabin (2002)		Chapman and Johnson (2002)	Fogg (2002) and Swearingen and Sinha (2002)
2003					McNee *et al.* (2003) and Cosley *et al.* (2003)
2004					Herlocker *et al.* (2004)
2005	Anderson (2005)			Dyer (2005)	Ziegler *et al.* (2005) and Ling *et al.* (2005)
2006	Ricci *et al.* (2006)			Pu and Chen (2006)	McNee *et al.* (2006a), McNee *et al.* (2006b), and Gretzel and Fesenmaier (2006)
2007	Fum *et al.* (2007), Rutledge-Taylor and West (2007), and Elsweiler *et al.* (2007)		Fontaine *et al.* (2007)	Felfernig *et al.* (2007)	Kuan *et al.* (2007) and Nguyen *et al.* (2007)
2008	Glushko *et al.* (2008), Fu (2008), Rutledge-Taylor *et al.* (2008), and Prins *et al.* (2008)				O'Brien and Toms (2008) and Felfernig *et al.* (2008a)
2009	Maanen and Marewski (2009), Gong (2009), and Yang and Wang (2009)			Craswell *et al.* (2008) and Thaler and Sunstein (2009)	
2010	Fu *et al.* (2010), Fu and Kannampallil (2010), and Yu and Li (2010)	Quijano-Sanchez *et al.* (2010)		Mojzisch and Schulz-Hardt (2010)	Bollen *et al.* (2010), Chen and Pu (2010b), Chen and Pu (2010a), O'Brien and Toms (2010), and Nanou *et al.* (2010)

Table 1.4: Part II of a timeline visualization of the reviewed publications to depict the evolution of techniques (from 2011 to 2021)

	Cognition-inspired	Personality-aware	Affect-aware	Decision Making	User-centric Eval.
2011	Blanco-Fernández *et al.* (2011)	Rentfrow *et al.* (2011) and Masthoff (2011)	Tkalcic *et al.* (2011)	Adomavicius *et al.* (2011), Zhang (2011), Mandl *et al.* (2011), and Moraveji *et al.* (2011)	Shani and Gunawardana (2011), Hu and Pu (2011), Pu *et al.* (2011), Ekstrand *et al.* (2011), Schwind *et al.* (2011), Yoo and Gretzel (2011), Knijnenburg *et al.* (2011), Cremonesi *et al.* (2011a), and Yannakakis and Hallam (2011)
2012	Fu and Dong (2012), Psychology (2012), Bollen *et al.* (2012), Wang and Yang (2012), Bellandi *et al.* (2012), and Doherty *et al.* (2012)	Tintarev and Masthoff (2012)	Konstan and Riedl (2012)	Yoo *et al.* (2012), Bettman *et al.* (1998), Teppan and Felfernig (2012), Murphy *et al.* (2012), Ranjith (2012), Bateman *et al.* (2012), and Smids (2012)	Pu *et al.* (2012), Knijnenburg *et al.* (2012a), Konstan and Riedl (2012), Knijnenburg *et al.* (2012b), Yoo *et al.* (2012), and Cremonesi *et al.* (2012)
2013	Sabater-mir *et al.* (2013), Kowald *et al.* (2013), Seitlinger *et al.* (2013), and Fehling (1993)	Golbeck and Norris (2013), Chen *et al.* (2013b), Wu *et al.* (2013), Tintarev *et al.* (2013), and Cantador *et al.* (2013)	Zheng (2013)	Chen *et al.* (2013a), Adomavicius *et al.* (2013), and Thaler *et al.* (2013)	
2014	Beel *et al.* (2014), Kowald *et al.* (2014), Zhao *et al.* (2014), Missier (2014), and Chavarriaga *et al.* (2014)			Adomavicius *et al.* (2014) and Hofmann *et al.* (2014)	Ekstrand *et al.* (2014), Surendren and Bhuvaneswari (2014), and Schwind and Buder (2014)
2015	Ren (2015), Kowald and Lex (2015), Musto *et al.* (2015), Bousbahi and Chorfi (2015), Muhammad *et al.* (2015), Beel and Langer (2015), and Beel *et al.* (2015)	Tkalcic and Chen (2015a)	Orellana-Rodriguez *et al.* (2015) and Deng *et al.* (2015)	Jameson *et al.* (2015), Karimi *et al.* (2015), Teppan and Zanker (2015), Stettinger *et al.* (2015a), Stettinger *et al.* (2015b), Turland *et al.* (2015), and Sunstein (2015)	Knijnenburg and Willemsen (2015)
2016	Seitlinger and Ley (2016), Jones (2016), Trattner *et al.* (2016), Kowald and Lex (2016), Stanley and Byrne (2016), Kopeinik *et al.* (2016), Schnabel *et al.* (2016), Harvey *et al.* (2016), and Mozer and Lindsey (2016)	Karumur *et al.* (2016), Fernandez-Tobias *et al.* (2016), and Rossi and Cervone (2016)		Grüne-Yanoff and Hertwig (2016)	Kaminskas and Bridge (2016), Ekstrand and Willemsen (2016), and Willemsen *et al.* (2016)
2017	Beel (2015), Kowald *et al.* (2017b), Kopeinik *et al.* (2017b), and Kopeinik *et al.* (2017a)	Ferwerda *et al.* (2017b), Ferwerda *et al.* (2017a), Nalmpantis and Tjortjis (2017), and Delic *et al.* (2017)	Piazza *et al.* (2017), Schedl *et al.* (2018), and Ravi and Vairavasundaram (2017)	Joachims *et al.* (2017), Elsweiler *et al.* (2017), Esposito *et al.* (2017), and Hertwig and Grüne-Yanoff (2017)	Herlocker *et al.* (2017), Jugovac and Jannach (2017), and Meske and Potthoff (2017)
2018	ALRossais and Kudenko (2018), ALRossais (2018), Thaker *et al.* (2018), Yago *et al.* (2018), Farrell and Lewandowsky (2018), and Chmiel and Schubert (2018)	Nguyen *et al.* (2018), Karumur *et al.* (2018), Wu *et al.* (2018), Lu and Tintarev (2018), Asabere *et al.* (2018), Adaji *et al.* (2018), and Felfernig *et al.* (2018a)	Ayata *et al.* (2018)	Jugovac *et al.* (2018), Felfernig *et al.* (2018b), Tran *et al.* (2018), Schneider *et al.* (2018), and Grüne-Yanoff *et al.* (2018)	Jugovac *et al.* (2018)
2019	Kowald *et al.* (2019), Jorro-Aragoneses *et al.* (2019), Zheng *et al.* (2019), Yang *et al.* (2019), and Zhang *et al.* (2019b)	Yang and Huang (2019), Sertkan *et al.* (2019), Recio-Garcia *et al.* (2009), and Nguyen *et al.* (2019)	Mizgajski and Morzy (2019)	Köcher *et al.* (2019), Karlsen and Andersen (2019), and Caraban *et al.* (2019)	Jin *et al.* (2019) and Goretzko *et al.* (2019)
2020	Kahana (2020), Lex *et al.* (2020), Kowald *et al.* (2020a), Contreras and Salamó (2020), and Güell *et al.* (2020)	Beheshti *et al.* (2020)	Perloff (2020)	Zimmerman *et al.* (2020)	
2021				Jesse and Jannach (2021)	Ortloff *et al.* (2021)

Table 1.5: Overview of surveyed papers that implement cognitive models to design and improve recommendation techniques.

Cognition	Sec.	References
Stereotypes	2.1	Elaine Rich, 1979; Rich, 1989; Blanco-Fernández *et al.*, 2011; Beel *et al.*, 2014; Beel and Langer, 2015; Beel *et al.*, 2015; Beel, 2015; ALRossais and Kudenko, 2018; ALRossais, 2018
Cogn. Models	2.1.1	Anderson, 2005; Fum *et al.*, 2007; Farrell and Lewandowsky, 2018; Neisser, 1967; Ormerod, 1990; Psychology, 2012; Jones, 2016; Glushko *et al.*, 2008; Fu, 2008; Fu *et al.*, 2010; Fu and Kannampallil, 2010; Fu and Dong, 2012; Anderson *et al.*, 1997
Memory	2.1.2	Seitlinger and Ley, 2016; Kahana, 2020; Ingwersen, 1984; Rutledge-Taylor and West, 2007; Rutledge-Taylor *et al.*, 2008; Anderson, 1974; Bollen *et al.*, 2012; Matlin and Stang, 1978; Ebbinghaus, 1885; Ebbinghaus, 2013; Yu and Li, 2010; Ren, 2015; Chmiel and Schubert, 2018; Yang *et al.*, 2019; Sabater-mir *et al.*, 2013; Maanen and Marewski, 2009; Kowald *et al.*, 2014; Trattner *et al.*, 2016; Kowald *et al.*, 2013; Kowald *et al.*, 2017b; Kowald and Lex, 2016; Kowald and Lex, 2015; Stanley and Byrne, 2016; Kowald *et al.*, 2020a; Kopeinik *et al.*, 2016; Kopeinik *et al.*, 2017b; Kowald *et al.*, 2019; Lex *et al.*, 2020; Zhao *et al.*, 2014; Missier, 2014; Schnabel *et al.*, 2016; Elsweiler *et al.*, 2007; Harvey *et al.*, 2016; Doherty *et al.*, 2012; Gemmell *et al.*, 2002; Lamming and Flynn, 1994
Attention	2.1.3	Seitlinger *et al.*, 2013; Kowald *et al.*, 2013; Kopeinik *et al.*, 2017a
CBR	2.1.4	Hammond, 2012; Kolodner, 2014; Riesbeck and Schank, 2013; Kolodner, 1992; Tversky, 1977; Burke *et al.*, 1996; Burke, 1999; Ricci and Werthner, 2001; Ricci *et al.*, 2002; Ricci *et al.*, 2006; Aguzzoli *et al.*, 2002; Gong, 2009; Yang and Wang, 2009; Wang and Yang, 2012; Musto *et al.*, 2015; Bousbahi and Chorfi, 2015; McSherry, 2005; Sharma and Ray, 2016; Muhammad *et al.*, 2015; Jorro-Aragoneses *et al.*, 2019; Pu *et al.*, 2012; McGinty and Reilly, 2011; Contreras and Salamó, 2020; Contreras and Salamó, 2020; Güell *et al.*, 2020
Competence	2.1.5	Fehling, 1993; Bellandi *et al.*, 2012; Chavarriaga *et al.*, 2014; Prins *et al.*, 2008; Yago *et al.*, 2018; Mozer and Lindsey, 2016; Thaker *et al.*, 2018

Table 1.6: Overview of our surveyed papers describing personality-aware recommendation algorithms and systems.

Personality-aware Rec. Sys.	Sec.	References
Personality	2.2	Tkalcic and Chen, 2015a; Ferwerda *et al.*, 2017b; Golbeck and Norris, 2013; Rentfrow *et al.*, 2011; Chen *et al.*, 2013b; Wu *et al.*, 2013; Nguyen *et al.*, 2018; Karumur *et al.*, 2018; Karumur *et al.*, 2016
Personality Elicitation	2.2.1	McCrae and John, 1992; Thomas, 1992; Felfernig *et al.*, 2018d; Holland, 1997; Bologna *et al.*, 2013; Stewart, 2011; Konert *et al.*, 2013; Paiva *et al.*, 2015; Goldberg *et al.*, 2006; Gosling *et al.*, 2003; John and Srivastava, 1999; Berkovsky *et al.*, 2019; Wu *et al.*, 2019; Ferwerda and Tkalcic, 2018; Golbeck *et al.*, 2011a; Golbeck *et al.*, 2011b; Golbeck, 2016
Personality Traits in RecSys	2.2.2	Asabere *et al.*, 2018; Yang and Huang, 2019; Adaji *et al.*, 2018; Nalmpantis and Tjortjis, 2017; Cantador *et al.*, 2013; Gelli *et al.*, 2017; Tintarev *et al.*, 2013; Wu *et al.*, 2018; Ferwerda *et al.*, 2017a; Lu and Tintarev, 2018; Fernandez-Tobias *et al.*, 2016; Beheshti *et al.*, 2020; Sertkan *et al.*, 2019
Personality in Group RecSys	2.2.3	Recio-Garcia *et al.*, 2009; Felfernig *et al.*, 2018a; Masthoff, 2011; Quijano-Sanchez *et al.*, 2010; Rossi and Cervone, 2016; Costa and McCrae, 1995; Charness and Rabin, 2002; Delic *et al.*, 2017; Nguyen *et al.*, 2019

Table 1.7: Overview of the surveyed papers describing affect-aware recommendation algorithms and systems.

Affect-aware RecSys	Sec.	References
Affect	2.3	Shiv and Fedorikhin, 1999; Orellana-Rodriguez *et al.*, 2015; Piazza *et al.*, 2017; Ferwerda *et al.*, 2017b; Golbeck and Norris, 2013; Rentfrow *et al.*, 2011; Chen *et al.*, 2013b; Wu *et al.*, 2013; Mizgajski and Morzy, 2019; Schäfer, 2016; Schedl *et al.*, 2018; Zheng, 2013
Modeling Affect	2.3.1	Russell, 1980; Mehrabian, 1980; Fontaine *et al.*, 2007
Affect in RecSys	2.3.2	Tkalcic *et al.*, 2011; Ravi and Vairavasundaram, 2017; Deng *et al.*, 2015; Ayata *et al.*, 2018

Table 1.8: Overview of the surveyed papers describing mechanisms of human decision making in light of recommender systems research.

Human Decision Making	Sec.	References
Decision Making	3	Yoo *et al.*, 2012; Chen *et al.*, 2013a; Bettman *et al.*, 1998; Jameson *et al.*, 2015; Adomavicius *et al.*, 2013; Tversky and Kahneman, 1974; Chapman and Johnson, 2002; Karimi *et al.*, 2015; Jugovac *et al.*, 2018
Decoy Items	3.1	Payne *et al.*, 1993; Huber *et al.*, 1982; Teppan and Felfernig, 2012; Teppan and Zanker, 2015
Serial Position Effects	3.2	Deese and Kaufman, 1957; Glanzer and Cunitz, 1966; Ranjith, 2012; Murphy *et al.*, 2012; Felfernig *et al.*, 2007; Schnabel *et al.*, 2016; Stettinger *et al.*, 2015a; Tran *et al.*, 2018; Hofmann *et al.*, 2014; Joachims *et al.*, 2017; Craswell *et al.*, 2008; Stettinger *et al.*, 2015b; Dyer, 2005
Framing	3.3	Tversky and Kahneman, 1981; Tversky and Kahneman, 1992; Mandl *et al.*, 2011
Anchor Effects	3.4	Mojzisch and Schulz-Hardt, 2010; Adomavicius *et al.*, 2011; Zhang, 2011; Köcher *et al.*, 2019; Adomavicius *et al.*, 2014; Felfernig *et al.*, 2018b
Nudging	3.5 & 3.6	Thaler and Sunstein, 2009; Thaler *et al.*, 2013; Tversky and Kahneman, 1974; Jesse and Jannach, 2021; Karlsen and Andersen, 2019; Caraban *et al.*, 2019; Elsweiler *et al.*, 2017; Esposito *et al.*, 2017; Turland *et al.*, 2015; Schneider *et al.*, 2018; Sunstein, 2015
Boosting	3.6	Grüne-Yanoff and Hertwig, 2016; Hertwig and Grüne-Yanoff, 2017; Grüne-Yanoff *et al.*, 2018; Zimmerman *et al.*, 2020; Ortloff *et al.*, 2021; Bateman *et al.*, 2012; Moraveji *et al.*, 2011

Table 1.9: Overview of the surveyed papers describing research on user experience and designing user studies.

User-centric Evaluation	Sec.	References
User-centric Evaluation	4.1	Ekstrand and Willemsen, 2016; Knijnenburg *et al.*, 2012a; McNee *et al.*, 2006b; Nalmpantis and Tjortjis, 2017; Chen and Pu, 2005; Konstan and Riedl, 2012; Xiao and Benbasat, 2007; Shin, 2020; McNee *et al.*, 2003; Ziegler *et al.*, 2005; O'Brien and Toms, 2008; Pu and Chen, 2006; Cosley *et al.*, 2003; O'Brien and Toms, 2010
Cognitive Dissonance	4.1.1	Festinger, 1954; Surendren and Bhuvaneswari, 2014; Schwind *et al.*, 2011; Kuan *et al.*, 2007; Schwind and Buder, 2014; Nguyen *et al.*, 2007
Persuasion	4.1.2	Fogg, 2002; Perloff, 2020; Meske and Potthoff, 2017; Yoo *et al.*, 2012; Gretzel and Fesenmaier, 2006; Jugovac *et al.*, 2018; Yoo and Gretzel, 2011; Nanou *et al.*, 2010; Cremonesi *et al.*, 2012; Felfernig *et al.*, 2008a; Herlocker *et al.*, 2000; Tintarev and Masthoff, 2012; Berdichevsky and Neuenschwander, 1999; Smids, 2012
Interactions & Interfaces	4.1.3	Knijnenburg *et al.*, 2011; Knijnenburg and Willemsen, 2015; Bollen *et al.*, 2010; Chen and Pu, 2010b; Chen and Pu, 2010a; Hu and Pu, 2011; Ekstrand *et al.*, 2014; Jugovac and Jannach, 2017
Attitudes & Beliefs	4.1.4	Cremonesi *et al.*, 2011a; Pu *et al.*, 2011; Swearingen and Sinha, 2002; Bollen *et al.*, 2010; Willemsen *et al.*, 2016; Jin *et al.*, 2019
User Study Design	4.2	Allen and Yen, 2001; McCroskey *et al.*, 1984; Yannakakis and Hallam, 2011; O'Brien and Toms, 2008; O'Brien and Toms, 2010; Goretzko *et al.*, 2019; Knijnenburg and Willemsen, 2015; Pu *et al.*, 2011; Knijnenburg *et al.*, 2012b; Ullman and Bentler, 2003

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