Recognition of user information behavior through music-related information searching patterns

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RECOGNITION OF USER INFORMATION BEHAVIOR THROUGH MUSIC-RELATED INFORMATION SEARCHING PATTERNS

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PREPOZNAVANJE INFORMACIJSKOG PONAŠANJA KORISNIKA PUTEM OBRAZACA PRETRAŽIVANJA INFORMACIJA O GLAZBI I GLAZBENIH ZAPISA

DOKTORSKI RAD

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About Supervisor

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Sonja Špiranec was born 1974 in Düsseldorf, Germany. She finished elementary and high school in Zagreb. She studied Information Sciences and German Laguage and Literature at the Faculty of Humanities and Social Sciences in Zagreb and graduated 1998. After her graduation, she begun to work at the National and University Library in Zagreb.In 2001. she enrolled in postgraduate studies in Information Sciences and begun to work as a research assistant at the Faculty of Humanities and Social Sciences. She gained her PhD in 2007 (title of the thesis: Model of organizing information in electronic learning environments).

Since 2013 she holds the position of an associate professor and researcher and is currently the chair of Institute of Information Studies. She is engaged in undergraduate, graduate and postgraduate teaching, mentoring and research. She has published numerous articles, one book and and was recently the editor of the book Worldwide Commonalities and Challenges in Information Literacy Research and Practice, published by Springer in 2013. She also serves in standing committees and program committees in a number of international events (INFuture, ECIL: European Conference on Information Literacy, INTED: International Technology, Education and Development Conference, EDULearn, Bobcatsss, IMCW: International Symposium on Information Management in a Changing World). She also has participated in international projects (Erasmus intensive programme Library, Information and Cultural Management 2011, 2012, 2013) and Information and Communication Technology in supporting the educational process (2012), COST Action TD1210 KnowEscape: Analyzing the dynamics of information and knowledge landscapes). Since 2006 she participated in different information and media literacy projects, initiatives and summits organized by UNESCO. In cooperation with colleagues from the Department of information management (Hacettepe University), she founded the European Conference on Information Literacy and serves as the chair of the Programme Committee and Co-chair of Standing Committee.

Fields of Interest:

- Organization of information (subject indexing) and subject access to information
- Information search process
- Information behavior and practice
- Evaluation and credibility of information
- Information Literacy

Projects:

- Organizacija, upravljanje i razmjena znanja u elektroničkom obrazovnom okruženju (šifra projekta 130-1301799-1755)
- Organizacija informacija i znanja u elektroničkom obrazovnom okruženju (šifra projekta: 0130462)
- ERASMUS: Akademska ljetna škola Library, Information and Cultural Management i Information
- ERASMUS: Communication Technology in supporting the Educational Process
- COST Action 1210: Analyzing the dynamics of information and knowledge landscapes (KNOWeSCAPE)
- RACOSS: Research Activity, Collaboration and Orientation in Social Sciences in Croatia and other post-socialist European Countries (Croatian Science Foundation)

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Abstract

This thesis is based on the inquiry of how we could quantify the information behavior patterns through the logs collected while people search and seek for the information. At the same time, it addresses the socio-cognitive characteristics of the user and explores how those characteristics could be predicted through the computer analysis of the logs collected while search tasks are done. It is based on the premise that if we could quantify information behavior patterns by computer, the output of such a process could be used as feedback for the information systems that are adaptive to the user's needs. Log analysis as a method in information science and particularly in the information behavior domain is rarely used. Most of the existing literature is based on qualitative research or quantitative methods such as surveys. And as we live in the times of ultra-large systems that already have some of those techniques implemented in them but closed in a black box, we must understand those techniques. The main challenge of this thesis approach is how to quantify behavior based on the logs collected. We could understand that logs collected are one of the rare data which could be collected and then processed by the computer to describe behavior. In particular, it is important as some theories told us that most human behavior is not based on rationality but is influenced by the environment. To simulate the environment of the user's day-to-day information searching process the laboratory experiment was chosen. Users were first given the survey that was used to describe their socio-cognitive characteristics from the perspective of information need and information behavior. After filling the survey, participants had to fulfill four information searching tasks in the domain of music, and logs from those searches were collected. The biggest challenge was based on the issue that by analyzing data by a human there was a clear difference between the user socio-cognitive characteristics and his logs collected in the process of information search. But if we want to design adoptive information systems computers should do such a process and use its output as feedback to adapt to the user. To do so algorithm was developed that transforms the absolute numbers into relative ones. And only after doing so the computer could process data and evaluate the prediction in terms of recognizing users' characteristics. As a result of this thesis, some user characteristics could be recognized through the logs and the algorithm showed results. And as such, this thesis provides the one step towards a better understanding of how users use information systems, how those information systems could be designed to be more adaptive and human-friendly.

Keywords: information beahviour, log analysis, machine learning, socio cognitive theory, information searching, information seeking, information retrieval, information use, music recomendation systems, information systems design

Sažetak

Doktorski rad se bavi istraživanjem mogućnosti kvantifikacije ljudskog informacijskog ponašanja. Ljudsko informacijsko ponašanje je disciplina informacijskih znanosti koja se bavi informacijskim potrebama, traženjem, pretraživanjem, procesuiranjem i korištenjem informacija. Polazna točka istraživanja je da se informacijsko ponašanje između ostalog odražava i u obrascima pretrage informacijskih izvora u obliku logova (digitalnih zapisa o interakciji korisnika s informacijskim izvorima). Logovi se mogu sakupiti, pohraniti, analizirati te prezentirati uz pomoć računala u svrhu kvantitativnog uvida u informacijsko ponašanje što i je glavni cilj ovog istraživanja. Kako kao društvo sve više koristimo digitalne uređaje, informacijske sustave te mobilne aplikacije tako kreiramo sve više i više logova. Ono što je bitno za društvo u cijelom je da logove koje kreiramo obično koriste velike korporacije koje svoje poslovanje temelje na analizi tih logova. Međutim istovremeno to i stvara disbalans u društvu, jer nekolicina tvrtki ima uvid u to kako se informacijski ponašamo, to koristi za kreiranje profita, dok društvo nema uvida u procedure kako se naši logovi obrađuju te kako se informacijski sustavi adaptiraju sukladno obradi tih logova. Istovremeno trenutno stanje možemo sagledati i kao početak jedne nove etape u dizajnu informacijskih sustava, koji su adaptivni te se prilagođavaju svakom korisniku sukladno njegovim informacijskim potrebama. Područje informacijskog ponašanja vezanog uz glazbu je izabrano zato što je glazbena industrija jedna od prvih koja je bila izložena utjecaju digitalizacije te se rapidno transformirala u zadnjih dvateset godina. Samim time i informacijski sustavi, ili još bolje rečeno socio tehnološki sustavi, koji omogućuju konzumaciju glazbe su se isto tako mijenjali. Od informiranja korisnika, distribucije glazbenih zapisa, konzumiranja glazbe do dijeljenja iskustava nastalih na temelju slušanja glazbe.

Metode korištene u istraživanju uključuju anketu koju su ispunili participanti laboratorijskog eksperimenta s ciljem sakupiljanja podataka koji opisuju njihove socio kognitivne karakteristike te analizu logova koji opisuju pretraživanje informacija sakupljenih tijekom eksperimenta. Nakon sakupljenih podataka o socio kognitivnim karakteristikama korisnika te njihovim informacijskim potrebama putem ankete, te logova sakupljenih za vrijeme traženja informacija o glazbi ili glazbenih zapisa pristupili se obradi podataka. Cilj je pronalaženje odnosa između logova koji opisuju korisničke obrasce traženja informacija te pronalaženjem statistički značajnih korelacija između socio-kognitivnih karakteristika korisnika i obrazaca traženja informacija. Svrha istraživanja je da se pronađu ispravne procedure, algoritmi te načini statističke obrade sakupljenih podataka kako bi računalo moglo iste koristiti za potrebe strojnog promatranja ponašanja korisnika u domeni glazbenog informacijskog ponašanja.

Informacijsko ponašanje je poddisciplina informacijskih znanosti koja se istražuje različitim metodologijama odnos čovjeka i informacije. Informacijsko ponašanje se bavi opisivanjem raznih načina kako ljudi komuniciraju s informacijama, s naglaskom na traženje i korištenje informacije. Kada govorimo o obrascima informacijskog ponašanja, odmičemo se od samih informacijskih

izvora te se fokusiramo na odnose između njih i procese traženja, pretraživanja i korištenja informacija od strane korisnika. Informacijsko ponašanje nastaje kao rezultat informacijskih potreba korisnika unutar okruženja koje može biti definirano kao radno, socio-kulturno, političko-ekonomsko ili fizičko. Bitno je razlikovati informacijsko ponašanje, traženje informacija, pretraživanje informacija te korištenje samih izvora informacija. Informacijsko ponašanje je ukupno ljudsko ponašanje proizašlo koje proizlazi iz odnosa s izvorima i kanalima informiranja. Informacijsko traženje (information seeking behaviour) je smisleno traženje informacija u svrhu ostvarivanja određenih ciljeva. U procesu traženja korisnik je u interakciji s više izvora informacija (npr knjižnica te informacijski sustav). Pretraživanje informacija (information searching behaviour) je mikro nivo ponašanja koji opisuje interakciju pojedinca s određenim informacijskim sustavom ili izvorom informacija.

Istraživanje se temelji na socio-kognitivnom teoretskom pristupu disciplini informacijskog ponašanja unutar informacijskih znanosti. Ovaj teoretski pristup pored kognitivnih definira i socijalne čimbenike kao bitne u procesu traženja informacija. Odnosno, fokus je na uzajamnosti socijalnih i kognitivnih čimbenika prilikom oblikovanja ponašanje. Ostali teorijski pristupi informacijskom ponašanju su obrađeni u drugom poglavlju koji se bavi teorijama informacijskog ponašanja. U istom poglavlju dan je i pregled relevantnih teorija iz domene dizajna informacijskih sustava s obzirom na to da samo istraživanje se javlja polaznom točkom za dizajn informacijskih sustava koji su adaptivniji prema korisniku nego kakve danas koristimo. Kao teorijska polazišta koja se koriste u istraživanjima informacijskog ponašanja predstavljene su sljedeća; *Psychodynamic theory, Activity Theory, Critical Theory (CT), Personal construct theory , Personality theory , Practice theory, Social-cognitive theory, Social phenomenology, A general theory of human information behavior (GTOHIB).* Informacijsko ponašanje proizlazi iz potrebe korisnika koji, da bi zadovoljio svoju informacijsku potrebu, koristi formalne i neformalne informacijske izvore i usluge, što će rezultirati uspješnim ili neuspješnim pronalaženjem relevantnih informacija. Istovremeno informacijsko ponašanje se i može definirati kao konstruktivno stvaranje značenja iz informacija u postupku traženja informacija. Kroz godine razvili su se različiti modeli informacijskog ponašanja koji se koristi prilikom istraživanja informacijskog ponašanja. Različiti istraživači predlažu različite konceptualne istraživačke okvire, važan teoretski doprinos u ovom znanstvenom polju pruža knjiga *Theory in information behavior research* koja nudi uvid u različite teoretske pristupe na kojima su građeni različiti modeli. Budući da su obrasci ponašanja tijekom traženja informacija povezani s informacijskim potrebama, Nicholas (2003) je razradio jedanaest perspektiva informacijskih potreba. To su subjekt po kojem se informacija traži, funkcija upotrebe informacija, priroda informacijskih izvora, nivo kompleksnosti i intelektualni nivo koji određuje minimalno znanje korisnika kako bi mogao razumjeti informaciju, točka gledišta s kojeg je informacija kreirana, kvantiteta i kvaliteta, vrijeme kada je informacija kreirana, brzina isporuke informacije, mjesto gdje se informacija koristi te gdje se nalazi te kako je informacija procesuirana te zapakirana. Wilson u svom drugom modelu informacijskog ponašanja, na kojem se temelji ovo istraživanje, definira da osoba u kontekstu ima informacijske potrebe te da postoje dva aktivacijska mehanizma informacijskog

ponašanja koja mogu biti objašnjena teorijom stresa i nošenja s istim (*stress and cope theory*) te teorijom rizika i nagrade (*risk/reward theory*) i teorijom socijalnog učenja (*social learning theory*). Osim aktivacijskih mehanizama Wilsonov drugi model uključuje i intervenirajuće variable poput psiholoških, demografskih, onih vezanih za uloge, onih koje opisuju okruženje te one koje karakteriziraju izvore informacija. Istraživanja informacijskog ponašanja moguće je provesti različitim metodama, od intervjua, upitnika, internetskih i telefonskih anketa, fokus grupa, promatranja, vođenja dnevnika, logova, audio zapisnika (*journals*), foto dnevnika, etnografskih istraživanja, do metode kritičnih faktora uspjeha i kritičnih incidenata te analize web logova. U četvrtom poglavlju je napravljena sistematska analiza korištenih metoda u istraživanju informacijskog ponašanja. Rezultati te analize ukazuju na relativno rijetko korištenje medote analize logova. Rezultati analize su stavljeni u kontekst predloženog socio tehnološkog modela informacijskog ponašanja. Model socio tehnološkog informacijskog ponašanja je proizašao kao rezultat ovog istraživanja. Ovaj model je predložen s ciljem proširenja okvire istraživanja i na interakciju socio i tehnološke faktora u procesu traženja, pretraživanja te korištenja informacija. S obzirom na to da na ljudsko informacijsko ponašanje sve više i više utječu tehnologije, odnosno računala i implementirani algoritmi koji upravljaju dinamikom, selekcijom i preporukama informacijskih objekata bitno je i obuhvatiti u istraživanju i taj odnos. Posebno jer tehnologije koje se koriste su obično sakrivene te ne postoje uvidi u principe rada algoritma preporučuju i prezentiraju informaciju prema korisniku. A ovisno o tome ovisi ljudsko informacijsko ponašanje. Pretraživanje informacija o glazbi i glazbenih zapisa specifičan je proces zbog toga što se korisnik ne oslanja na samo na riječi nego i na neka druga svojstva, poput obrazovanja i kulturnog predznanja korisnika, konteksta gdje se pojavila informacijska potreba kod korisnika ili afiniteta prema tipu glazbe. Za potrebe ovog istraživanja je izrađena analitička matrica temeljena na postojećim istraživanjima, koja uključuje sljedeće perspektive: pristupanje i analiza sadržaja, preporuke glazbenih sadržaja, pretraživanje i dohvaćanje informacija, proces traženja informacija te socijalno-kognitivni utjecaj informacija na iskustvo korisnika. Predložena analitička matrica se tijekom istraživanja i razvila u gore spomenuti model socio tehnološkog informacijskog ponašanja. U petom poglavlju opisano je istraživanje te su predstavljeni rezultati obrade sakupljenih podataka. Primarni cilj istraživanja je utvrditi mogućnosti strojnog promatranja informacijskog ponašanja putem sakupljenih logova te ustanoviti postoje li korelaciju između obrazaca traženja informacija te socio-kognitivnih karakteristika korisnika.

Istraživanje se temelji te analizira procesa traženja informacija o glazbenim zapisima te pronalaženje samih glazbenih zapisa. Taj proces se odražava u logovima koji su sakupljeni uz pomoć računala prilikom pretrage web stranica od strane korisnika. Logovi su sakupljeni putem postojećeg računalnog programa napisanog između ostalog i za tu namjenu. U logu se za svaki novi posjet nekoj stranici nalaze identifikacijska oznaka korisnika koji je tu web stranicu posjetio, link te stranice, vrijeme kada je stranica učitana te vrijeme kada je stranica napuštena. Iz linka se može ustanoviti domena web stranice te ključne riječi koje je korisnik koristio prilikom pretrage (ako su korištene). Istovremeno svaki korisnik ima svoje jedinstvene socio-kognitivne karakteristike koje su opisane temeljem podataka sakupljenih anketom koju je svaki sudionik

eksperimenta ispunio. Sam eksperiment se sastojao od tri dijela. Prvo su svi sudionici dobili na ispunjavanje anketu kako bi se sakupili podatci o njihovim socio kognitivnim karakteristikama. Nakon toga, sudionicima eksperimenta predstavljena su dva zadatka za traženja glazbenog zapisa, te dva zadatka za pronalaženja informacija o kupnji karata za glazbeni događaj. Nakon toga, svaki sudionik eksperimenta se prijavio na računalo s jedinstvenom korisničkim imenom i lozinkom te pristupio izvršenju zadanih zadataka, odnosno počeo je tražiti informacije sukladno zadanim zadatcima. Kada je svaki pojedinačni zadatak bio izvršen, sudionik je bio zamoljen da se prijavi na određeni web link kako bi se u kasnijoj analizi podataka mogli razdijeliti sakupljeni logovi za svaki zadatak. Nakon izvršenih pretraživanja sukladno zadanim zadatcima računalni program koji sakuplja logove je generira datoteku u kojoj su zabilježeni svi koraci traženja informacija. Tako sakupljeni su podatci o tome koje je web stranice svaki pojedinačni sudionik eksperimenta posjetio te kada je njima pristupio i kada ih je napustio. Ovim putem se generirao skup podataka koji odražava informacijsko ponašanje korisnika, odnosno kvantitativno i objektivno opisuje svaki korak u procesu pretraživanja informacija. Anketa je izrađena na temelju Wilsnon-ovog drugog modela informacijskog ponašanja te Nicholas-ovim perspektivama informacijskih potreba. Podatci sakupljeni anketom opisuju informacijske potrebe kroz subjekt po kojem se informacija traži (ključne riječi), po funkciji zašto se traži (kućna zabava ili nove spoznaje), prirodi (npr kritika ili povijesnim činjenicama), kompleksnosti izvora same informacije (dnevne novine ili specijalizirani časopisi), točke gledišta odnosno utjecaja objektivnosti izvora informacija, kvantitete i kvalitete informacija, pravovremenosti, geografskom mjestu izvora te važnosti formata kako je predstavljena. Putem anketa sakupljeni su podatci koji opisuju intervencijske varijable koje predlaže Wilson u svom drugom modelu. One su; personalne karakteristike, demografski podatci, emocionalni i edukativni utjecaji te ekonomske dimenzije vezane uz pretraživanje i konzumiranje glazbe, društveno/interpersonalne i situacijske varijable te stavovi prema izvorima informacija.

S obzirom na to da se istražuju socio-kognitivni aspekti koji utječu na način traženja informacije, izabrani teoretski okviri za potrebe ovog istraživanja (informacijske potrebe i istraživanje društvenih karakteristika korisnika) daju mogućnost sakupljanja najviše relevantnih podataka. Sakupljanjem ova dva skupa podataka, dobivaju se podatci koji karakteriziraju socio-kognitivne karakteristike informacijskog ponašanja svakog pojedinog korisnika koje se mogu uspoređivati s podatcima koji kvantitativno opisuju koje web stranice i u kojim vremenskim intervalima je korisnik posjetio.

Nakon sakupljanja podataka u laboratoriju podatci su se naknadno pročistili, odnosno udaljili korisnici te s njima povezani podatci koji nisu ispunili sve zadatke, nisu ispunili anketu u potpunosti, nisu slijedili uputstva za izvršenje zadataka pretraživanja informacija ili sakupljeni logovi nisu bili primjereni za obradu zbog tehničkih grešaka prilikom sakupljanja istih. Tako pripremljeni podatci, raspodijeljeni u dva skupa (socio-kognitivne karakteristike i logovi o pretraživanju informacija) su se statistički analizirali s ciljem pronalaženja korelacija te prediktivnih vrijednosti istih. Istraživanje se sprovelo nad uzrokom studenata iz Zagreba, koji su

biti izabrani neprobabilističkim tehnikama uzorkovanja. Nezavisne varijable su zadatci informacijskog traženja (information seeking tasks) glazbe. Zavisne varijable su obrasci pretraživanja informacija. Intervencijska varijabla su karakteristike studenta.

Za potrebe istraživanja postavljene su tri hipoteze. One su; 1) različite informacijske potrebe korisnika rezultiraju će različitim obrascima pretraživanja informacija, 2) okruženje u kojem korisnik traži informacije utječe na obrasce traženja informacija, te 3) da je na temelju zapisa logova generiranih strojnim promatranjem procesa traženja informacija, mogu se predvidjeti karakteristike korisnika koji pretražuje informacije. Za potrebe dokazivanja hipoteza obavljene su dvije iteracije obrade podataka. Za potrebe dokazivanja hipoteza 1 i 2 korištena je eksplorativna faktorska analiza i regresijska analiza, dok za potrebe dokazivanja hipoteze 3 razvijen je algoritam te su korištena regresijska analiza, AUROC (Area Under Receiver Operating Curve) te LASSO (Least Absolute Shrinkage and Selection Operator). Potvrđivanjem Hipoteza 1 je utvrđeno da postoji povezanost između informacijskih potrebama korisnika te obrazaca pretraživanja informacija kroz ukupno vrijeme traženja informacija, broj koraka koliko korisnik napravi da dođe do željene informacije te broju različitih domena kroz koje je korisnik "prošao" tražeći informacije. Dokazivanjem Hipoteze 2 utvrđeno je da okruženje korisnika utječe na obrasce traženja informacija. Podatci su ukazali da postoji povezanost između vrste sveučilišne i veleučilišne edukacije korisnika i broja napravljenih koraka, vremena potrebnog da se pronađe informacija te broj domena kroz koje je korisnik "prošao" kako bi se došlo do željene informacije. Potvrđivanjem Hipoteze 3 dokazano je da je moguće predvidjeti pojedine socio kognitivne karakteristike korisnika temeljem analize logova. Dvije karakteristike su dokazane da imaju prediktivnu vrijednost temeljem LASSO te AUROC analize, a to su znanje o glazbenom žanru kojeg korisnik voli ili prati te u kojoj mjeri korisnik se želi informirati o glazbi.

Na teorijskoj razini u sklopu ovog istraživanje predložen je socio tehnološki model informacijskog ponašanja koji se kao takav može koristiti za potrebe istraživanja u domeni informacijskog ponašanja te za potrebe dizajna adaptivnih informacijskih sustava. Sistematska analiza objavljenje literature iz područja informacijskog ponašanja ukazala je na trendove korištenih znanstvenih metoda. Istraživanje osim primarnih ciljeva vezanih uz dokazivanje hipoteza pokušalo je i teoretski obuhvatiti dva pravca unutar istraživačke domene unutar samih informacijskih znanosti; pravac koji je usredotočen na sustav (engl. system-oriented) i pravac usmjeren na korisnika (user-oriented). Isto tako istraživanje je dalo i smjernice za oblikovanje i arhitekturu adaptivnih informacijskih sustava koji se temelje na automatskom prilagođavanju informacijskim potrebama i karakteristikama korisnika. Na metodološkoj razini istraživanje je povezalo kvantitativne obrasce pretraživanja i traženja informacija s kvantitativnim opisom karakteristika korisnika koji traži glazbene zapise i informacije putem sakupljenih logova te ukazalo na mogućnosti i doseg postupaka strojnog promatranja korisnika u domeni istraživanja informacijskog ponašanja.

Ako je moguće prepoznati karakteristike korisnika te njegove informacijske potrebe putem strojnog promatranja obrasca pretraživanja informacija, onda možemo tvrditi da obrazac traženja informacija postaje ulazni signal koji informacijski sustav može koristiti kako bi se adaptirao korisniku. Isto se ovim istraživanjem potvrdilo kao moguće.

Ključne riječi: informacijsko ponašanje, analiza logova, strojno učenje, socio kognitivna teorija, pretraživanje informacija, traženje informacija, korištenje informacija, dohvaćanje informacija, sustavi glazbenih preporuka, dizajn informacijskih sustava

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INTRODUCTION

Information Behavior is a sub-discipline of information science that explores different approaches to human beings and information relationships. Information behavior deals with describing different ways in which people communicate information, focusing on searching and using information.[1] When we talk about patterns, we get detached from things and focus on relationships between them.[2] Information behavior is a result of information needs of users within an environment that can be defined as working, socio-cultural, political-economic or physical.[3],[4] There is a difference between information behavior, information seeking, searching for information, and the use of information sources themselves. Information Behavior is the totality of human behavior stemming from relationships with sources and channels of information. Information seeking behavior is a meaningful search for information to achieve certain goals. In the process of searching the user is interacting with more sources of information (e. g., library and information system). Searching Information (Information Search Behavior) is a micro-level of behavior that describes the interaction of an individual with a particular information system or source of information. [5]

This study examines the impact of socio-cognitive characteristics of users on the information search process. It analyzes the relationship between information search patterns of music content and music records and the socio-cognitive characteristics of the user seeking information. For the purposes of research, two sets of data are generated. The first set consists of computer-generated logs that describe information retrieval patterns. The second set is based on data describing socio-cognitive characteristics of users surveyed. Statistical analysis of these two sets is carried out with the purpose of establishing mutual dependence.

The research is based on socio-cognitive theoretical approach to the discipline of information behavior within the information sciences. This theoretical approach, besides cognitive, defines

[1] Bates, M. J., 2010. Information behavior. Encyclopedia of library and information sciences, 3, 2381–2391.

[2] Kelso, J. S., 1997. Dynamic patterns: The self-organization of brain and behavior. MIT press.

[3] Wilson, T. D., 1981. On user studies and information needs. Journal of documentation, 37(1), 3–15.

[4] Wilson, T. D., 2006. On user studies and information needs. Journal of documentation, 62(6), 658–670.

[5] Wilson, T. D., 2000. Human information behavior. Informing science, 3(2), 49–56.

social factors as essential in the process of searching for information. That is, the focus is on the reciprocity of social and cognitive factors in shaping behavior. [6] Other theoretical approaches to information behaviors considered as the basis of research are Activity Theory[7],[8] and Personal Construct Theory. [9],[10] Activity theory explains the relationship between the subject, the object, and the instruments that influence the information behavior, while the Personal Construct Theory deals with an individual and does not include social aspects that influence the process of seeking information.

Information behaviors arise from the needs of users who, in order to satisfy their information needs, use formal and informal sources of information and services, which will result in successful or unsuccessful finding of relevant information.[11] C. Kuhlthau[12] defines information behavior as constructive creation of meaning from information in the process of information seeking. Over the years different models of information behaviors have evolved and an extensive overview of the model is presented in Case[13], and in Fisher, Erdelez and McKechnie.[14] Given that, different researchers propose different conceptual research frameworks. The theoretical contribution in the domain is provided by the Wilson book[15], which gives us insights into different theoretical approaches according to which different models have been constructed. Since patterns of behavior during information search are related to information needs, Nicholas[16] has elaborated eleven perspectives of information needs. This is the subject for which information is sought: the function of using information, the nature of information sources, the level of complexity and the intellectual level that determines the minimum knowledge of the user

6 Pálsdóttir, A., 2013. Chapter 6 – Social cognitive theory in Wilson, T. D. (Ed.), 2013. Theory in information behaviour research. Sheffield, UK: Eiconics Ltd.

7 Vygotsky, L., 1978. Mind in society. Cambridge, MA: Harvard University Press.

8 Wilson, T. D., 2008. Activity theory and information seeking. Annual Review of Information Science and Technology, 42, 119–161

9 Kelly, G. A., 1963. A theory of personality: The psychology of personal constructs. New York: Norton.

10 Wilson, T. D. (Ed.), 2013. Theory in information behaviour research. Sheffield, UK: Eiconics Ltd.

11 Wilson, T. D., 1999. Models in information behaviour research. Journal of documentation, 55(3), 249–270.

12 Kuhlthau, C. C., 199). Inside the search process: Information seeking from the user's perspective. JASIS, 42(5), 361–371.

13 Case, D. O. (Ed.), 2012. Looking for information: A survey of research on information seeking, needs and behavior. Emerald Group Publishing.

14 Fisher, K. E., Erdelez, S. & McKechnie, L. (Eds.), 2005. Theories of information behavior. Information Today, Inc.

15 Wilson, T. D. (Ed.), 2013. Theory in information behaviour research. Sheffield, UK: Eiconics Ltd.

16 Nicholas, D., 2003. Assessing information needs: tools, techniques and concepts for the internet age. Routledge.

in order to understand the information, the point of view from which the information was created, the quantity and the quality, the time when information was created, the speed of delivery of information, where information is used and where it is and how information is processed and packed.[17] *Theory in Information Behaviour Research* Wilson, in his second model of information behavior on which this research is based, states that the person in the context has information needs and that there are two activation mechanisms of information behavior that can be explained by stress and cope theory, risk and risk reward theory and social learning theory. In addition to activation mechanisms, Wilson's second model includes both intervening variables such as psychological, demographic, role-related, environmental and characterizing sources of information. Information seeking research can be conducted through different methods, ranging from interviews, questionnaires, internet and telephone surveys, focus groups, observation, logging, logs, journals, photo journals, ethnographic research, methods of critical success factors and critical incidents analysis of web logs[18] Lee and Cunningham[19] give an overview of information behavior research in the context of music sources, which featured 198 studies of users. When talking about the use of machines for the purposes of observing users behavior while searching for information on the Internet and the analysis of digital logs, important review work is presented in Jamali, Nicholas and Huntington[20]; Taksa, Spink and Jansen [21], Dumais, Jeffries, Russell, Tang and Teevan [22] Significant research related to this study is presented in Inskip et al.[23], where information users are grouped according to their characteristics (including their professional needs) and their information needs are analyzed using the analytical framework of already mentioned eleven perspectives of information needs by Nicholas[24]. Searching for music and music information is a specific process because the user does not rely on words alone but on

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17 Nicholas, D., 2003. Assessing information needs: tools, techniques and concepts for the internet age. Routledge.

18 Bawden, D. & Robinson, L., 2012. Introduction to information science. London: Facet.

19 Lee, J. H. & Cunningham, S. J., 2013. Toward an understanding of the history and impact of user studies in music information retrieval. Journal of Intelligent Information Systems, 41(3), 499–521.

20 Jamali, H. R., Nicholas, D. & Huntington, P., 2005. The use and users of scholarly e-journals: a review of log analysis studies. In Aslib Proceedings (Vol. 57, No. 6, pp. 554–571). Emerald Group Publishing Limited.

21 Taksa, I., Spink, A. & Jansen, B. J., 2009. Web log analysis: Diversity of research methodologies. In Handbook of research on web log analysis (pp. 506–522). IGI Global.

22 Dumais, S., Jeffries, R., Russell, D. M., Tang, D. & Teevan, J., 2014. Understanding user behavior through log data and analysis. In Ways of Knowing in HCI (pp. 349–372). Springer, New York, NY.

23 Inskip, C., Butterworth, R. & MacFarlane, A., 2008. A study of the information needs of the users of a folk music library and the implications for the design of a digital library system. Information Processing & Management, 44(2), 647–662.

24 Nicholas, D., 2003. Assessing information needs: tools, techniques and concepts for the internet age. Routledge.

other features as well, such as education and cultural anticipation of the user, the context in which the need for information appeared by the user or by the affinity to a certain type of music. [25] An analytical matrix based on the existing research has been developed, which includes the following perspectives: access and analysis of the content, music content recommendations, search and retrieval of information, information seeking process and the socio-cognitive impact of information on the experience of the user.[26]

The aim of the research is to explore the ability of identifying user information behavior through information search patterns on music and music records. The research hypotheses are: a) different user information needs will result in different proprietary information search patterns, b) the user environment affects information search patterns and c) on the basis of the records generated by machine observation of the information search process, characteristics of the user who searches the information can be predicted.

Material, informants, methodology and research description

The research is a quantitative quasi-laboratory experiment. The methods used are surveys and an analysis of logs collected through the interaction between users and the computer when searching information. Participants in the experiment are students who are selected in order to represent different fields of science.

The research analyzes the process of searching music information and finding music tracks themselves. This process is reflected in the logs collected by computer while users search different web sites. The logs are collected by the existing computer program that was made for this purpose. For each new visit to a page, the log contains the identifying tag of the user who visited that site, the link to that page, the time the page was loaded, and the time the page was left. The link can be used to identify the domain of a website and the key words that the user used while searching (if they were used). At the same time, each user has their own unique

[25] Lee, J. H., 2010. Analysis of user needs and information features in natural language queries seeking music information. Journal of the American Society for Information Science and Technology, 61(5), 1025–1045.

[26] Lugović, S. (2014). Research Dimensions in Information Seeking of Music: A Plea for the Socio-technical Perspective. In Information Literacy. Lifelong Learning and Digital Citizenship in the 21st Century (pp. 722–732). Springer International Publishing.

characteristics that influence the information behavior which are analyzed through the collection of the data through a survey that each experiment participant fills in. The experiment itself consists of three parts. First, all participants are given a survey to fill in to collect data about their characteristics. After that, the participants of the experiment were presented with two tasks to search for a music track, and two tasks to find information about buying tickets for a music event. After that, each participant of the experiment logs into the computer operating system with a unique username and password and accesses the given tasks and begins to look for information in accordance with the given tasks. After completing each individual task, the participant logs on to a particular web link in order to divide the collected logs for each task for the later analysis of the data. After the searches have been made according to the given tasks, the user logs out and the computer program that generates the logs creates a file that records all the steps. This way the data are collected indicating which web sites each individual participant of the experiment has visited, when they accessed them and when they left them. In this way data are collected that reflect the user's information behavior, and quantitatively and objectively describe each step in the process of searching information. The survey was based on Wilson's second model of information behavior[27] and Nicholas's perspective on information needs[28]. The data collected by the survey describe the information needs related to the subject, content of the search for information (key words), by the function of looking for (home entertainment or new discoveries), the nature (e.g. criticism or historical facts), the complexity of the source of the information itself (daily newspapers or specialized journals), the point of view or influence of the objectivity of the source of information, quantity and quality of information, timeliness, geographic location of the source and the importance of the format presented. The survey also collects information on intervention variables that affect information behavior, such as personal characteristics, demographic data, emotional and educational influences, and economic dimensions related to the search and music consumption, social/interpersonal and situational variables, as well as attitudes to the sources of information.

[27] Wilson, T. D., (1997). Information behaviour: an interdisciplinary perspective. Information processing & management, 33(4), 551–572.
[28] Nicholas, D., (2003). Assessing information needs: tools, techniques and concepts for the internet age. Routledge.

When designing the questionnaire for the needs of classifying the characteristics of users, two other theoretical bases were considered. One is the *Big Five* personality test[29], while the other is the model of classification of music users in four categories presented by Celma[30]. What is examined are the socio-cognitive aspects that affect the way information is searched, the chosen theoretical frameworks for the purpose of this research (information needs and the research of social characteristics of users) and provide the possibility of collecting the most relevant data. By collecting these two sets of data, we obtain the data that characterize the socio-cognitive characteristics related to the information behavior of each individual user that can be compared to the logs data that quantitatively describe the times and pages when the user visited them.

After collecting the data in a laboratory, the data are subsequently cleaned and the users who did not complete their tasks were discarded, as well as their related data, including those who failed to do the required tasks, those who did not fill in the survey in its entirety, or those who did not follow the instructions to completing the tasks of searching information or collected logs were not appropriate for processing due to technical mistakes upon their collection. Such prepared data, divided into two sets (user characteristics and information search logs) are statistically analyzed for the purpose of finding the correlations and predictive values of the data. Cross-validation of data is used for the purposes of proving the correlations of these predictive value variables. The research is conducted on the sample of students from Zagreb, which are selected by non-probabilistic sampling techniques. The independent variables are the information seeking tasks of music. The dependent variables are patterns of searching information. The intervention variables are the characteristics of the students.

If it is possible to identify the characteristics of the user and their information needs by means of machine observation of the information search process logs, then we can state that the information search logs, if recognized and processed by machine, become an input signal that the information system can use to adapt to the user.

[29] Barrick, M. R. & Mount, M. K., 1991. The big five personality dimensions and job performance: a meta-analysis. Personnel psychology, 44(1), 1–26.

[30] Celma, O., 2010. Music Recommendation and Discovery: The Long Tail, Long Fail, and Long Play in the Digital Music Space. Springer.

Expected scientific contribution of the proposed research

The scientific contribution of the research can be expressed at a theoretical and methodological level.

At the theoretical level the research results are as follows:

• Link theoretically and methodologically the two exploratory paradigms of information sciences: a system-oriented and user-oriented approach, thus contributing to the integrative approach to the domains of information behavior, information retrieval, information systems and machine learning.

• Provide insights into the relevance of socio-cognitive constructs in the context of music search as a sub-discipline of information search.

• Propose new guidelines for the design and architecture of adaptive information systems based on the automatic adaptation to the user information needs and characteristics.

At the methodological level the research will:

• Link quantitative information search patterns with quantitative descriptions of user characteristics that search for music tracks and information.

• Point out to the opportunities and reaches of machine observation procedures in the domain of information behavior.

• Contribute to further development of quantification of information behavior through surveys and logs, focusing on Wilson's second model of information behavior.

The structure of the dissertation is based on five chapters. The first chapter presents the outline of the theoretical perspectives of information behaviour and information systems design with particular focus on exploring information behaviour theories and information system design theories. This chapter gives the overview of the extensive theoretical departure points in the domain of information behaviour. Each theory is put in the context of the information behaviour research and some of the relevant researches are outlined. The second chapter proposes socio technical information behaviour model, which is used as a conceptual framework of this study. Socio technical information behaviour model is a result of the extensive research of the existing

work in the field of information behaviour. As such, it is related to the existing researche by other authors and previous work of the author of this study. The third chapter presents a quantitative and qualitative literature review on research methods in the field of information behavior, with a specific emphasis on log analysis as the main data collection technique used in study. Literature review is based on the one previous study[31], using the same sources from which research papers are retrieved; the same classification of the papers is used that are grouped in the same way. By doing so, this chapter contributes to the extended period of time in which research papers are analyzed. In the fourth chapter research methodology is explained and research results are presented in the relationship to hypothesis of the research. In the discussion chapter, results are discussed, followed by conclusion which elaborates future direction and research concepts including its implications are elaborated.

[31] Greifeneder, E., 2014, December. Trends in information behaviour research. In: Proceedings of ISIC: the information behaviour conference

THEORETICAL PERSPECTIVES OF INFORMATION BEHAVIOR AND INFORMATION SYSTEMS DESIGN

There is a difference between theory in physical and social science. In physical science, theories are predictive and testing theories are used to collect relevant quantitative data and apply mathematical techniques in analysis of those data.

In social science, of which we consider the field of information behaviour to be part, theories are rather different in character. They tend to propose alternative explanations of social phenomena, rather than the prediction of future behaviour. [32]

The role of the theory in social science is moderate as phenomena studied, such is the case with study of human information behaviour, where phenomena could be affected by means used to study it.
The main aim of this research is to explore how human information behaviour could be quantitatively described.

What different socio-cognitive characteristics of the users looking for the information could be recognized from the data collected? In order to achieve this, it is essential to gain a deeper understanding of those characteristics. It is more about being able to explain some social phenomena than predict future behaviour, but research will also evaluate predictive strength of detected correlations between variables used.

It is inquiry about possibilities to use machines to gather data describing users' socio-cognitive characteristics and their interaction with information system IS through the means of web searching logs that reflect the information searching patterns. When we can do this (and if we can), then we could adapt information systems to users' behaviour. Observing and deepening understanding of interaction between users and information systems is vital step before we could start predicting what behaviour will be.

This chapter presents theories related to the information systems design and related challenges followed by theories used in the information behaviour research and how they could contribute to

[32] Wilson, T. D., 2013. Theory in information behaviour research, page 6.

information systems design. The last part of the chapter will discuss holistic approach to the information system design based on the integration of the behavioural and design science.

Information systems design theories

We use multiple information systems on a daily basis. We use them for different purposes such as work, entertainment, personal interests, learning and cooperation. But there is no common understanding and agreement on what the information system is. To open up such a discussion, some of the definitions are proposed below and their related scientific disciplines background.

R. Buckminster Fuller in his book *Cosmography*[33] defined the role of the design science in which information systems could be attached as:

The function of what I call design science is to solve problems by introducing into the environment new artifacts, the availability of which will induce their spontaneous employment by humans and thus, coincidentally, cause humans to abandon their previous problem-producing behaviors and devices.

Herbert Simon in his book *The Science of Artificial*[34] proposed definition of the information processing systems, that he called symbol systems, as artefacts of which the main reason for existence is adaptivity to environment. They are goal seeking, information processing systems that usually serve a larger system they are a part of. Such systems must have possibilities to acquire information from the environment and encode them into internal symbols (that the system could process) and at the same time produce symbols that could initiate some actions upon in the environment. They consist of tangible devices such as computers and humans.

So, information systems are designed artefacts to solve problems by processing data from the environment creating the information that is used to act upon the environment they operate in.

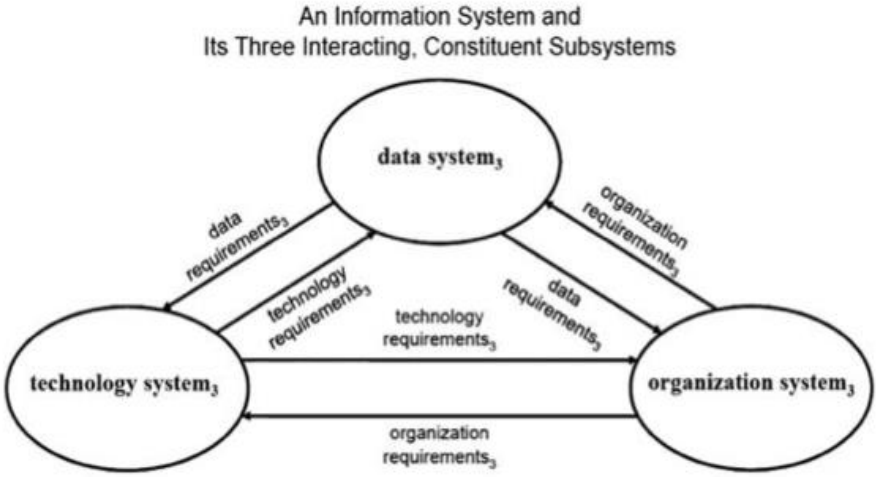
But to understand them better, the open closed dichotomy proposed by Hughes in book *The*

[33] Fuller, R. B., 1992. *Cosmography: A posthumous scenario for the future of humanity*. The Estate of R. Buckminster Fuller.

[34] Simon, H. A., 1996. The sciences of the artificial. MIT press.

evolution of large technological systems[35] could be used.

By his observation, technological systems (that are understood as a technology-culture interface) tend to incorporate environment into the system reducing uncertainty. In this phase they could be called open systems. However, as more and more aspects of environment are put under system control, they become more closed and as such become detached from the environment increasing the level of internal uncertainty that is usually tried to be controlled by procedures, routines and bureaucracy.[36] It is aligned with Lee's stating: *research in the information systems field examines more than just the technological system, or just the social system, or even the two side by side; in addition, it investigates the phenomena that emerge when the two interact*[37]. In his recent work Lee[38] proposed another way of mapping information system (Figure 1). It is based on the premise that information system could be understood as *a continuous state of emergence from the interactions among its three constituent subsystems: the technology system, the organization system, and the data system.*



[35] In: Bijker, W. E., Hughes, T. P. and Pinch, T., 1987. The Social Construction of Technological Systems, Cambridge: MIT Press, pp. 51–82.

[36]Bijker, W. E., Hughes, T. P. and Pinch, T., 1987. The Social Construction of Technological Systems, Cambridge: MIT Press, pp. 51–82.

[37] Lee, A. S. (2001) Editorial, MIS Quarterly, 25(1), pp. iii–vii.

[38] Lee, A. S., 2010. Retrospect and prospect: information systems research in the last and next 25 years. Journal of Information Technology, 25(4), 336–348.

Figure 1 – Way of mapping information system[39]

Gregor[40] offered a taxonomy of theory types in IS research. It is based on the five theory types:

- **Analysis** theory type that is focused on analysis and description, no causal relationships are observed and there are no predictions made.
- **Explanation** theory type is about explanation, but there are no testable propositions.
- **Prediction** theory type provide predictions and testable propositions, but do not deal with causality.
- **Explanation and Prediction (EP)** theory type provides prediction, testable propositions and causal explanation.
- **Design and action** theory type gives explicit prescriptions for constructing artefact.

In the list proposed we could see two major groups of theory types:

- one about understanding and
- the other about prediction.

But when we understand we could predict, if we could predict, then we could design better information systems. Also, it is possible that building theory starts with understanding and as researchers understand the phenomena better, they develop studies over time.

Theory could also become of predictive nature. As authors of the one of the most used models for evaluating Information Systems stated:

The creation of the Delone & McLean IS (D&M IS) Success Model was driven by a process understanding of IS and their impacts.[41]

In addition, there are predictive values in the model proposed, as based on the success studies conducted it is possible to identify and use independent variables that could predict success of

[39] Lee, A. S., 2010. Retrospect and prospect: information systems research in the last and next 25 years. Journal of Information Technology, 25(4), 336–348.
[40] Gregor, S., 2006. The nature of theory in information systems. MIS quarterly, 611–642.
[41] Delone, W. H. & McLean, E. R., 2003. The DeLone and McLean model of information systems success: a ten-year update. *Journal of management information systems*, 19(4), 9–30. (page 16).

information system. Below are selected citations that address limitations of predictability in the context of Information Systems.

- *Such technological entailments are **far from simple, straightforward, certain, or predictable**, and they are associated with a range of organizational outcomes, many of which are emergent and unanticipated.* [42]
- *The outcome of technology development and use cannot be reliably predicted, as both the technical and social are mangled together in the process to produce specific, situated instantiations. Rather than seeing humans with clearly-defined goals applying technologies with clearly-defined properties to achieve clearly-defined organizational effects, therefore, we need to **understand the process of information systems development** and use as an ongoing double dance of agency.* [43]
- *One important reason to specify information due to function is to make clear what kind of conditions are present when an information system is to be developed for a certain type of information. In an analysis made earlier about information systems handling operative and directive information, it was found that until the middle of 1980's relatively little research was focusing on demands or needs of the user in relation to the development of information systems.*[44]

Analyzing the above statements, we could see that challenge is in predicting the impact of information systems to the organizations, tasks at hand users fulfil with information system and the user behaviour. As users interact with information provided through the information system, information behaviour as a sub-discipline in information science could provide a solid theoretical background to understand the user and predict his behavior. Such theoretical perspectives will be discussed in the second part of this chapter.

In two theories related to information system research, a divide between user driven research and artefact design driven research is evident. Those are information system research framework

[42] Orlikowski, W. J. & Scott, S. V., 2008. Sociomateriality: Challenging the Separation of Technology, Work and Organization. The Academy of Management Annals, 2, 433–474.

[43] Jones, M., 1998. Information systems and the double mangle: steering a course between the Scylla of embedded structure and the Charybdis of strong symmetry.

[44] Malmsjö, A., 1996. Information seeking behaviour and development of information systems: A contextual view.

proposed by Hevner and colleagues[45] and Technology acceptance Model (TAM) proposed by Davis[46]. Design science information system research framework includes three cycle view of design science research[47], one cycle is related to the relevance, another is related to the design and the third related to the rigor.

Research framework is proposed in Figure 2 while three cycles are presented in Figure 3.

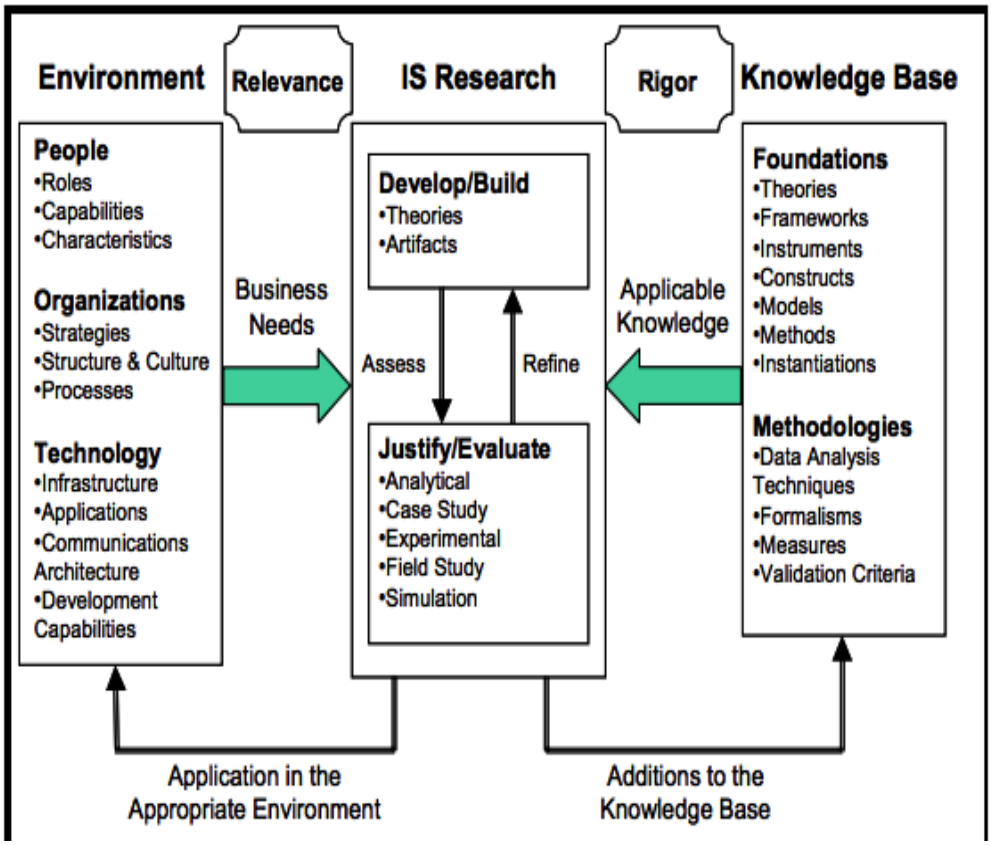


Figure 2 – Information Systems Research Framework[48]

[45] Hevner, A. R., March, S. T., Park, J. & Ram, S., 2008. Design science in information systems research. Management Information Systems Quarterly, 28(1), 6.

[46] Davis, F. D., 1985. A technology acceptance model for empirically testing new end-user information systems: Theory and results (Doctoral dissertation, Massachusetts Institute of Technology).

[47] Hevner, A. R., 2007. A three cycle view of design science research. Scandinavian journal of information systems, 19(2), 4.

[48] Hevner, A. R., March, S. T., Park, J. & Ram, S., 2008. Design science in information systems research. Management Information Systems Quarterly, 28(1), 6.

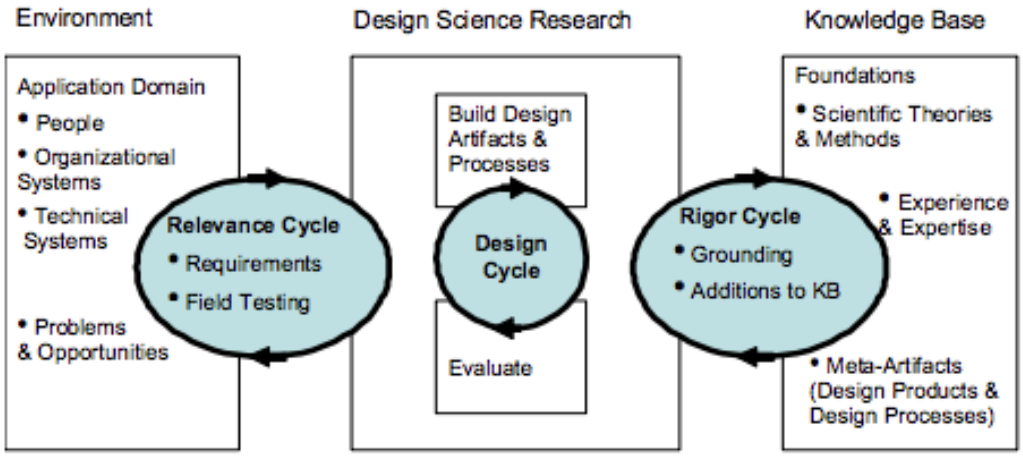


Figure 3 – Design Science Research Cycles[49]

For the purpose of this analysis, it is important to quote from the Hevner and colleagues[50]: *We include not only instantiations in our definition of the IT artifact but also the constructs, models, and methods applied in the development and use of information systems.* ***We do not include people or elements of organizations in our definition, nor do we explicitly include the process by which such artifacts evolve over time.***

One of the most cited papers in the domain of the information systems design does not include people into the focus of information system research. On the other hand, there is Davis Technology Acceptance Model (TAM) (*Figure 4*)[51] used to study how users accept and use technologies. It proposes two main variables that will impact new technology use. They are perceived usefulness (PU) and perceived ease of use (PEOU) and are explained by Davis as follows:

- **Perceived usefulness (PU)** – *people tend to use or not to use an application to the extent*

[49] Hevner, A. R., 2007. A three cycle view of design science research. Scandinavian journal of information systems, 19(2), 4.

[50] Hevner, A. R., March, S. T., Park, J. & Ram, S., 2008. Design science in information systems research. Management Information Systems Quarterly, 28(1), 6.

[51] Davis, F. D., 1985. A technology acceptance model for empirically testing new end-user information systems: Theory and results (Doctoral dissertation, Massachusetts Institute of Technology).

they believe it will help them perform their job better[52].

- **Perceived ease of use (PEOU)** – *even if potential users believe that a given application is useful, they may, at the same time believe that the systems is too hard to use and that the performance benefits of usage are outweighed by the effort of using the application*[53].

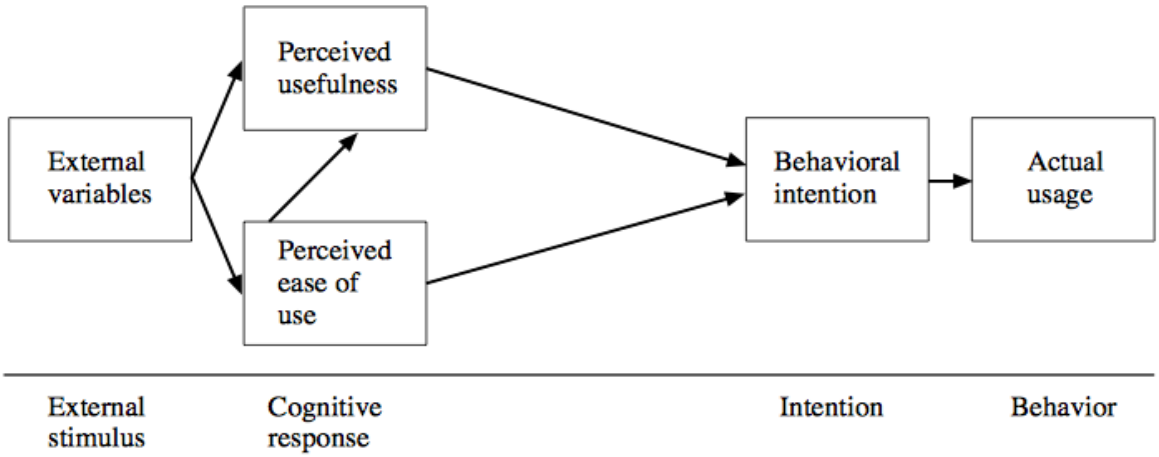


Figure 4 – Davis Technology Acceptance Model (TAM) [54]

What a present challenge to Technology acceptance model (TAM) is that over the years of conducting empirical studies that aimed to predict system use, only 40% of tests were proven successful. [55]

Evidence shows that there is a challenge how to analyze and research information systems. On one side of the axis, TAM do not include technologies into the model while design science withing the framework of information systems research does not include people.

As an answer to overcome such limitations of those two theories is the above mentioned Delone & McLean IS (**D&M IS**) Success Model.

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[52] Davis, F. D., 1989. Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS quarterly, 319–340.

[53] Davis, F. D., 1989. Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS quarterly, 319–340.

[54] Davis, F. D. & Venkatesh, V., 1996. A critical assessment of potential measurement biases in the technology acceptance model: three experiments. International Journal of Human-Computer Studies, 45(1), 19–45.

[55] Legris, P., Ingham, J. & Collerette, P., 2003. Why do people use information technology? A critical review of the technology acceptance model. *Information & management*, 40(3), 191–204.

The D&M IS success model builds on the three levels of looking on information systems. Those levels are:

- **technical level** related to the efficiency and accuracy of communication in the IS that creates information
- **semantic level** is about how successfully information conveys intended meaning
- ***effectiveness level*** *is about how information effects the receiver.*

The D&M IS success model is presented in Figure 5. This is the last version of the model updated after ten years of research.

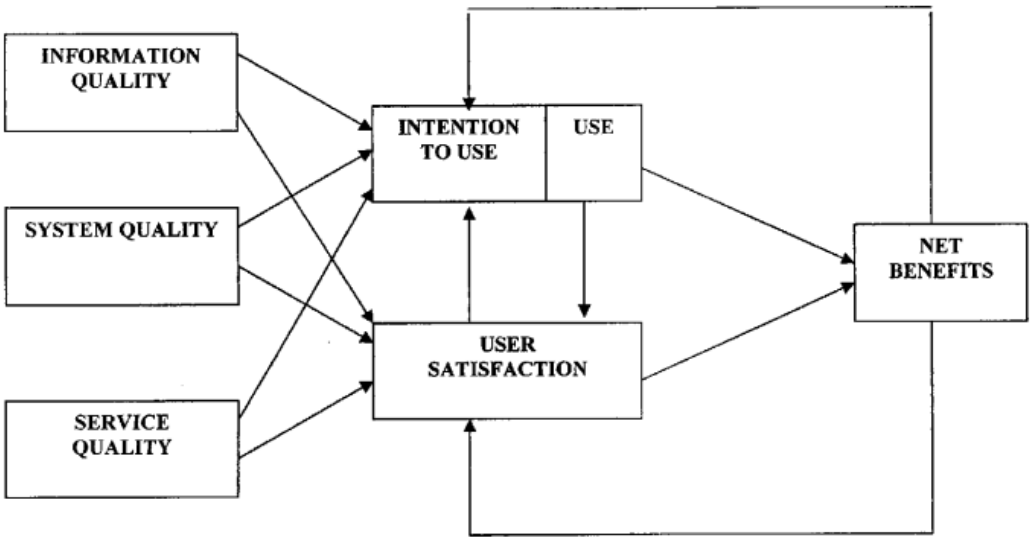

Figure 5 – Updated DeLone and McLean D&M IS Success Model[56]

In the D&M IS Success Model "systems quality" evaluates technical aspects, „information quality" evaluates semantic aspects and "use, user satisfaction, individual impacts", and "organizational impacts" are related to the aspect of effectiveness of information systems.
Before any prediction can be made, a broader understanding is needed. As stated in Figure 5, the better the quality of the information, system and service is, the better user satisfaction will be, and the information system will be used more creatively and more beneficially.

[56] DeLone, W. H. & McLean, E. R., 2003. The DeLone and McLean model of information systems success: a ten-year update. *Journal of management information systems*, 19(4), 9–30. (page 24).

Those three levels are aligned with the Deacon three types of information presented in Table 1.[57] Information 1 will be related to the technical level, Information 2 will be related to the semantic level and Information 3 is related to the effectiveness level.

Table 1 – Deacon's Three types of Information

Type of information	Underlying theories	Focus on	Semiotics perspectives
Information 1	Shannon	data, pattern, signal, data communications	syntax (what it exhibits)
Information 2	Shannon + Boltzmann	intentionality, "aboutness"," reference, representation, relation to object or referent	semantics (what it conveys)
Information 3	Shannon + Boltzmann + Evolution	function, interpretation, use, pragmatic consequence	pragmatics (what it is for)

A qustions arises about potential benefits of different levels and variables proposed and how they result in the user experience of the information system.

A closer look at the If we look at the Table 2 which gives an overview of the e-commerce success metrics, we could underline that adaptability, personalization and responsiveness are factors that user experience and based on such experience the information system will be used more successfully.

Terefore, if we design information system, we must implement mechanisms that will make it adaptive, personalized and responsive to the information need at hand.

[57] Dodig-Crnkovic, G., 2012. Physical computation as dynamics of form that glues everything together. Information, 3(2), 204–218, citing Deacon, T. W., 2011. Incomplete nature: How mind emerged from matter. WW Norton & Co.

Table 2 – E-Commerce Success Metrics (DeLone and McLean, [58])

Systems quality	Information quality	Service quality	Use	User satisfaction	Net benefits
Adaptability	Completeness	Assurance	Nature of use	Repeat purchases	Cost savings
Availability	Ease of understanding	Empathy	Navigation patterns	Repeat visits	Expanded markets
Reliability	Personalization	Responsiveness	Number of site visits	User surveys	Incremental additional sales
Response time	Relevance		Number of transactions executed		Reduced search costs
Usability	Security				Time savings

Langefors[59] underlines change as one of the fundamental problems of systems development. He specifies his reasons as follows:

Such changes appear on the macro-level where the object system of the information system, the organization for instance, changes in order to adapt to changes in the environment. This causes the users to tackle new kinds of problems needing new kinds of support from the information system. Changes also appear on the micro-level where individual states, or processes, in the system change, causing the information units to change.

This meand that change continues on different levels impacting use and operations of the information system and poses another challange in the design of the information system. It could be argued that one axis related to the theories that range from understanding through prediction toward design of the artefacts, while another axis could be related to the level of information system openness and adaptivity. There is a need to understand the environment and the user to be

[58] DeLone, W. H. & McLean, E. R., 2003. The DeLone and McLean model of information systems success: a ten-year update. *Journal of management information systems*, 19(4), 9–30. (page 26).

[59] Information Seeking Behaviour and Development of Information Systems. A Contextual View https://pdfs.semanticscholar.org/5248/3d817930e9868d27b439c8068c5182c84cc4.pdf.

able to design adaptive information systems. Succeeding in those qualitative methods will not be enough, as more and more information systems are used daily and user interactions with different information systems increase.

As dynamics and complexity are increased, there is a need to look for the avenues in which computers could be used to gain a deeper understanding of the users information behaviour. The concept that addresses such challenges is the concept called Ultra Large Systems (**ULS**) consisting of numerous interactions. Data can be collected from in which we have a large number of interactions, and we can collect data from the system interactions, particularly patterns of people's behaviour. Since such a systems are decentralized, they need to have a mechanism implemented in them so they can adapt to changes. People are not just users of the system but the elements of it. Collective behaviour is of the interest for system design and analysis, as behaviour is a factor in how users use, view, and accept the system. Social interactions are functions of how participants use technology and technology supports their needs. [60]

Research by the Orlikowski and Scott[61] showed that over 95% of the articles published in top management journals do not take into account the role of technology in organizational life. Based on their analysis they propose the concept s*ociomateriality, which* challenges the existing paradigm that conceptualizes technology, work and organization separately.

Sociomateriality is built under the premises that interplay between humans and technologies are not fixed and pre-given, but organizations are *held to be a recurrently enacted and patterned set of relations, reproduced over time and space*. It is rooted in the practice studies and "the practice turn"[62] that understands practice *as arrays of human activity*, but also includes those of *nonhumans such as machines and the objects of scientific investigation*.

Sociomateriality as a concept anchoring information systems research to the practice theory proposing the holistic view to the user and technology he uses, it opens up another challenge related to the information system design. As research is based on the management journals it is

[60] Northrop, L., Feiler, P., Gabriel, R., Goodenough, J., Linger, R., Longstaff, T., & Wallnau, K., 2006. Ultra-large Systems: the software challenge of the future.

[61] Orlikowski, W. J. & Scott, S. V., 2008. Sociomateriality: challenging the separation of technology, work and organization. The academy of management annals, 2(1), 433–474.

[62] Schatzki, T. R., K. Knorr-Cetina, E. Savigny (Eds.), 2001. The practice turn in contemporary theory. London: Routledge.

fair to ask about the economy of the information systems.

Below is a list of the points that should be taken into consideration when information systems are researched in both terms, fundamental academic research and design and implementation. They are as follows:

- artifacts
- problem solving
- process information
- adaptive to environment
- part of larger systems (socio-technical)
- act upon environment (by them self or with the user)
- could be open and closed
- capacity to reduce uncertainty
- to consist of technology, organization and data systems
- to be in continuous state of emergence based on interaction of the above three sub systems
- that could be analyzed, explained, predicted and designed
- to be useful and easy to use
- to have technical, semantic and effectiveness level
- to have information, system and service quality that will impact net benefits
- to be shaped by factors such as adaptability, personalization and responsiveness that create user experience
- to be in constant process of change that happens on micro and macro level
- to be built under premise that people are not only users, but they are part of the information system
- to be construct in which technology, work and organization are not separate
- to be observed through the behavioral, design and economic perspective.

Connecting Information System research and Information Behavior research

Talja and Hertel[63] pointed and elaborated the background of the shift in information science research offered by Dervin and Nilan[64]. They proposed a shift from the study of users through the view of the system of characteristics and features to more holistic studies that focus on the user from the user's viewpoint. This turn resulted in the shift from quantitative to qualitative studies, replacing earlier metatheories (Vakkari,[65]). Table 3 presents a lost of of alternative characteristics proposed and outlined as a contrast to the classical paradigm (Talja and Hertel,[66]).

Table 3 – Comparison of traditional and alternative paradigms by Talja and Hertel [67]:

Contrast	***Traditional paradigm***	***Alternative***
Objective versus Subjective Information	*Traditional information needs and uses studies focused on objective information, that is, constructed "information" mainly as something that has some element of correspondence to reality.*	*The alternative paradigm focuses on the uniqueness of the life-worlds of users who are constructed as actively seeking and making sense of information* (Dervin and Nilan, 1986: 13).
Mechanistic, Passive versus Constructivist, Active Users	*Traditional user studies assumed that all information, document delivery and information system use is beneficial, "ignoring the strategies that people actually use for bridging their information needs".*[68]	*The user-centered approach focuses on questions such as "how do people define needs in different situations?"* (ibid: 16).

63 Talja, S. & Hartel, J., 2007. Revisiting the user-centered turn in information science research: An intellectual history perspective. Information research, 12(4), 12–4.

64 Dervin, B. & Nilan, M., 1986. Information needs and uses. Annual review of information science and technology, 21, 3–33.

65 Vakkari, P., 1997. Information seeking in context: a challenging metatheory. In P. Vakkari, Savolainen, R. & Dervin, B. (Eds.), Information seeking in context: proceedings of an international conference on research in information needs, seeking and use in different contexts (pp. 451–464). London: Taylor Graham.

66 Talja, S. & Hartel, J., 2007. Revisiting the user-centered turn in information science research: An intellectual history perspective. Information research, 12(4), 12–4.

67 Talja, S. & Hartel, J., 2007. Revisiting the user-centered turn in information science research: An intellectual history perspective. Information research, 12(4), 12–4.

68 Dervin, B. & Nilan, M., 1986. Information needs and uses. Annual review of information science and technology, 21, 3–33.

Trans-Situationality versus Situationality	*Traditional studies attempted to describe elements of user behavior that apply to all users across situations.*	*There are few conceptual approaches dealing with situational variables. The situationality focus requires systems to make repetitive needs assessments* (ibid: 14).
Atomistic versus Holistic Views of Experience	*Traditional studies focused on user behavior primarily in the context of user intersection with systems.*	*The alternative paradigm calls for looking at information behaviors outside system contexts* (ibid: 14).
External behavior versus Internal Cognitions	*Traditional research focused on contacts with sources and systems as observable indicators of needs*	*The alternative approach sees information needs as internal, psychological, cognitive states* (ibid: 15).
Chaotic versus Systematic Individuality	*Traditional studies considered it necessary to base systems and observations on orderly patterns of behavior*	*The alternative paradigm argues for the right of the user to be different* (ibid: 15).
Qualitative versus Quantitative Research	*Quantitative techniques were the most compatible with traditional assumptions*	*The alternative paradigm seeks to supplement these with inductive qualitative approaches* (ibid 16).

Another table presenting contrasting research questions used in person and system oriented information behavior research is provided by Case[69] and it is presented in Table 4.

Table 4 – Contrasting Examples of Information Behavior Research Questions

	Person Oriented	**System Oriented**
Task-oriented studies	●How do lawyers make sense of their tasks and environment? ●How does a manager learn about job-related information outside of formal organizational channels? ●What happens when a voter has too much information about a	• What kinds of documents do engineers need for their work, and how might the corporate information center supply them? • How satisfied and successful are student searches of a university library's Web-

[69] Case, D., 2007. Looking for Information. A Survey of Research on Information Seeking, Needs and Behavior.

	candidate or an issue?	based catalog? • How much use do medical doctors make of medical databases?
Non task-oriented studies	● How do the elderly learn about and cope with problems or opportunities that come up in their daily lives? ● Why do TV viewers choose one program over another, and what satisfactions do they achieve in doing so? ● Why do people browse in stores when they have no explicit need or intention to buy?	● How does the public use a library for personal pleasure and growth: what they ask for, borrow, and read? ● How do we persuade teenagers to act in healthy and responsible ways? What messages about drug abuse do they attend to, in which medium, and why? ● Why do people ignore safety warnings on packages and advertisements?

There is no much value in separating those two paradigms (system and user); to do a deep research there is a necessity to understand the user and the system being used by the users and their interdependence (how they are related to each other?), adoption dynamics based on feedbacks from each other (how they adopt according to each other?), controlling mechanisms and related hierarchy (how the system controls the user behavior and how the users control the systems?) and their influence on the wider environment (how a user using information systems influences the environment?).

Gaining an insight into the information behavior requires looking at the user and information system as one system performing functions in the environment. By performing those functions, it changes its own properties (user + information system), it changes properties of the user and the information system, and it changes the environment. For example, Google search presents the results based on the user's interests and their past behavior, user's changes in their knowledge interacting with the search engine, there is also evidence the change in the society based on the users using Google to search for information. Phenomena that could be observed are the information seeking patterns that reflect the information system, user, user & information system as one system and the environment. Such information seeking patterns could be quantitatively analyzed in terms of web search logs, which is the main aim of this thesis.

Bates[70] pointed out that Dervin and Nilan's propositions were based on the review of the *literature* from 1978 and they missed the body of research in information behavior before that time, which eventually turned out to be a user-centered and fruitful in terms of quantitative methods, too.

Theories used in Information behavior research

Information behavior is *the totality of human behavior in relation to sources and channels of information, including both active and passive information seeking, and information use* (Wilson[71]), then if the information system could better understand user behavior, it could be more adaptive to the user behavior and provide better information, system and service quality, resulting in higher benefits at the end.

According to Demetis and Lee[72], two types of understanding an be distinguished. One is human centric cognitive understanding based on reflection and the other is *technologized understanding; this signals the a priori acceptance or rejection of any information, which would then prompt a computational response (another utterance) on the basis of a pre-coded algorithmic rationality*.

But to develop algorithms that could process such a signal on the basis of pre-coded rationality, light needs to be shed on thaw in fact such signals convey in terms of information. Analyzing human information behavior could give rise to "human understanding" and transfer it to *technologized understanding.*

As this research is focused primarily on the aspects of human information behavior, the following text in this chapter will describe different theories used in information behavior research presented in the book *Theory in information behavior research* (Wilson, [73]). Among theories from the book, we extend the chapter with two theories that are not presented in the book, but are also important to the human information behavior studies:

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[70] Bates, M. J., 2004. Information science at the University of California at Berkeley in the 1960s: a memoir of student days. Library Trends, 52(4), 683–701.

[71] Wilson, T. D., 2000. Human information behavior. Informing science, 3(2), 49–56.

[72] Demetis, D. & Lee, A., 2017, January. When Humans Using the IT Artifact Becomes IT Using the Human Artifact. In *Proceedings of the 50th Hawaii International Conference on System Sciences*.

[73] Wilson, T. D. (Ed.), 2013. Theory in information behaviour research. Sheffield, UK: Eiconics Ltd. [E-book]

- Psychodynamic theory and
- General Theory of Human Information Behavior published by Wilson himself in 2016.

After each theory is briefly outlined presented, the key points that are relevant in the context of this PhD thesis will be presented.

Psychodynamic theory

Psychoanalytic theory focuses on the *unconscious inner conflicts as people strive to achieve their goals.*[74] Behavior is viewed as an outcome of needs, conflicts, drives and motives.
Unconscious processes influence people's feelings and the things they attend (Pervin and John,[75]). Our unconsciousness, thoughts and feelings influence our decision-making and emotional states. Decisions are not just based on a cost-benefit analysis. Emotions are stronger decisions predictor than cognitive attitudes, although attitudes include emotional and cognitive component (Westen,[76]). Disagreement between the cognitive and psychoanalytic perspectives regarding the nature of the unconscious are presented in Table 5. [77]

Table 5 – Comparison of theoretical views of the unconscious

Psychoanalytic perspective	Cognitive perspective
Irrational, unconscious processes	*Sees no fundamental difference between conscious and unconscious*
Emphasis on motives and desires	*Emphasis on thoughts*

[74] O'Shaughnessy, J. & O'Shaughnessy, N. J., 2004. Persuasion in advertising. London: Routledge, p. 166.
[75] Pervin, L. A. & John, O. P., 2001. Personality: theory and research. 8th ed. New York, NY: John Wiley & Sons, Inc.
[76] Westen, D., 2007. The political brain: the role of emotion in deciding the fate of the nation. New York, NY: Public Affairs, p. 78.
[77] Albright, K. S., 2011. Psychodynamic perspectives in information behaviour. Information Research, 16(1), pp.16–1.

Focuses on motivational features of the unconscious	*Focuses on non-motivating features of the unconscious*

Shedler[78] identifies the following seven features distinguishing psychodynamic therapy from other psychological perspectives:[79]

- focus is on the expression of emotions and affect
- it observes how individuals avoid feelings and thoughts that are distressing
- goal is to identify patterns and recurring themes
- it observes how past and present experiences are related
- its focus on analysis of interpersonal relations
- in psychodynamic therapy therapeutic relationships is important
- it encourages individuals speak freely so they could understand their self-perception and views of their experience and relationships.

To understand effects of the unconscious on the human interacting with information we could use findings from brain research, revealing how people think and analyzing relationship between conscious and unconscious mind. [80]

This could open new perspectives in the understanding how complex relationship between conscious, unconscious, body and society influence how people use information.[81]

Zaltman[82] identifies six fallacies of assumptions that are useful to identify the limitations of the cognitive perspective of information behavior. The fallacies are cited below:

- *Users think in well-reasoned linear ways.*
- *Users can plausibly explain their thinking and behavior.*

78 Shedler, J., 2010. The efficacy of psychodynamic psychotherapy. American Psychologist, 65(2), 98–109.
79 Albright, K. S., 2011. Psychodynamic perspectives in information behaviour. Information Research, 16(1), pp.16–1.
80 Damasio, A., 2003. Looking for Spinoza: joy, sorrow, and the feeling brain. Orlando, FL: Harcourt, Inc.
81 Albright, K. S., 2011. Psychodynamic perspectives in information behaviour. Information Research, 16(1), pp.16–1.
82 Zaltman, G., 2003. How consumers think. Cambridge, MA: Harvard Business Press.

- *User's minds, bodies, and surrounding culture can be studied independently of one another.*
- *User's memories accurately reflect their experience.*
- *Users think primarily in words.*
- *Users can receive magic bullets of messages and [always] accurately interpret their meaning.*

So, if we limit our research only to the cognitive perspective it may lead to conclusions based on incomplete findings. Including psychodynamic perspective could help in development of the more precise insights to the human information behavior. [83] There are estimations that up to 85 – 95% of thought takes place outside of people's awareness.[84],[85],[86] In that case, human information behavior could be investigating only other 5 – 15%. [87]

Psychodynamic theory – relevance in the context of this dissertation

If user behavior is unconscious and emotionally driven, then it is of importance to measure the emotions. Affective computing as a computer science sub discipline provides us with the techniques, algorithms and tools. It is also important to consider the limitation of the cognitive paradigm to which this theory points in terms of information behavior. A user's affective states must be considered as a signal that could be used to adopt information system to the user information needs.

In terms of music related information behavior, the psychodynamic theory could be very valuable in the process of designing research. As music is experienced not just in cognitive terms but also in terms of feelings, it offers the theoretical framework to design research instruments such as surveys and interviews to gain insights into the factors that influence music related information behavior. The psychodynamic theory's main focus is on the expression of emotions and affect that could be expressed in the process of selecting music as a response to the states that emerged in a particular moment in a particular environment. If we collect information searching logs as

[83] Albright, K. S., 2011. Psychodynamic perspectives in information behaviour. Information Research, 16(1), pp.16–1.

[84] Zaltman, G., 2003. How consumers think. Cambridge, MA: Harvard Business Press.

[85] Westen, D., 2007. The political brain: the role of emotion in deciding the fate of the nation. New York, NY: Public Affairs.

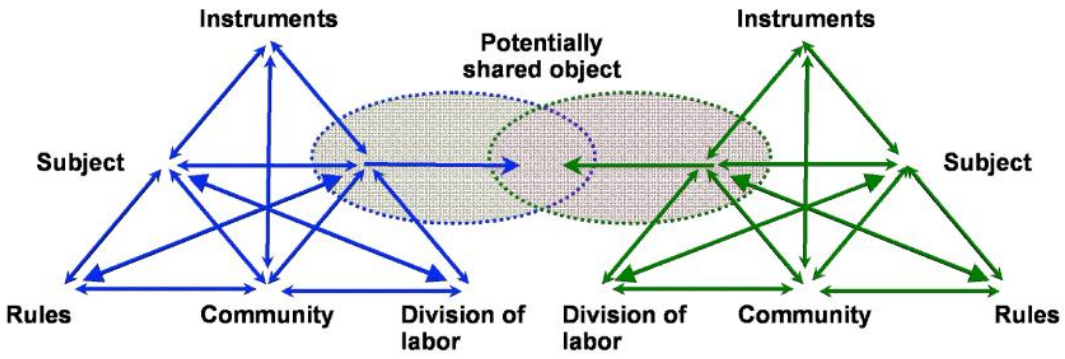
[86] Lindstrom, M., 2010. Buyology: truth and lies about what we buy. New York, NY: Broadway Business.

[87] Albright, K. S., 2011. Psychodynamic perspectives in information behaviour. Information Research, 16(1), pp.16–1.

data about user information behavior and data representing user affective states, then we could find the causality of the affective states and information behavior. Adding to the analysis data about how and which information resources are used, based on the observation of what is retrieved from the information system, there is a possibility to develop strong models that could recognize and potentially predict user information behavior. As the psychodynamic theory among others deals with the motivation and desires, adding quantitative data collected by surveys predictive power of the model could be improved.

Activity Theory

Engeström[88] pointed out to to three generations of activity theory. The first one is built around Vygotsky's mediated action, the second around Leont'ev's activity system and the third one develops the idea of multiple activity systems that interact around a partially shared object. Engeström[89] proposed a model of two activity systems and potentially shared objects presented in Figure 6.



88 Engeström, Y., 2009. The future of activity theory: A rough draft. *Learning and expanding with activity theory*, 303–328.

89 Engeström, Y., 2009. The future of activity theory: A rough draft. *Learning and expanding with activity theory*, 303–328.

Figure 6 – Two activity systems and potentially shared objects) (Engeström,[90])

In this model, we can see that two different subjects along with associated rules, communities, tools, and division of labor access shared objects. Such approach is useful in analyzing the interaction of user and information system. A user looks for information and information system that store structured data. Stored data become information when they have meaning to the user. At that moment the user and information system share the object, which is information.

Six general principles of activity theory are: [91]

- **Unity of consciousness and activity:** pointing that human mind exist and emerges based on the human interaction with the environment.
- **Object-orientation:** activity is directed toward objects that could have determinable 'reality' (real reality, such as raw materials) and/or a socio-culturally determined reality (such as group of people).
- **Internalization/externalization:** our mental process is created as internationalization of external activities. By acting upon the external world, consciousness is formed.
- **Mediation:** activity is mediated by tools, which could be real objects but also mental tools such as language and symbols. Rules, norms and division of labor could also be viewed as a tool, as hey are mental constructs used in interaction with the object and could assist or constrain such an interaction[92]
- **The hierarchical structure of activity:** consisting of activity, actions and operations and their relationship with motives, goals and conditions.

The principle of development – states that activity develops in time and in cultural-historical context and that actions taken towards the objects affect that development. Transformation occurs as a result of the activity system (or, rather, the participants in that system) responding to and dealing with contradictions. Prominent examples of the application of activity theory in

[90] Engeström, Y., 2009. The future of activity theory: A rough draft. *Learning and expanding with activity theory*, 303–328.

[91] Wilson, T. D., 2013. Theory in information behaviour research. Chapter 1.

[92] Wilson, T. D., 2006. A Re-Examination of Information Seeking Behaviour in the Context of Activity Theory. Information research: an international electronic journal, 11(4), p. 4.

information behavior research include Kuhthau's Zone of intervention[93], Atwell and Dowell's[94] study of journalists' information seeking behavior, Allen's study of information behavior of police officers. Xu's[95] and Xu and Liu's[96] study of interactive retrieval systems research.[97]

Activity theory – relevance in the context of this dissertation

By using the web search log analysis method and by means of computers to analyze large amounts of data, we could extend the time span of the research. If we use software installed at the research participant computer, or just collect the logs that are created by the interaction of the user and information system in place, it is possible to collect data describing a longer period of time, to increase the number of research participants and observe the different variables influencing human information behavior over the process of satisfying information needs that has a longer time span. In music related information behavior, there is evidence great of a great level of change in the terms which tools are used to search and listen to music and how people interact with the music. Activity theory could help us to structure the data collected and later analyze them accordingly. Also, using the process view to the activity theory could help us to design information systems that are more adaptive to the user information behavior based on the feedback from different sequences in the process such as motivations, goals, subjects, objects and outcomes of the information seeking and search process. It also supports the analysis of the two-activity system using shared objects. We could look at the one-activity system as human looking for information and others as as information system that stores, structures and distributes information resources. By doing so, we have covered both social and technical aspects of the user interaction with information system and have the opportunity to analyze it on micro level (one-activity system) and macro level (two-interacting activity systems).

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93 Kuhlthau, C. C., 2004. Seeking meaning: A process approach to library and information services (Vol. 2). Westport, CT: Libraries Unlimited.

94 Attfield, S., Blandford, A. and Dowell, J., 2003. Information seeking in the context of writing: A design psychology interpretation of the „problematic situation". *Journal of Documentation*.

95 Xu, Y., 2007. The dynamics of interactive information retrieval behavior, Part I: An activity theory perspective. *Journal of the American Society for Information Science and Technology*, 58(7), pp. 958–970.

96 Xu, Y. and Liu, C., 2007. The dynamics of interactive information retrieval, Part II: An empirical study from the activity theory perspective. *Journal of the American Society for Information Science and Technology*, 58(7), pp. 987–998.

97 Kuhlthau, C. C., 2004. Seeking meaning: A process approach to library and information services (Vol. 2). Westport, CT: Libraries Unlimited., p. 129.

Critical Theory (CT)

According to Benoit[98], Critical Theory could be used in information studies as follows:

- Critical Theories (and critical theories) as interpretative frameworks
- Information seeking behavior as emancipatory motivation
- Legitimation problems – from late capitalism to technology-based information society
- Theory and practice in our scientific civilization
- Knowledge and human interests
- Theory of communication
- The theory as used in information studies.

So, it is possible to see a clear application of perspectives of Critical Theory in different fields of librarianship and information science, including the use of the technology, information professionals, their role, libraries transformation processes, legitimacy of information sources, various use of computer based system supporting different social and work roles and processes, processes related to informing public and their impact on society (fake news, info wars), how knowledge is created and coded into information resources, records and documents, how those are distributed, consumed and evaluated and what the ethical norms and responsibilities of the agencies involved in the human information behavior processes are.

Critical theory – relevance in the context of this dissertation

Should there be a need to design the information systems that are adaptive and such adaptivity is based on the data collected about the user information behavior, it is important to implement ethical norms into such systems. Also, observing human and machine as two components of one system that is looking for a steady state, based on satisfying the information needs, critical theory could be used to support decisions to be made about the properties of the mechanisms that define such a system performance. In terms of music related information behavior, in today's reality in which it is possible to easily manipulate consumers by means of algorithms implemented in the

[98] Benoit, G., 2007. Critical theory and the legitimation of library and information science. Information Research, 12(4), 12–4.

platforms such as Facebook and Google, where music is played based on the recommendation algorithms such as on YouTube and Spotify and social constructs are easily composed and decomposed, critical theory could give us interpretative frameworks to analyze behavior.

Personal construct theory

Personal construct theory encompassed theories of personality and clinical psychologies focusing on general processes by which people make sense of and navigate their social worlds. It explains that humans construct knowledge and word understanding through processes of cognitive constructions. [99]

The personal construct theory was published for the first time by psychologist Gorge Kelly[100] in his book *The Psychology of Personal Constructs*. The theory offered contracts to behaviorism of those days that understand individual as a passive responder to stimuli from environment. [101] Kelly[102] pointed that *a person's processes are psychologically channelized by the ways in which he anticipates events*.

On the basis of their experiences, individuals develop a personally organized system of interpretations to understand the world they live in. Such personal construct system is used in current situation interpretations and to anticipate events in the future. At the same time, individuals could appreciate and share other people's systems of personal constructs. [103]

As more and more information is available to the users it is also important to understand internal cognitive processes of those users. Orlikowski and Gash[104] propose that we must understand expectations, values, assumptions and beliefs of information users.

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[99] Reynolds, R., 2013. Personal construct theory. *Theory in information behaviour research*, 68–82.

[100] Kelly, George A., 1955) *The Psychology of Personal Constructs: Vol 1 and 2*. New York: WW Norton.

[101] Fransella, F. E., 2005. The essential practitioner's handbook of personal construct psychology. John Wiley & Sons Ltd.

[102] Kelly, G., Kelly, G. A. and Kelly, G. A., 1963. A theory of personality: The psychology of personal constructs (No. 152). WW Norton & Company.

[103] Tan, F. B. & Hunter, M. G., 2002. The repertory grid technique: A method for the study of cognition in information systems. *Mis Quarterly*, 39–57.

[104] Orlikowski, W. J. and Gash, D. C., 1994. Technological frames: Making sense of information technology in organizations, ACM Transactions on Information Systems (12:2), pp. 174–201.

In orer to support his theory empirically, Kelly developed repertory grid method that was used in research and clinical psychotherapy. RepGrid was also used in the information systems research. The RepGrid contains three major components – **elements, constructs, and links.**[105] They are explained in Table 6:

Table 6 – Elements, explanation and examples of use in IS research[106]

Components	**Explanation**	**Example in IS**
Elements are the subject within the domain of investigation.	They define the entities upon which the administration of the RepGrid is based.	For example, to explore the critical success factors (CSFs) of IS projects, IS researchers can use IS projects as elements in the RepGrid.
Constructs represent the research participant's interpretations of the elements.	Further understanding of these interpretations may be gained by eliciting contrasts resulting in bi-polar labels.	Using the same example, research participants may come up with bi-polar constructs such as "high user involvement – low user involvement" to differentiate the elements (i.e., IS projects). The labels represent the CSFs of IS projects.
Links are ways of relating the elements and constructs	The links show how the research participants interpret each element relative to each construct. Further, the links reveal the research participant's interpretations of the similarities and differences between the elements and constructs.	From the example above, a seven-point rating scale can be used to get participants to differentiate between the IS projects (i.e., elements) along each elicited CSF (i.e., construct).

A prominent example of applying Personal Construct theory in information behavior research is Kuhlthau's Information Search Process which explains constructive process of information user engaging in building knowledge and deriving the meaning from their inquiry.[107] Her model of information search process will be presented in Chapter 3 in more detail. She proposed the

[105] Easterby-Smith, M., 1980. The design, analysis and interpretation of repertory grids, *International Journal of Man Machine Studies* (13), pp. 3–24.

[106] Tan, F. B. & Hunter, M. G., 2002. The repertory grid technique: A method for the study of cognition in information systems. *Mis Quarterly*, 39–57.

[107] Reynolds, R., 2013. Personal construct theory. *Theory in information behaviour research*, 68–82.

principle of uncertainty for information seeking pointing to the relationship between uncertainty and cognitive state that cause affective symptoms (anxiety and lack of confidence). Also, a change in the knowledge states results in parallel changes in feelings of increased confidence. To expand this principle, she proposes six corollaries: process corollary, formulation corollary, redundancy corollary, mood corollary, prediction and interest corollary. [108]

Personal construct theory relevance in the context of this dissertation

The Kuhlthau model of information search process could be used in the description of the music related information behavior as it includes in parallel physical, cognitive and affective factors influencing information behavior. The same model could be useful in the process of storing data about the user information behavior and in analyzing correlations and causality between different components of the model. Also, in order to desing information systems that are personalized to the user and his information needs, then understanding in which stage the process is, is of importance. If the information searching process could be recognised , more effective information retrieval mechanisms could be designed. The RepGrid technique and Kuhltau six corollaries are great frameworks that could be used for the purpose of information system research and design.

Personality theory

According to Boyle et al.[109], there are four core principles of personality traits. They are:

- **stability**: personal traits remain stable across a life span
- **genetic base**: traits are related to genetic structure
- **generality**: expresses traits in multiple contexts and situations
- **interactionism**: situational factors moderate expressions of traits.

In the 1990s, personality psychology researchers reach an agreement on five core dimensions of personality, The Big Five. Costa and McCrae the five-factor model is based on the following

[108] Kuhlthau, C. C., 2018. Longitudinal Evidence of the Influence of the ISP on Information Workers.
[109] Boyle, G. J., Critique of the five-factor model of personality. Critique, 1, pp.1–2008.

dimensions: negative emotionality, extraversion, openness to experience, agreeableness and conscientiousness (in order of decreasing robustness)[110]. There are two main processes that manifest personality. The first is interaction between genetically based traits and the environment resulting in adoption characteristics. The second one is interaction between characteristic adaptation and environment in time (at any given moment) resulting with specific behavior and experiences.[111] According to Peterson and Higgins[112] there are *Alpha factor Stability* and the *Beta factor Plasticity* mirroring two essential adaptive mechanisms. One is maintaining stability and the other one is interacting with new stimuli. They are complementary, as plasticity is needed to maintain stability in novel situation and stability is needed to provide security for unknown situations. [113]

In information science and information behavior research, the personality theory framework was used by Heinström,[114], who concluded that each of the five-factor model dimensions have its own impact on information behavior. Heinström[115],[116] was one of the first who studied the influence of personality in terms of five-factor model to information behavior. Result showed that each of the five dimensions had their impact on information seeking behavior. Hyldegård[117] studied interactions between personality traits and the influence of context to the information behavior in a group setting. Results confirmed that personality influences information behavior, underlined context as an important factor and impact of being part of a group influenced the impact of

[110] Costa, P. T. and McCrae, R. R., 1992. Normal personality assessment in clinical practice: The NEO Personality Inventory. *Psychological assessment*, 4(1), p. 5.

[111] McCrae, R. R. and Costa Jr, P. T., 2008. The five-factor theory of personality.

[112] DeYoung, C. G., Peterson, J. B. and Higgins, D. M., 2002. Higher-order factors of the Big Five predict conformity: Are there neuroses of health?. Personality and Individual differences, 33(4), pp. 533–552.

[113] DeYoung, C. G., Peterson, J. B. and Higgins, D. M., 2002. Higher-order factors of the Big Five predict conformity: Are there neuroses of health?. Personality and Individual differences, 33(4), pp. 533–552.

[114] Heinstrom, J., 2010. From fear to flow: personality and information interaction. Elsevier.

[115] Heinström, J., 2002. Fast surfers, broad scanners and deep divers: personality and information-seeking behaviour. Åbo akademis förlag-Åbo Akademi University Press.

[116] Heinström, J., 2003. Five personality dimensions and their influence on information behaviour. Information research, 9(1), pp. 9–1.

[117] Hyldegård, J., 2009. Beyond the search process – Exploring group members' information behavior in context. Information Processing & Management, 45(1), pp. 142–158.

personality. Other examples of research based on Personality theory include Kwon and Song[118], Stokes and Urquhart[119], Halder, Roy and Chakraborty[120].

Personality theory – relevance in the context of this dissertation

As people are different in terms of their personality traits, understanding those differences could help in explaining human information behavior and by doing so design better and more adaptive information systems. But at the same time, it is important to understand that different context, situations, environment and social ties could result in different information behavior without dependence on personality traits. To understand processes between the user, the environment and the information system, understanding that there are two parallel processes going on (*Alpha factor Stability* and the *Beta factor Plasticity*) could help. In terms of music related information behavior knowing how much a user is open to interaction with new stimuli (or to the new music and related information resources) could help to understand behavior of the user but also to design recommendation systems that will support user music information needs. To do so logs collected from the interaction of the user and computer could be of great help.

Practice theory

Schatzki's[121] defined practice theory as *a practice is a temporally evolving, open-ended set of doings and sayings linked by practical understandings, rules, teleo-affective structure and general understandings*. **Practical understanding** are skills and knowledge to perform; **rules** are guidelines how to perform; ***teleo-affective structure*** is about how activities, tasks and projects are organized around end but also about the mood and feelings around those activities and ***general understandings*** are social beliefs and values expressed in practice.

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[118] Nahyun, K. and Hana, S., 2011. Personality, traits, gender and information competency among college students. *Malaysian Journal of Library & Information Science*, 16(1), pp. 87–107.

[119] Stokes, P. and Urquhart, C., 2011. Profiling information behaviour of nursing students: part 1: quantitative findings. *Journal of Documentation*.

[120] Halder, Santoshi, Anjali Roy, and P. K. Chakraborty, 2010. The influence of personality traits on information seeking behaviour of students. *Malaysian Journal of Library & Information Science* 15, no. 1: 41–53.

[121] Schatzki, T., 2002. The site of the social. University Park, PA: Pennsylvania State University Press.

The social order is based on people, artifacts, organism and things. They are linked by spatial, causal, intentional and prefiguring relations.[122] The meaning of entities (including people) arises from such a changing, complex and indeterminate relations.

Cox[123] proposed four pre-occupations of the practice approach:

1. Materiality and embodiment – relates to the concrete activity in the material world including *performative power of saying or not saying things.* So, the activities of the humans in a world of material objects (including information systems) in a physical space is the central to practice theory approach.

2. Process, routine and change – performance of a practice is based on the activities played out in a space and a time. Those activities could be observed as a process, and such a process is a primary concern of the practice approach. Temporal rhythm of activities of bodies and use of objects in particular space define the practice.

3. Social construction and social identity – people learn and operate within social conventions, and they constitute practice. Practice is rarely uniform and social actors must continuously renegotiate pre-given recipes. Embedded meaning (of a practice) is a social construction represented through different social groups as cultural understanding.

4. Knowing – In practice approach, knowing is viewed as anti-positivist, anti-cognitivist and anti-rationalist. Knowledge is situated into the practice rather than seen as facts and truth. It is shaped through practice arrangements and actively negotiated. So, knowledge is always being reshaped, and it is local, situated, historically contingent and temporary accomplished.

Gherardi's[124] used practice approach to study nature of knowledge in organizations that is of relevance to information science, in particular in the domain of knowledge management

[122] Schatzki, T., 2002. Social science in society. Inquiry, 45(1), pp. 119–138.

[123] Cox, A. M., 2013. Information in social practice: A practice approach to understanding information activities in personal photography. Journal of Information Science, 39(1), pp. 61–72, p. 105.

[124] Gherardi, S., 2008. Situated knowledge and situated action: What do practice-based studies promise. The SAGE handbook of new approaches in management and organization, pp. 516–525.

(Nicolini,[125])

Orlikowski[126] observed how convention in practice emerges between participants and the use of technology and how this use impacts human behavior. As technology processes data into information and put it in use by humans, such dialectics between participants and technology influence human information behavior, too. Other relevant examples of using practice theory in information behavior research include Nicollini[127], Mckenzie[128] or Savolainen's everyday life information seeking (ELIS) model[129]. In his later work he developed a *more sociologically and contextually oriented* model of information activities**.** Shift is from individual information need towards problem solving active information seeking, information use and share acknowledging social factors (Savolainen, [130]) Widen et. al.[131] proposed framework of workplace information practices that can be used to evaluate research opportunities. Practice theories offer research departure points that facilitate observing the dynamic relationship, ways of knowing and its outcomes as a result of human information behavior. They help in focus on people engagement in particular social settings with related experiences, relationships and embodied knowledge.[132]

Practice theory – relevance in the context of this dissertation

Orlikowski work is of particular interest as it points to the importance of the ways how information is processed by technologies and its impact on a user. When talking about music recommendation engines integrated into the information systems supporting user music-related information behavior, then it is important to know how they work and what the impact to the user

[125] Nicolini, D., 2011. Practice as the site of knowing: Insights from the field of telemedicine. Organization science, 22(3), pp. 602–620.

[126] Orlikowski, W. J., 2000. Using technology and constituting structures: A practice lens for studying technology in organizations. Organization science, 11(4), pp. 404–428.

[127] Nicolini, D., 2011. Practice as the site of knowing: Insights from the field of telemedicine. Organization science, 22(3), pp. 602–620.

[128] McKenzie, P. J., 2002. Communication barriers and information-seeking counterstrategies in accounts of practitioner-patient encounters. Library & Information Science Research, 24(1), pp. 31–47.

[129] Savolainen, R., 2005. Everyday life information seeking, pp. 143–148.

[130] Savolainen, R., 2008. Everyday information practices: A social phenomenological perspective. Scarecrow Press.

[131] Widen, G., Steinerová, J. & Voisey, P., 2014. Conceptual modelling of workplace information practices: a literature review. *Information Research*, 19(4).

[132] Lloyd, A., 2010. Corporeality and practice theory: exploring emerging research agendas for information literacy. *Information Research*, 15(3), 15–3.

is. A big shift has been evidenced in how music is consumed in terms of technologies (from CD player to streaming services), how technology processed music-related information (from print media to social media and user generated content) and how users behave (from buying music to listening to it for free). Practice theory frameworks could be used in the process of storing data collected about user information behavior (logs, network analysis, statistics of content usage) and at the same time embracing the information system theories and user information behavior theories. Practice theory proposes that a research interest is not just about the user as a detached agent from the information system used and social environment operating in it. It could be useful if we try to observe user and information system as one system aiming toward the steady state to fulfil task at hand as it describes dynamics of the environment in which such a system operates (such as how tools are developed, who made decisions and why, what are expected outcomes and how people cooperate based on the tools used to process information).

Social-cognitive theory

Importance of self-efficacy in relation to factors that motivate human information behavior are discussed by Savolainen[133] pointing to the usefulness of psychological theories and that bridging them with human information behavior studies is a significant contribution to the renewal of the concepts and models. People live in social systems and networks and such networks provide a pathway through which styles of behavior are spread based on the psychological factors that control their acquisition and adoption.[134] So, human information behavior is shaped by social and cognitive factors, and humans behave in social networks and system they shape and are shaped by at the same time. *People are self-organizing, proactive, self-reflecting, and self-regulating, not just reactive organism shaped and shepherded by environmental events or inner forces*.[135]

[133] Savolainen, R., 2012. Conceptualizing information need in context. Information Research, 17(4), p. 534.
[134] Bandura, A., 2001. Social cognitive theory: An agentic perspective. Annual review of psychology, 52(1), pp. 1–26.
[135] Bandura, A., 2001. Social cognitive theory: An agentic perspective. Annual review of psychology, 52(1), pp. 1–26.

According to Bandura[136], human agency has four core properties, and they are:

- **intentionality:** commitment to plans and strategies to toward desired outcomes
- **forethought**: ability to anticipate the outcomes of actions and set goals
- **self-reactiveness**: monitor courses of action toward fulfilling goals
- **self-reflectiveness:** thinking about capabilities, evaluating motives, values, and life goals.

The Socio-cognitive theory is based on "triadic reciprocal causation" in which there is interaction between environmental factors, intra personal factors and behavior.[137] Experience can be looked as a source of information to the human(s) in focus. These experiences are vicarious and personal. Vicarious experiences are reading, observing and/or listening to others. They are important if person(s) had to rely only on personal direct experiences as sources of knowledge. If they are not used together, then the process of learning could be time consuming. So, observation influence human(s) understanding of social reality and their beliefs.[138] In their everyday life, people are linked, directly and indirectly, to social networks that serve as communication systems through which they receive motivation and advice about desired changes in behavioral patterns. How human(s) organizes information, selects actions and assign meaning to them are partly defined by cognitive factors. The social-cognitive theory points to the importance of social networks through which new behavior is diffused and underline importance of self-efficacy as a cognitive mediator of action. Self-efficacy is underlined as a one of the main activating mechanisms in Human information Behavior.[139] So, human(s) based on the self-efficacy behave and have expectations to the outcome. As it is presented in Figure 7.

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136 Bandura, A., 2006. Toward a psychology of human agency. Perspectives on psychological science, 1(2), pp. 164–180.

137 Bergman, Z., Bergman, M. M. and Thatcher, A., 2019. Agency and Bandura's model of Triadic Reciprocal Causation: An exploratory mobility study among Metrorail commuters in the Western Cape, South Africa. Frontiers in psychology, 10, p. 411.

138 Bandura, A., 2001. Social cognitive theory: An agentic perspective. Annual review of psychology, 52(1), pp. 1–26.

139 Wilson, T. D., 2007. Evolution in information behavior modeling: Wilson's model. In, K. Fisher, S. Erdelez & L. McKechnie, (Eds.). Theories of information behavior, (pp. 31–36). Medford, NJ: Information Today. [Slightly revised and updated October 2007] [Available at http://InformationR.net/tdw/publ/papers/2005SIGUSE.html]

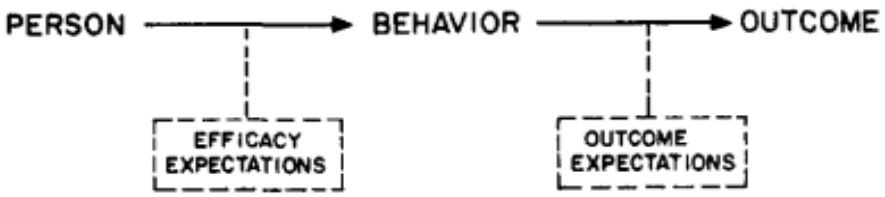

Figure 7 – Diagrammatic representation of the difference between efficacy expectations and outcome expectations (Bandura,[140])

Bandura[141] pointed to mastery experience, vicarious experience, social persuasion and somatic and emotional states as the four main sources of influence to human(s) sense of efficacy. They are explained below. [142]

1. Mastery experience – People develop their sense of self-efficacy through continuous evaluation of their performance. They increase their sense of self-efficacy by completing tasks successfully (for that particular task) while failure to do so could weaken their sense of self-efficacy. Mastery experience is probably the most influential in the process of establishing self-efficacy beliefs.

2. Vicarious experiences – (observational learning) could enhance self-efficacy as by observing others in the process of similar situations in which they successfully complete the task, making judgments about their performance. But such social models observed do not serve only as a standard for judgment of competence, but they also provide information on how activities can be approached.

3. Social persuasion – is about how people's self-doubts about their competence to handle a task can be neutralized through verbal encouragement.

4. Somatic and emotional states – could influence self-efficacy beliefs. If people are presented with a way to cope with stressful situations their efficacy beliefs could be advanced. Also,

[140] Bandura, A., 1977. Self-efficacy: toward a unifying theory of behavioral change. Psychological review, 84(2), 191.
[141] Bandura, A., 1998. Health promotion from the perspective of social cognitive theory. Psychology and health, 13(4), pp. 623–649.
[142] Bandura, A., 1977. Self-efficacy: toward a unifying theory of behavioral change. Psychological review, 84(2), p. 191.

emotional factors (such as mood) could also improve people's self-efficacy judgments, while tensions and stress can represent inability and could result in lower self-efficacy.

Before people act, they try to predict the possible results of their behavior and the decision about whether or not to carry out the specific behavior is built on the outcome of that prediction (Wilson,[143]). Positive outcome expectancies encourage, and negative ones discourage human(s) action (including information behavior). So, human(s) that have positive beliefs in outcomes of actions are more likely to act.

Instances of socio-cognitive theory frameworks can be found in Wilson's 2nd model of information behavior, where he proposes that self-efficacy is one of the activating mechanisms that influence information behavior, pointing that her/his beliefs about desired outcome will impact whether a particular behavior is conducted or not[144]. Another model is proposed by Savolainen [145] pointing out that an individual's self-efficacy beliefs about his or her ability to find information on the web will influence his or her information seeking activities. Other information behavior research based on socio-cognitive framework can be found in Ford[146].

Socio-cognitive theory – relevance in the context of this dissertation

The socio-cognitive theory provides us with a theoretical framework that could help overcome separation between social and cognitive factors in information behavior. Norbert Wiener[147] said back in 1950 that *a pattern is a message and may be transmitted as a message*. Bandura pointed out that new behavior diffuses over social networks. So, if peope want to transmit pattern of behavior, they must first recognize it in terms of new information behavior patterns. This could be achieved by observation that could be qualitative or by collecting search logs. When patterns are recognized then it is necessary to describe them in mathematical terms for the purpose of digitalization, so machines could process them and make exchanges between themselves, or between the machine and the human. For example, if a high level of satisfaction could be

[143] Wilson, T. D., 2013. Theory in information behaviour research. Eiconics Ltd, p. 128.

[144] Wilson, T. D. and Walsh, C., 1996. Information behaviour: An inter-disciplinary perspective: A review of the literature. London: British Library Research and Innovation Centre.

[145] Savolainen, R., 2002. Network competence and information seeking on the Internet: From definitions towards a social cognitive model. *Journal of documentation*.

[146] Ford, N., 2004. Modeling cognitive processes in information seeking: From Popper to Pask. Journal of the American Society for Information Science and Technology, 55(9), pp. 769–782.

[147] Wiener, N., 1988. The human use of human beings: Cybernetics and society (No. 320). Da Capo Press.

measured with the high level of satisfaction with the music played by the recommendation algorithms implemented in the information system such as YouTube, the information system could automatically find another user with similar socio-cognitive characteristics and play him or her the same play list. Over the time and feedback in terms of inputs from the content consumer, systems could improve. As it is rooted on triadic causation between behavior, intra personal and environmental factors, it could be very useful for music information behavior research, as music is experienced differently in a particular environment (such as night club or working in the room), selection will depend on some intra personal factors such as mood and will result in different behavior (relax or dance). As the social system acts as a regulatory mechanism, observation of the influence of the social system on the subject of observation habituate could gain a proper understanding of a particular music information behavior. In today's reality, which is on one side computer driven with the use of music recommendation algorithms, while on the other side are many choices to search for new music, understanding the role of the efficacy and beliefs in the outcome of the process of information seeking and searching behavior is of high importance. Also, concepts such as mastery experience, vicarious experience, social persuasion and somatic and emotional states could be great classification used in the analysis of the music information behavior. Socio-cognitive theory could be a source of the factors that could be used as an input in developing music information behavior prediction models that could be implemented in the information systems supporting music experience, seeking, searching and retrieval, recommendation and consuming.

Social phenomenology

According to Wilson and Savolainen, social phenomenology combines philosophical and sociological ideas in order to study the reciprocal interactions among the processes of human action, situational structuring, and reality construction in the context of life-world[148].

There is evidence of impact of social phenomenology on information science through human information behavior research. Increased popularity of qualitative research methods comes from

[148] Wilson, T.D., 2013. Theory in information behaviour research. Eiconics Ltd., p. 141.

the realization that just counting of occurrences of actions is not enough to understand the motivations and aims and overall information behavior of information seeker. [149]

Research is focused on human experience of the world instead of the world itself.

It is important to understand that action is happening in temporal dialectic, based on how things happened in the past (habitual actions), present moment performance (actual constraints of action) and projection of the future actions. On the other hand, objects in everyday reality of a person in focus capture his attention through her or his interests. The interests of the person in focus determine the relevance of those objects and trigger actions based on closer considerations. Another important relevant factor is an individual's stock of knowledge regarding definition of situation and possible actions. If the perception made of objects in reality of the person in focus are compatible with his/her expectations, they indicate that the stock of knowledge at hand is sufficient and relevant to master the situations being encountered.

So, stock of knowledge could be understood as the tool to engage with everyday human information behavior. People tend to structure their everyday life word and knowledge of it into various regions of relevance and they are: [150]

1. **The world within actual reach** represents the life-world that is directly at hand and actions taken serve the needs for everyday projects and where life or daily plans take place. This world has a temporal character of the present. Such a world, within actual reach, is the space of primary relevance (regarding actions and thinking) and could be observed immediately. It could change and rearrange based on our actions. As it results in direct action, it could be characterized as a zone of operation.
2. **The world within potential reach** represents objects of interests that are not directly at hand but can be accessed if needed. It is characterized by the remembered past and potential reach in the future. With development of information and communication technologies and internet, there is evidence diminishing differentiation between world of actual reach and within potential reach as we have most of the global information at disposal.

[149] Wilson, T. D., 1981. On user studies and information needs. Journal of Documentation, 37(1), 3–15. Retrieved 27 October, 2007 from http://informationr.net/tdw/publ/papers/1981infoneeds.html.
[150] Wilson, T. D., 2013. Theory in information behaviour research. Eiconics Ltd.

3. **Relatively irrelevant regions** do not have connections with a person's immediate interests at the particular moment in time.
4. **Absolutely irrelevant regions** are the regions of the life-world that have no relevance to the actor in focus because it cannot influence processes and things in this area.

Savolainen[151] pointed out that Schutz's conception of the regions of decreasing relevance could be used to study information sources preferences, how people filter information and with whom they share information. Central to phenomenology are concepts such as perception, intentionality and interpretation. They are integral to individual activities to searching for information and determining relevance.

Social phenomenology – relevance in the context of this dissertation

Social phenomenology helps in understanding the meaning in social interaction and actions performed by individuals. It could be used to map the social networks that influence the process of music information searching and seeking, how music is consumed in different groups and how those settings impact users in focus. It helps in explaining why people act in the way they do, what common understandings are between them, how those understandings change over time (and how they are related to their actions). By deeper understanding of music-related information seeking behavior through qualitative research, information systems could be designed to support information seeking and searching processes and enhance the music experience. Understanding actions of the user is essential for the design of an information system that is adaptable to user actions. It could also help in understanding different types of ideal types of behavior and help in to classifying human information behavior accordingly and implement such classification into the design of the music related information systems.

A general theory of human information behavior (GTOHIB)[152]

Based on his previous two models of information behavior published[153],[154], Wilson proposed General Theory of Human Information Behaviour[155].

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151 Savolainen, R., 2008. Everyday information practices: A social phenomenological perspective. Scarecrow Press.
152 Wilson, T. D., 2016. A general theory of human information behaviour. Information Research, 21(4).
153 Wilson, T. D., 1981. On user studies and information needs. *Journal of Documentation*, 37(1), 3–15.

Wilson in[156] defines the following terms important to understand different levels on which human information behavior is happening:

- ***Information Behavior*** *is the totality of human behavior in relation to sources and channels of information, including both active and passive information seeking, and information use.*
- ***Information Seeking Behavior*** *is the purposive seeking for information as a consequence of a need to satisfy some goal.*
- ***Information Searching Behavior*** *is the 'micro-level' of behavior employed by the searcher in interacting with information systems of all kinds.*
- ***Information Use Behavior*** *consists of the physical and mental acts involved in incorporating the information found into the person's existing knowledge base.*

In the same paper, Wilson's 2nd was presented as a model of information theory.

This and other models of information behavior will be discussed in the chapter that gives an overview of different models and their development. The differences between models and theories are to be discussed accordingly. In the recent Wislon on paper[157] information box presenting processing and use box was extended into two boxes, one representing information use and the other representing information processing. Information is processed and related to investigation of psychologist and cognitive scientist, but also to the information processing theory in the area of problem solving, learning, formation of the concepts and constructs, short term memory, perception and language behavior.[158] At the same time, the information processing theory is also related to the development of computers and analogies between how humans and computers process information.

Information use according to Wilson[159], could be satisfaction of the original need, exchange with other persons and transfer of the information directly to someone else. Information could be used to provide background information, help in dealing with specific tasks and was transferred to colleagues and clients. GTOHIB could be also applied in other related research, in particular

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154 Wilson, T. D., 1999. Models in information behaviour research. *Journal of Documentation*, 55(3).

155 Wilson, T. D., 2016. A general theory of human information behaviour. Information Research, 21(4).

156 Wilson, T. D., 2000. Human information behavior. Informing science, 3(2), 49–56.

157 Wilson, T. D., 2016. A general theory of human information behaviour. Information Research, 21(4).

158 Simon, H. A. & Newell, A., 1971. Human problem solving: The state of the theory in 1970. American Psychologist, 26(2), 145. (page 148).

159 Wilson, T. D., 1981. On user studies and information needs. Journal of Documentation, 37(1), 3–15. Retrieved from http://informationr.net/tdw/publ/papers/1981infoneeds.html.

communication studies by including person in the context of the scope of study (that exists in the 2nd Wilson model). Figure 8 reduced total human information behavior to one box and person in context as another.

Figure 8 – Reduced total human information behavior to one box and person in context as another

Adding an *information sources* box to include all possible sources, including people that may be drawn upon (Figure 9).

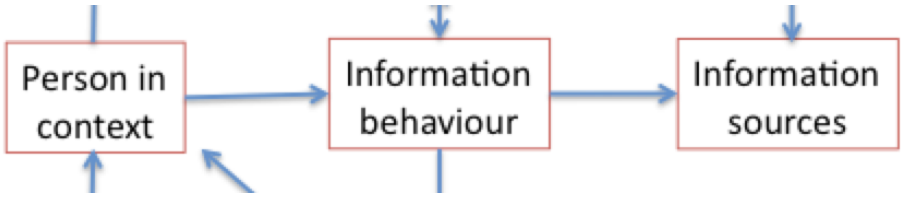

Figure 9 – Adding an *information sources* box to include all possible sources

Person in context could be viewed as a member of the *audience*, and various communication media could be defined resulting in the *outputs* that serve as information sources for the information seeker.

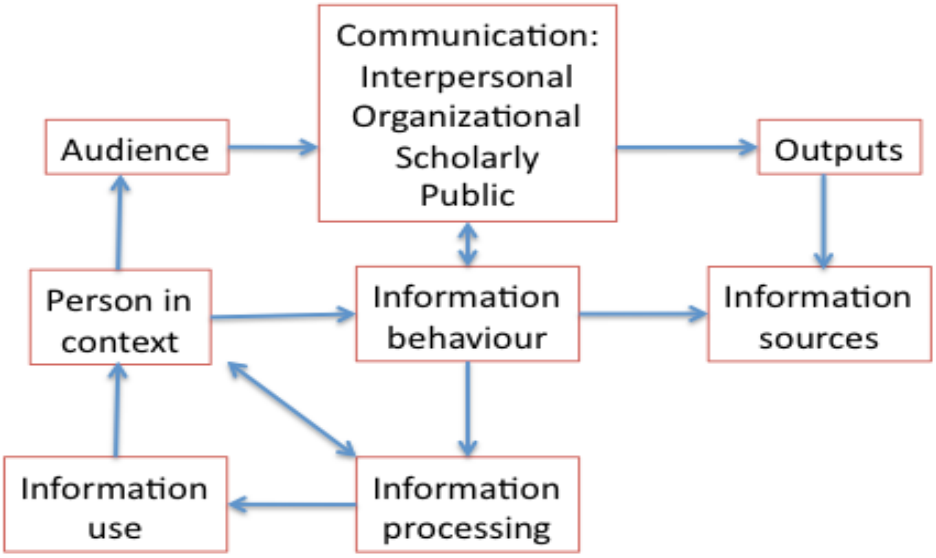

Figure 10 – The new concept and connections

The new concept and connections presented in Figure 10 provide relationship and areas that could be researched separately or how they interact with each other. It also helps in integrating the existing body of research and provide with foundations based on which a theory of human information behavior could be developed. [160]

As shown in Figure 11, feedback collected from the person in context that uses and processes information behaving accordingly, could be used to optimize communication processes. Such perspective opens up that GTOHIB could be used and in Human Computer Interaction research[161] and such feedback could be used for the purpose of controlling behavior of the information system. So, the information system based on the feedback about the person in context could adopt and present relevant information to the user. Examples of such feedback could be found in music recommendation engines used by YouTube and Spotify, as they play music automatically based on the user and the context he or she is in. More about them could be found in the work of Lugovic. [162]

[160] Wilson, T. D., 2016. A general theory of human information behaviour. Information Research, 21(4).

[161] Wilson, T. D., 1999. Models in information behaviour research. Journal of Documentation, 55(3),

[162] Lugovic, S., 2016. Overview of Approaches and Future Challenges for Development of Music Recommendation Socio-Technical Systems, Chapter in: Trends in Music Information Seeking, Behavior, and Retrieval for Creativity, IGI Global.

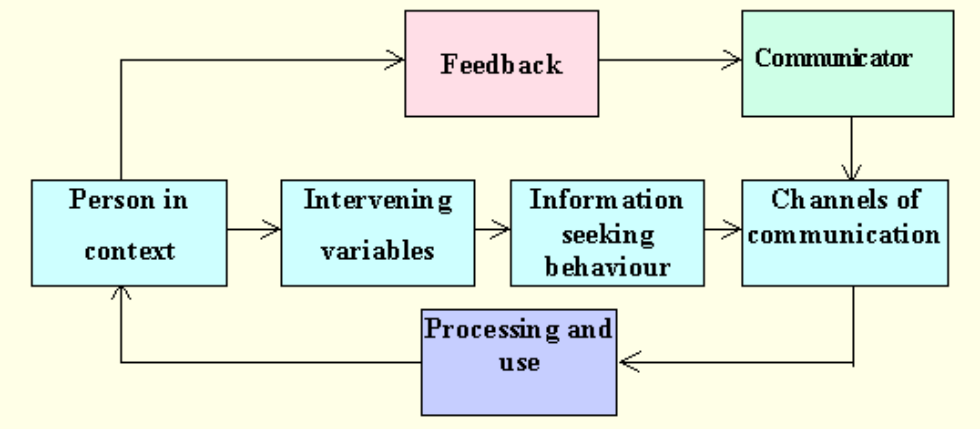

Figure 11 – Relationship between communication and information behavior[163]

Key underlying propositions of Wilson GTOHIB are[164]:

1. *To satisfy various needs that arise in the course of existence, humans interact with information.*
2. *Those needs arise in different situations related to a person's work, family life, social relationship and are affected by different factors from socio-cultural to physical.*
3. *Different factors affect a person's motivation to satisfy the needs and the significance of those factors is related by the person's assessment of the importance of those needs satisfaction.*
4. *Characteristics of the person, means avaliable that exist to discover information and/or their social relations are intervening variables that affect a person's ability to seek information after deciding to do so.*
5. *Information seeking behavior can be iterative or episodic and may be influenced by the expectated outcome in terms of success or failure.*
6. *Information can be discovered as a result of accidental discovery, information monitoring or result of deliberate search.*
7. *Information seeking is the one aspect of information behavior, other activities are information sharing and exchange, information transfer to others (whose needs are*

[163] Wilson, T. D., 1999. Models in information behaviour research. Journal of Documentation, 55(3).
[164] Wilson, T. D., 2016. A general theory of human information behaviour. Information Research, 21(4).

known) and information rejection and avoidance. All of them play a part in information discovery.

8. *Information behavior may be collaborative, individual and collective.*

Human information behavior as a research field developed over the years producing a significant number of publications and with general theory of human information behavior finally got its own research departure point with this work of Wilson.

Key takings for this thesis

Probably the most important part of the GTOHIB related to this research is about the relationship and feedback between different logical blocks defining information behavior. On the one hand, the information about a person in context could be send back as feedback to the the music-related information system and, based on it, design adaptive functionalities. On the other hand, it opens up a perspective to observe and gain better insights into the influence of the music related information systems to the user information behavior. It is very important to understand how users music information behavior changed with the development and increase of the popularity of music streaming services that have implemented recommendation engines in them. At the same time increased use of the smartphones decreases the physical space of behavior even further as music is played from the same device where users search and seek information about the music being listen to. What makes this phenomenon fascinating is that at the same time physical space is decreased, information space is increased (more options avaliable just by a click on the smartphone).

Holistic view on the user and information system

In the above presented overview of the different information systems and information behavior theories it is evident that they cover different aspects of the information processing. One aspect is related to the information systems, how they are designed, why they are used and how they influence social environment in which they exist. Abbasi and his colleagues pointed out to the three information research traditions, behavioral research, design research, and economics of

information systems[165].

Table 7 presents how the information system could respond to the human information behavior, information seeking, searching and use.

Table 7 – Human information behavior and pattern-based information system capabilities

User View (Wilson, 2000)	Patterns (System View)
Information Behavior - as totality of human behavior exposed to sources and channels of information	Totality of behavior of the system according to the patterns recognized
Information Seeking Behavior is the purposive seeking for information as a consequence of a need to satisfy some goal.	Capabilities of system to restructure according to patterns recognized (representing information needs)
Information Searching Behavior is the 'micro-level' of behavior employed by the searcher in interacting with information systems of all kinds.	Capability of generating new functions according to the user searching behavior based on searching patterns recognized
Information Use Behavior consists of the physical and mental acts involved in incorporating the information found into the person's existing knowledge base	Capabilities of the system to act upon patterns recognized, including reflections to previous activities conveying information

Continuous change on the different levels impacting the use and operations of the information system provides us with another challenge in the design of the information system. We could argue that we could have one axis related to the theories that range from understanding through prediction toward design of the artefacts while another axis could be related to the level of information system openness and adaptity.

Accordingly, to be able to predict, it is necessary to understand that the awareness of different views together with applications of those views in analysis are necessary.

[165] Abbasi, A., Sarker, S. & Chiang, R. H., 2016. Big data research in information systems: Toward an inclusive research agenda. Journal of the Association for Information Systems, 17(2).

There are two groups of scientific studies that are important for that purpose, one is behavioral science and the other is design science. Tables 8 shows their differences as well as how those differences could be "flipped" for the purpose of holistic view.

Table 8 – Identified polarities of behavioral science vs. design science in information systems research

	Behavioral science	**Design science**
Ontological temporality	Existing reality	New reality
Basic aim	Truth	Utility
Study focus	Use behavior	Designed artifacts
Basic procedure	Data collection	Creation through design
Basic epistemic types	Explanation & description	Prescription through design principles and design theory
Type of conjecture	Causality hypothesis	Design idea & design hypothesis

Table 9 – Flipping polarities of behavioral science and design science

	Behavioral science	**Design science**
Ontological temporality	Implications of new knowledge for changing reality	Existing reality as a vantage point for design
Aim	Interest in utility of existing artifacts	Statements of existing and changed reality need to be true

Study focus	Use behavior in relation to designed artifacts & practices	Need to study design behavior and use of new artifacts
Procedure	Possibility to create prescriptions about design from collected data	Collection of data about design process & product
Epistemic types	Prescriptions can be derived from explanations	Descriptions & explanations are needed for formulating prescriptions
Type of conjecture	Hypotheses can concern different designs	Hypotheses about causality concerning artifact properties and use behavior & effects

Importance of holistic views,[166] pointing that early social science studies focus either on human behavior or the environment, not on the complex relationship of those two. To a similar conclusion came Ropohl[167], discussing challenges that socio technical system research approach could help to overcome it. Another perspective that complements socio technical approach is ecological ecosystem perspective by Friedman & Allen[168], that is concerned with the nature of interactions between individuals (or group, family, or community) and the greater environment. Also, it is important that the ecosystem perspective views human(s) as cause and effect of their dynamic situation, in which every change a human makes causes reactive change in the larger system. So, we could have the view of human(s) agents behaving in an environment that consists of social constructs and technical artifacts.

This chapter provides an overview of various theories that address human information behavior from the perspective that includes interaction between humans and information systems. Applying those theories into the development of information systems gives rise to novel possibilities for machine-based observation of human and information system as one system

166 Bronfenbrenner, U.,1979. The ecology of human development: Experiments by nature and design. Cambridge, MA: Harvard University Press.

167 Ropohl, G., 1999. Philosophy of socio-technical systems. Techné: Research in Philosophy and Technology, 4(3), 186–194.

168 Friedman, B. D. & Allen, K. N., 2011. Systems theory. Theory & practice in clinical social work, 2, 3–20.

having its own behavior. Those approaches will be elaborated in the next chapter in more in detail. But what is the takeaway point based on the overview of the above presented theories? It could clearly be stated that human information behavior could and should impact the performance of the information systems, but at the same time performance of the information systems have an impact on human information behavior. And if we the performance of such socio technical systems that include humans, their behavior and design principles implemented in information systems can be observed and analyzed, then it is possible to change current paradigms of design of information systems. Such socio technical system features are related to the characteristics of the human using the information system, different behavioral theories explaining why such behavior happens and the characteristics of the information systems. As mentioned above information system consist of technology, data and organizational factors. Combining all those variables together and being able to quantify behavior based on the logs that are collected by machine through the interaction between information system and its users, process them with the aim to provide insights (which actually is information) could be initial step toward designing more adoptive information system. Such information systems should be able to detect human information behavior, based on information needs and accordingly adopt to it.

CONCEPTUAL FRAMEWORK OF THE STUDY – PROPOSAL OF A SOCIO-TECHNICAL INFORMATION BEHAVIOR MODEL

This chapter presents the author's own model of information behavior and puts it in relation to other information behavior models. In the analysis of a different model additional focus will be on putting the information behavior discipline in the context of information systems design. Departure point is that the users of the information system and information system by itself are understood as one system that develops toward the steady state when it is able to perform actions based on the information processed and used. Properties of the user and information system should be understood as not deterministic, but as emerging and dynamic, and are changed accordinglyby interaction between user and information system.

Wilson proposed definition of four relevant terms related to information behavior[169]. They are cited in Table 10:

Table 10 – Definition of four relevant terms of Information Behavior

Information Behavior *is the totality of human behavior in relation to sources and channels of information, including both active and passive information seeking, and information use. Thus, it includes face-to-face communication with others, as well as the passive reception of information as in, for example, watching TV advertisements, without any intention to act on the information given.*
Information Seeking Behavior *is the purposive seeking for information as a consequence of a need to satisfy some goal. In the course of seeking, the individual may interact with manual information systems (such as a newspaper or a library), or with computer-based systems (such as the World Wide Web).*
Information Searching Behavior *is the 'micro-level' of behavior employed by the searcher in interacting with information systems of all kinds. It consists of all the interactions with the system, whether at the level of human computer interaction (for example, use of the mouse and clicks on links) or at the intellectual level (for example, adopting a Boolean search strategy or determining the criteria for deciding which of two books selected from adjacent places on a library shelf is most useful), which will also involve mental acts, such as judging the relevance of data or information retrieved.*

169 Wilson, T. D., 2000. Human information behavior. Informing science, 3(2), 49–56.

Information Use Behavior *consists of the physical and mental acts involved in incorporating the information found into the person's existing knowledge base. It may involve, therefore, physical acts such as marking sections in a text to note their importance or significance, as well as mental acts that involve, for example, comparison of new information with existing knowledge.*

Bates[170] defined Information behavior as a *currently preferred term used to describe the many ways in which human beings interact with information, in particular, the ways in which people seek and utilize information. Information behavior is also the term of art used in library and information science to refer to a sub-discipline that engages in a wide range of types of research conducted in order to understand the human relationship to information*.

Prominent models of information behavior

Kuhlthau[171] defined information search process (ISP*)* as *the user's constructive activity of finding meaning from information in order to extend his or her state of knowledge on a particular problem or topic. It incorporates a series of encounters with information within a space of time rather than a single reference incident. Uncertainty and anxiety are an integral part of the process, particularly in the beginning stages*. Those activities, according to her, incorporate three realms: ***physical****, (actual actions taken);* ***affective*** *(feelings experienced); and* ***cognitive*** *(thoughts concerning both process and content).* Kuhlthau information search process is presented in Figure 12[172]:

170 Bates, M. J., 2010. Information behavior. *Encyclopedia of library and information sciences*, 3, 2381–2391, https://pages.gseis.ucla.edu/faculty/bates/articles/information-behavior.html.

171 Kuhlthau, C. C., 1991. Inside the search process: Information seeking from the user's perspective. Journal of the American society for information science, 42(5), 361.

172 Kuhlthau, C., 2005. Information search process, available at http://wp.comminfo.rutgers.edu/ckuhlthau/information-search-process/.

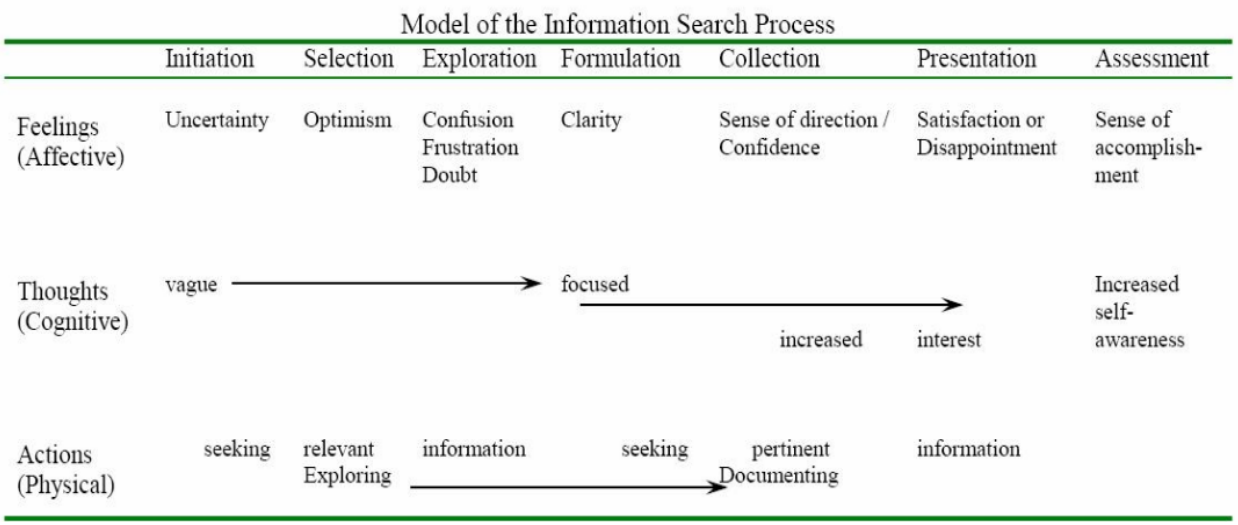

Figure 12 – Model of the Information Search Process

Ellis proposed[173]: *If researchers' information seeking patterns are broken down into their basic behavioral characteristics - and the retrieval system is provided with facilities that reflect those characteristics - then users should be able to recreate their own information seeking patterns while interacting with the system*. This claim could be extended towards the design of adoptive information systems, as if the users were able to recreate their own information seeking patterns, then information systems should also be able to recreate them automatically and support the new users in their process of information retrieval.

Ellis[174] also underlined six characteristics related to different features of the various patterns, providing a framework to support information retrieval system design. Those are:

- ***Starting****: activities characteristic of the initial search for information.*
- ***Chaining:*** *following chains of citations or other forms of referential connection between materials.*
- ***Browsing****: semi-directed searching in an area of potential interest.*
- ***Differentiating:*** *using differences between sources as filters on the nature and quality of*

173 Ellis, D., 1989. A behavioural approach to information retrieval system design. Journal of documentation, 45(3), 171–212.

174 Ellis, D., 1989. A behavioural approach to information retrieval system design. Journal of documentation, 45(3), 171–212.

the material examined.

- ***Monitoring:*** *maintaining awareness of developments in a field through the monitoring of particular sources.*
- ***Extracting:*** *systematically working through a particular source to locate material of interest.*

According to Ellis, those characteristics do not define hierarchic sequence, nor a set of search heuristics, but a set of related categories that describe individual information seeking patterns.

Dervin[175] proposed the term *Sense-Making* as a set of methods and a concept used to study how people *construct sense of their worlds and, in particular, how they construct information needs and uses for information in the process of sense-making*. Sense making is indispensable to all types of communications (intra-personal, interpersonal, mass, cross-cultural, societal, or inter-national) and according to Dervin, it is widely applicable in information behavior research. Sense making is defined as behavior, both internal (i.e., cognitive) and external (i.e., procedural), which allows the individual to construct and design his/her movement through time-space. Information use and seeking are central to the sense of making concept. Such methodological perspectives are applicable in the process of information system design, as they challenge the system design paradigm that views information as a thing to be dispensed, transmitted, or disseminated.[176] This approach opens the avenues to include the humans and their information behavior into the design of information systems and mechanics implemented in them for that purpose. So, it is not just about machine processing data and providing users with the information, but it is about how information changes behavior of users and how the information system adapts to those changes. Naumer, Fisher and Dervin[177] suggested the following implications of Sense Making methodology to the information system design:

- Reconceptualizes people as information designers struggling to make sense out of an incomplete reality rather than as information seekers attempting to gather information that describes an objective "reality".

175 Dervin, B., 1983. An overview of sense-making research: Concepts, methods, and results to date. The Author.

176 Dervin, B., 1983. An overview of sense-making research: Concepts, methods, and results to date. The Author.

177 Naumer, C., Fisher, K. & Dervin, B., 2008. Sense-Making: a methodological perspective. In Sensemaking Workshop, CHI'08.

- Reframes information design as a meta activity focused on designing systems that assist people to make and unmake their own sense.
- Provides information system designers with grounded methods to better understand their users and develop systems responsive to users' sense-making needs.
- Provides information system designers with ways to understand and begin to bridge the gaps between chaos and order encouraging information system designers to focus on the processes people use to bridge these gaps.
- Provides information system designers with analytic tools such as the gap bridging metaphor, situation-gap-outcome triangle and a roster of research tested potential "verbs" or processes to guide system development approaches.

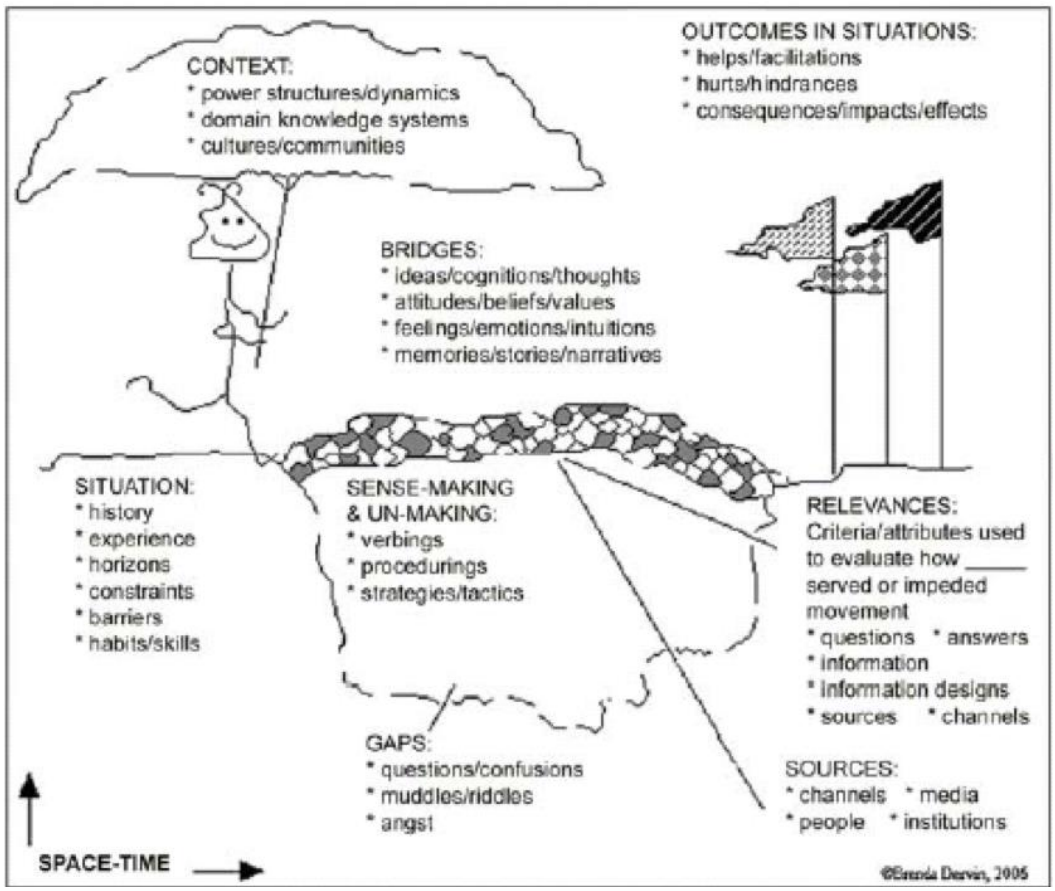

Figure 13 – The Sense-Making Metaphor[178]

[178] Naumer, C., Fisher, K. & Dervin, B., 2008, April. Sense-Making: a methodological perspective. In Sensemaking Workshop, CHI'08.

Ingwersen[179] proposed a cognitive theory for information retrieval (IR) interaction which attempts a comprehensive understanding of essential IR phenomena and concepts, such as the nature of information needs, cognitive inconsistency and retrieval overlaps, logical uncertainty, the concept of 'document', relevance measures and experimental settings. This approach is rooted more in sociological and psychological methods used in information system (and/or information retrieval) evaluation and design.

Saracevic[180] pointed out to relevance as an important concept in information retrieval, but also applicable to different aspects of the information behavior. Below is the cited text elaborating its importance and relationship to information behavior, seeking, searching and using.

Relevance is an important factor related to any interactive exchange of information, such as communication between people, in the processes of information seeking and searching and any other activities related to making the use of information needed. Relevance is used for assessing filtering, ranking, accepting (or rejecting) and classifying information at disposal. In general, relevance could be understood as *a degree of appropriateness or effectiveness to the 'matter at hand.* Relevance evolves along the process of changes of cognitive horizons and intentions of person looking for information. Relevance is a basic cognitive notion that dynamically changes in the process in which our mind interacts with information sources. It is a mechanism that comes as a part of cognition.[181]

Belkin and his colleagues[182] suggested that any single information-seeking interaction is a complex activity, which can be characterized according to its values on a relatively small set of factors, or dimensions. They proposed a model of information seeking behavior based on the four dimensions of information seeking strategies. Those dimensions are presented in Figure 14.

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179 Ingwersen, P., 1996. Cognitive perspectives of information retrieval interaction: elements of a cognitive IR theory. Journal of documentation, 52(1), 3–50.

180 Saracevic, T., 1996, October. Relevance reconsidered. In Proceedings of the second conference on conceptions of library and information science (CoLIS 2), (pp. 201–218).

181 Saracevic, T., 1996, October. Relevance reconsidered. In Proceedings of the second conference on conceptions of library and information science (CoLIS 2), (pp. 201–218).

182 Belkin, N. J., Cool, C., Stein, A. & Thiel, U., 1995. Cases, scripts, and information-seeking strategies: On the design of interactive information retrieval systems. Expert systems with applications, 9(3), 379–395.

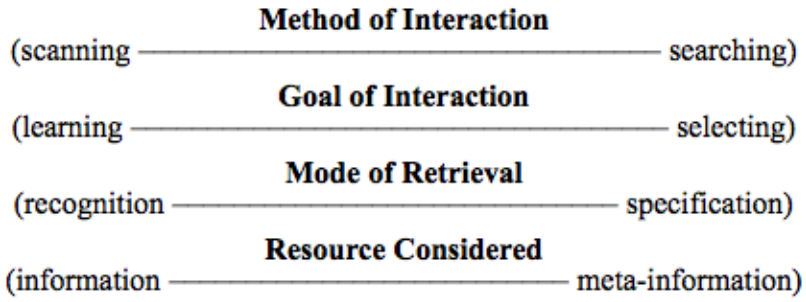

Figure 14 – Four dimensions of information seeking strategies[183]

Socio-technical model of information behavior

Different definitions from the different researches define information behavior from different perspectives (cognitive, socio cognitive, constructivist, positivist**).** In general, information behavior could be defined as a total behavior of the agent (agent could be human, artificial, biological, or a system containing two and more of those three types of agent) expressed through one or more iterative sequences of the meta process that starts from the moment agent experienced the signal from environment that triggers information need, till the moment he has processed information, used it or acted upon environment based on the information (or has not used by intentionally avoiding it).

By extending definition of information behavior toward the agent (that could be human, artificial, biological or system that consist two or more of the mentioned), it is possible to apply information behavior principles towards the design of information system which are in frequent use today, as they also behave under influence of the information collected from the environment and implement some kind of logic in them to process such information. Extending the definition to describe the behavior of the system containing more than one agent (i.e., human + artificial) there is a possibility to analyze social information behavior (meaning how group of people

[183] Belkin, N. J., Cool, C., Stein, A. & Thiel, U., 1995. Cases, scripts, and information-seeking strategies: On the design of interactive information retrieval systems. Expert systems with applications, 9(3), 379–395.

behave) but also the socio technical information behavior (meaning how group of people behave together as they start to use new technology). The first is used in the situation where information is placed strategically to change the behavior of humans and the second one is used when the social system gets some new technology or, better to say, information system to use and such use could change their behavior. Furthermore, the proposed definition is a paradigm independent and could be used across different paradigms, such as affective (or phenomenological), behavioral and cognitive. By defining it as a one or set of iterative sequences, we could gain better insights into the process of the change of the agent states along the way to satisfy information needs. If we include the change of the environment in the analysis, we could also gain insights into the results of the information behavior. All the above mentioned in the view of the author, are partly missing in the above cited definitions by other authors or they did not communicate it directly.

For that purpose, the author of this thesis developed an analytical matrix separating those sequences into five major "blocks" of information behavior. Such an analytical matrix could be also used as another model of information behavior. It is presented in Figure 20. The matrix includes the following "blocks":[184]

- socio-cognitive information experience
- information seeking process
- information searching and retrieval
- recommendation of information sources and resources
- information processing and use analysis.

Also, this matrix could be used in the process of IS design and development.[185] Important aspect of the proposed matrix is that it opens the potential of integrating social and technical perspectives into research and analysis. It also extends the scope of the analysis to the agent and/or agents' interactions through the proposed "blocks". The agent could be human or artificial and could interact with social or technical systems. For example, the agent could be software that

184 Lugovic, S., 2016. Overview of Approaches and Future Challenges for Development of Music Recommendation Socio-Technical Systems. In Trends in Music Information Seeking, Behavior, and Retrieval for Creativity (pp. 121–145). IGI Global.

185 Lugović, S., 2014, October. Research dimensions in information seeking of music: A plea for the socio-technical perspective. In European Conference on Information Literacy (pp. 722–732). Springer, Cham.

recognizes the faces in public transport (it interacts with social structures) or software that collects pictures from the web sites (it interacts with technical structures).

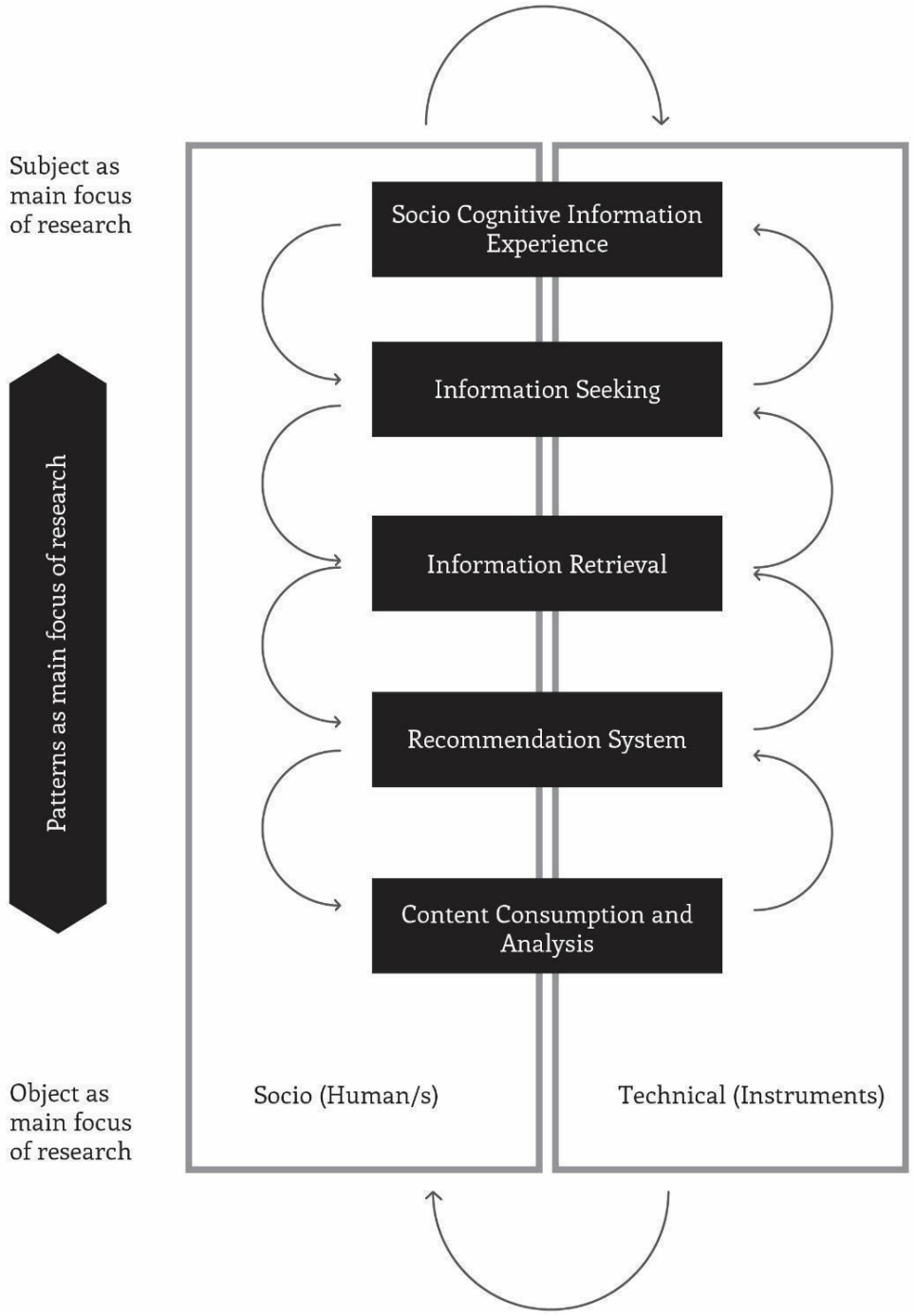

Figure 15 – Socio-technical model of information behavior

The idea of this analytical matrix is based on the propositions from Saracevic[186] and Järvelin & Ingwersen[187] described in Table 11.

Table 11 – Synthesis of Järvelin & Ingwersen different Research Dimensions and Sarcevic relevance Frameworks

	Järvelin & Ingwersen *Nine* Dimensions	**Saracevic Five relevance frameworks**
Socio-cognitive information experience	**Actor dimension** covers the actor's declarative knowledge and procedural skill; perceived work task dimension; covers the actor's perception of the work task; perceived search task dimension; covers the actor's perception of the search task.	**Psychological relevance** is viewed as a dynamic, ever-changing interpretation of information need in relation to presented texts.
Information seeking process	**Work task dimension** covers the work task set by the organization, the social organization of work, collaboration between actors and the physical and system environment; **Search task dimension** covers necessary seeking and retrieval practices.	**Communication Framework**: communication in terms of exchange of messages between a source and a destination, with possible interference of noise and inclusion of feedback
Information searching and retrieval	**Access and interaction dimension** covers strategies of information access, interaction between the actor and the interface.	**Situational framework** in which relevance is „… a dynamic concept that depends on users' judgment of the quality of the relationship between information and information needs at a certain point in time."
Information recommendation	**Algorithmic search engine dimension** covers the representation of documents	**Interactive Framework:** interactive processes are highly dynamic, involving a

[186] Saracevic, T. 1996. Relevance Reconsidered. In: Ingwersen, P., Pors, N. O. (eds.) Proceedings of the Second Conference on Conceptions of Library and Information Science (CoLIS 2), pp. 201–218. Copenhagen.

[187] Järvelin, K., Ingwersen, P., 2004. Information Seeking Research Needs Extension Towards Tasks and Technology. Information Research 10(1), 212, http://InformationR.net/ir/10-1/paper212.html.

	or information and information needs; **algorithmic interface dimension** covers tools for visualization and presentation of information objects, collections and their organization.	simultaneous poly-representation, multiple representations and models constructed by various elements. Relevance, while not directly addressed in this model, is strongly implied.
Information processing and using analysis	**Document dimension** covers document contents and genres and collections in various languages and media.	**System Framework**: involves documents/texts that are represented in the given way, then organized in a file, and made ready for matching to a query which is accomplished by a given algorithm incorporated in the system.

It is important to mention that information retrieval as a central block of the matrix was developed in the course of the research. The name of this block during the author's research evolved from information retrieval to the information search and retrieval as it includes search and retrieval. By Wilson's definition, information search behavior is *the 'micro-level' of behavior employed by the searcher in interacting with information systems of all kinds*[188], and it could include retrieval as well.

Information retrieval (IR) is a sub-field of both computer science and information science that deals with the processing of documents containing free text, so that they can be rapidly retrieved based on keywords specified in a user's query.[189] An IR system does not inform (i.e., change the knowledge of) the user on the subject of their his inquiry. It merely informs on the existence (or non-existence) and whereabouts of documents relating to their request. [190] Following the above definitions, the main difference between search and retrieval is that search involves mental activity while retrieval does not. IR is related to the queries processing and retrieval of documents (text, multimedia, records) and data in the system with the aim to pinpoint to the user where they could be found. But in any case, existence (or non-existence) of the documents and their exposition to the user will influence user behavior. An alternative paradigm in IR could be found

188 Wilson, T. D., 2000. Human information behavior. Informing science, 3(2), 49–56.

189 Nadkarni, P. M., 2002. An introduction to information retrieval: applications in genomics. The pharmacogenomics journal, 2(2), 96.

190 Lancaster, F. W., 1968. Information Retrieval Systems: Characteristics, Testing and Evaluation, Wiley, New York.

in the work Ingwersen[191] the cognitive theory of IR that considers cognitive space as an important aspect of information retrieval. Further in this chapter the proposed matrix will be supported by putting different authors' work in the context of proposed socio technical information behavior model.

Block I – Socio-cognitive information experience

Kuhtlau[192] also stresses the importance of cognitive and affective aspects in the user's information behavior. In her model representing user's sense making process of information seeking, she incorporated three dimensions of activities. They are: *physical, actual actions taken; affective, feelings experienced; and cognitive, thoughts concerning both process and content*. She also referenced to Wilson's[193] statement that interaction between the user and the information system may be influenced by affective and cognitive needs.

Affective aspects are, according to Kuhlthau[194], the main driving force of information use. Information system could shape the user information behavior including the shapes the users' emotional states without them being aware of such action.[195] Facebook experiment on their users provides evidence that emotional states can be transferred to others via emotional contagion, leading people to experience emotions without their awareness that those are being shaped by mechanics implemented in information system.[196]

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191 Ingwersen, P., 1996. Cognitive perspectives of information retrieval interaction: elements of a cognitive IR theory. Journal of documentation, 52(1), 3–50.

192 Kuhlthau, C. C., 1991. Inside the search process: Information seeking from the user's perspective. Journal of the American society for information science, 42(5), 361.

193 Wilson, T. D., 1981. On user studies and information needs. Journal of documentation, 37(1), 3–15.

194 Kuhlthau, C. C., 1991. Inside the search process: information seeking from the user's perspective. Journal of the American Society for Information Science, 42, 361–371.

195 Kashmir, H., Ex-Facebook Data Scientist: Every Facebook User Is Part Of An Experiment At Some Point, Forbes, 2014 (In 2014 such a research was published, based on Facebook users that raised ethical considerations. More insight into the case: http://www.forbes.com/sites/kashmirhill/2014/07/07/ex- facebook-data-scientist-every-facebook-user-is-part-of-an- experiment-at-some-point/, retrieved 3. 9. 2019.

196 Kramer, A. D., Guillory, J. E., Hancock, J. T., 2014. Experimental Evidence of Massive-scale Emotional Contagion Through Social Networks. In: Fiske, S. T. (ed.) Proceedings of the National Academy of Sciences, vol.

The concept of *Ultra Large Information systems* (ULS) is based on large number of interactions of users and data about those interactions could be collected and analyzed and behavior recognized.[197] As such, ULS are decentralized systems with adapting mechanisms implemented in them. People in such systems are not just users of the systems but the elements of it, and collective behavior is of the interest to the system designers. Collective behavior is a factor in how users use, view and accept such a system, whereas social interactions are functions of technology supporting their information needs and use. Those socio technical systems behave in dependence on the experience of the agents (human and/or artificial).

One of the two information behavior activating mechanisms presented in Wilson 2nd model of information behavior is stress and cope[198]. Stress is defined as appraisal of relationship between a person and the environment in terms of available resources and well-being.[199] Coping is defined as a person's ability to master, reduce or tolerate internal and external demands created by stressful situations he experiences.[200] Kleiber and his colleagues pointed that emotion-focused coping: [...] *involves cognitive activities that do not alter the relationship with the environment but do alter the way in which the person-environment relationship is perceived.* [201]

Wilson [202] noted that *need* is a subjective experience appearing in the mind of the person in need and it is not accessible by the observer. Bumkrant[203] defined need as *a cognitive representation of a future goal that is desired*. Morgan and King[204] connected needs and three kinds of motives:

111(24), pp. 8788–8790. Princeton University, Princeton http://www.pnas.org/content/111/24/8788.full.pdf.

197 Northrop, L., Feiler, P., Gabriel, R. P., Goodenough, J., Linger, R., Longstaff, T., Kazman, R., Klein, M., Schmidt, D., Sullivan, K. and Wallnau, K., 2006. Ultra-Large-Scale Systems: The Software Challenge of the Future. Pittsburgh, PA: Software Engineering Institute, Carnegie Mellon University.

198 Wilson, T. D., 1997. Information behaviour: an interdisciplinary perspective. Information processing & management, 33(4), 551–572.

199 Folkman, S., 1984. Personal control and stress and coping processes: a theoretical analysis. Journal of Personality and Social Psychology, 46, 839–852.

200 Folkman, S. & Lazarus, R. S., 1985. If it changes it must be a process: study of emotion and coping during three stages of a college examination. Journal of Personality and Social Psychology, 48, 150–170.

201 Kleiber, C., Montgomery, L. A. & Craft-Rosenberg, M., 1995. Information needs of the siblings of critically ill children. Children's health care, 24(1), 47–60.

202 Wilson, T. D., 1981. On user studies and information needs. Journal of documentation, 37(1), 3–15.

203 Burnkrant, R. E., 1976. A motivational model of information processing intensity. Journal of Consumer Research, 3(1), 21–30.

204 Morgan, C. T., & King, R. A., 1971. Introduction to psychology, 4th ed. New York: McGraw-Hill.

psychological, unlearned and social. This is aligned with Wilson's analysis[205] of needs defining them as cognitive, affective or physiological. Needs have cognitive component as recognized in the concept of the need for cognition.[206,207] Cohen and colleagues[208] described the need for cognition as *a need to structure relevant situations in meaningful, integrated ways. It is a need to understand and make reasonable the experiential world, need for cognition may be said to qualify as a need since it directs behavior toward a goal and causes tension when this goal is not attained.*[209] Accordingly, cognitive processes are those that process signals from the environment, trigger behavior and influence stress and cope of the user that seeks (or avoids) information and are related to the internal characteristics of the user. It is hard to observe the user's process happening in his mind, but we could observe his information seeking behavior and describe it with quantitative data, in particular through logs collected while user or users are interacting with the system.[210] Need for cognition has been incorporated into Epstein's dual-system theory of personality called cognitive-experiential self-theory (CEST).[211] CEST is a dual process of perception of the individual, analytical-rational and intuitive-experiential. The analytical-rational system is logical and slow, while intuitive-experiential is fast and emotionally driven. They operate in parallel and interact triggering behavior. [212] This concept could be used in the design of irrational algorithms in information systems. As humans behave rationally and irrationally, design of irrational artificial agents could be seen as one of the objectives of future research in artificial intelligence. That concept discussed here could support IS designers to design IS that are more realistic and correspond to the real nature of the reality.

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205 Wilson, T. D., 1981. On user studies and information needs. Journal of documentation, 37(1), 3–15.

206 Cacioppo, J. T. & Petty, R. E., 1982. The need for cognition. Journal of personality and social psychology, 42(1), 116.

207 Petty, R. E., Cacioppo, J. T., Kao, C. F. & Rodrigues, R., 1986. Central and peripheral routes to persuasion: An individual difference perspective. Journal of Personality and Social Psychology, 51(5), 1032–1043.

208 Cohen, A. R., Stotland, E. & Wolfe, D. M., 1955. An experimental investigation of need for cognition. Journal of Abnormal and Social Psychology, SI, 291–294.

209 Cohen, A. R., Stotland, E. & Wolfe, D. M., 1955. An experimental investigation of need for cognition. Journal of Abnormal and Social Psychology, SI, 291–294.

210 Lugović, S. & Dunđer, I., 2017, May. Automatic information behaviour recognition. In: Information and Communication Technology, Electronics and Microelectronics (MIPRO), 2017, 40th International Convention on (pp. 1217–1220). IEEE.

211 Petty, R. E., Briñol, P., Loersch, C. & McCaslin, M. J., 2009. The need for cognition. Handbook of individual differences in social behavior, 318–329.

212 Epstein, Seymour, 2003. In: Handbook of psychology: Personality and social psychology, Vol. 5. Millon, Theodore (Ed.); Lerner, Melvin J. (Ed.); Hoboken, NJ, US: John Wiley & Sons Inc, pp. 159–184. [Chapter].

Wilson[213] defined user world as *the totality of experiences centered upon the individual as an information user*. He also pointed to the importance of various *reference groups* user could identify (i.e., professional community, peer group). Except cognitive aspects of information need as a trigger of information behavior, there are also social aspects and user experiences involved. An example of phenomenological research studying information need could be found in Omiunu [214]. Omiunu defined information need and seeking behavior as *daily experience individuals undergo especially to fulfilling certain task*. Based on how research participants reported experiences, how information needs are recognized and discovered, Omiunu reported that *information needs process is an unprogrammed, unconscious, unsystematic and unscientific search behavior discovery of a gap or of ignorance*.
Kuhlthau [215],[216] associated feelings, thoughts and actions with the information search process and information search as a part of the wider scope of information behavior.

As feelings and thoughts come before action, we could understand them as a trigger of information seeking behavior and they could be explained in terms of socio-cognitive experience a user has. According to Wilson [217], feelings of uncertainty related to information need influence a user's feeling of doubt, confusion and frustration. Result (or output) of information seeking and searching activities will change those state of the user resulting in the change of his socio-cognitive experience. In order to design better information systems, we have to design algorithms that will be able to recognize the user's feelings of doubt (e.g., recognize when the user is not sure in the output of the information system), confusion (e.g., the user does not know what he is looking for) and frustration (e.g., the user does a lot of queries and hits the keyboard aggressively).

Dervin[218] defines her sense making as behavior, both internal (i.e., cognitive) and external (i.e.,

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213 Wilson, T. D., 1981. On user studies and information needs. Journal of documentation, 37(1), 3–15.

214 Omiunu, O. G., 2014. Conceptualizing information need: A phenomenological study. Journal of Library and Information Sciences, 2(2), 29–54.

215 Kuhlthau, C. C., 1991. Inside the search process: information seeking from the user's perspective. Journal of the American Society for Information Science, 42, 361–371.

216 Kuhlthau, C. C., 1994. Seeking meaning: a process approach to library and information services., Norwood, NJ, Ablex Publishing.

217 Wilson, T. D., 1999. Models in information behaviour research. Journal of documentation, 55(3), 249–270.

218 Dervin, B., 1983. An overview of sense-making research: Concepts, methods and results. Paper presented at the annual meeting of the International Communication Association, Dallas, TX, May.

procedural) which allows the individual to construct and design his/her movement through time-space. She also assumes that all information is subjective**.** Sense making approach has also focused on how individuals use the observations of others as well as their own observations to construct their pictures of reality and use those pictures to guide behavior. Such understanding opens up a new perspective in the design of information system as it includes the user and his subjective interpretation of received information in the design of the information system. And this subjectivism is not related only to the information system as a source of information, but also to the social environment in which the user operates in particular moments. So a different social environment could result in different subjective interpretations of the information provided by information system.

Dervin's Sense Making [219] research approach include two or more aspects of the following:

- ***SITUATIONS:*** *The time-space contexts at which sense is constructed.*
- ***GAPS:*** *The gaps seen as needing bridging, translated in most studies as "information needs" or the questions people have as to construct sense and move through time-space.*
- ***SITUATIONS*** *are included because it is posited that sense-making is situational.* ***GAPS*** *are included because they are assumed to be what sense-making is all about.*

Ingwersen[220] proposen a theory that views information retrieval (IR) interactions as a cognitive process happening in all information processing activities and it could be applied to the user in a situational context. Ingwersen[221] associated his views with socio-hermeneutic approaches to information transfer and knowledge communication, separating it from the cognitive and rationalist traditions. In his statement that *individual cognitive space and, in particular, the current cognitive/emotional structures and states are determined by the experiences gained through time in a social and historical context* we could find support that a user has socio-cognitive experience and such experience triggers information seeking behavior. That is aligned with the Cole's definition of information need, stating that signal from environment triggers the information processing of the user, making it interactive process of the user and his

[219] Dervin, B., 1983. An overview of sense-making research: Concepts, methods and results. Paper presented at the annual meeting of the International Communication Association, Dallas, TX, May.
[220] Ingwersen, P., 1996. Cognitive perspectives of information retrieval interaction: elements of a cognitive IR theory. Journal of documentation, 52(1), 3–50.
[221]Ingwersen, P., 1992. Information retrieval interaction (Vol. 246). London: Taylor Graham.

environment[222]. At the same time, information seeking behavior could change the information socio-cognitive experience of the user. Or how Ingwersen[223] stated that the receiver of the communicated signs, at the place of a cognitive/emotional level, changes his states in terms of knowledge and cognition. So, we evidence feedback loop from information seeking behavior to the socio-cognitive experience of the user. Ingwersen[224] also positions concept of the information from the cognitive perspective, stating that *on the one hand information being the result of a transformation of a generator's knowledge structures (by intentionality, model of recipients' states of knowledge, and in the form of signs); and on the other hand, being something which, when perceived, affects and transforms the recipient's state of knowledge*. He is even going further posting the question *whether or not we should regard the notion of the information need as an outdated construct that should be replaced by the notion of a dynamic cognitive state?* (Harter,[225]). But this is *inconsistent with most problem solving and information seeking theory and empirical results*,[226],[227] *since it implies that in all circumstances all the searcher's cognitive structures are simultaneously dynamic and variable.*[228]

His cognitive theory proposes that *we should explore the phenomena related to, and the development of, the cognitive structures supplementing the internal information need on the user side of the interaction process.*[229]

By doing so, we could separate and thus observe a user's cognitive structures, information need and interaction process as causal variables. A new cognitive structure could result in a new information need developing new information seeking and searching activities. It is possible to propose that new cognitive states will also change social ties of the user and a way how he experiences signs and signals or his information experience.

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222 Cole, C., 2012. Information need: A theory connecting information search to knowledge formation. American Society for Information Science and Technology by Information Today, Incorporated.

223 Ingwersen, P., 1996. Cognitive perspectives of information retrieval interaction: elements of a cognitive IR theory. Journal of documentation, 52(1), 3–50.

224 Ingwersen, P., 1992. Information retrieval interaction (Vol. 246). London: Taylor Graham.

225 Harter, S. P., 1992. Psychological relevance and information science. Journal of the American Society for information Science, 43(9), pp. 602–615.

226 Kuhlthau, C. C., 1993. A principle of uncertainty for information seeking. Journal of documentation.

227 Belkin, N. J. and Vickery, A., 1985.Interaction in information systems. British Library, London (LIR Report 35).

228 Ingwersen, P., 1996. Cognitive perspectives of information retrieval interaction: elements of a cognitive IR theory. Journal of documentation, 52(1), 3–50.

229 Ingwersen, P., 1996. Cognitive perspectives of information retrieval interaction: elements of a cognitive IR theory. Journal of documentation, 52(1), 3–50.

Bates[230] defines information behavior as a term assumed *cover all instances where people interact with their environment in any such way that leaves some impression on them – that is, adds or changes their knowledge store*. In this definition we could put a user as a starting point of the observation. Such a user will, at the same time, interact with the signs and signals existing in the environment (including his social ties), changing his internal cognitive states and experience. Such interactions and changes of states will trigger his information seeking behavior.

Ellis[231] described eight different behaviors related to the process of the information seeking, and they are elaborated in Table 12 and Figure 16.

Table 12 – Ellis's Features of Information Seeking process

Starting:	*the means employed by the user to begin seeking information, for example, asking some knowledgeable colleague*
Chaining	*following footnotes and citations in known material or 'forward' chaining from known items through citation indexes*
Browsing	*semi-directed or semi-structured searching*
Differentiating	*using known differences in information sources as a way of filtering the amount of information obtained*
Monitoring	*keeping up-to-date or current awareness searching*
Extracting	*selectively identifying relevant material in an information source*
Verifying	*checking the accuracy of information*
Ending	*which may be defined as 'tying up loose ends' through a final search.*

[230] Bates, M. J., 2010. Information behavior. Encyclopedia of library and information sciences, 3, 2381–2391.

[231] Ellis, D., 1989. A behavioural approach to information retrieval system design. Journal of documentation, 45(3), 171–212.

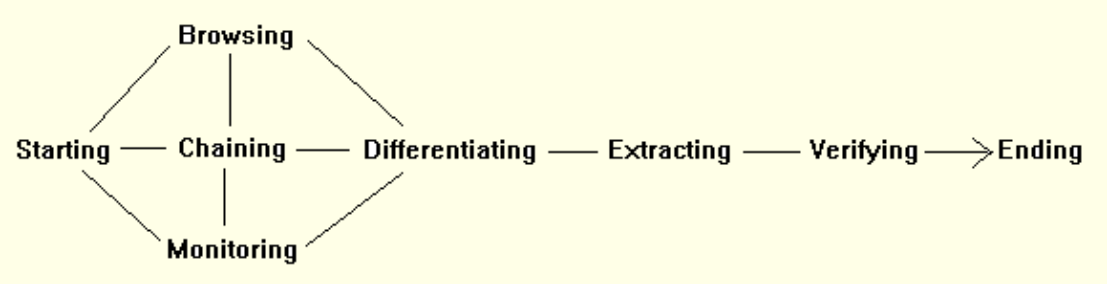

Figure 16 – A process model based on Ellis's 'characteristics'

Important contribution from Ellis's work is that patterns of information seeking are presented as basic behavioral characteristics and as such, could be used in design of information systems (reflecting those characteristics). This is aligned with concept of trails proposed by Bush[232] which states that it is possible to beat the mind in terms of speed and flexibility to follow the trail to find information regarding the information system that has data structured and has better performance and clarity to serve data to users. When a person has a complex task at hand it includes numerous sources of information, information system that is designed in a way to replicate trails. By doing so, there is no necessity for humans to replicate that information seeking and searching trails repeatedly and lose time and resources to do it. If an information system could recognize a user socio-cognitive information experience it could adopt, serve the information needed by the user in a more effective way.

In the Starting phase, according to Ellis[233], a researcher finds a key paper or key author in the area where he was unfamiliar with and starts initial search for information. He also points out that users rely on contacts from the colleagues with whom they are working in the area of interest to bring news and information. The more the user becomes involved with the domain of the interests, the more his social ties become important to his information seeking activities. Also, colleagues are important in the process of recommendation of important information sources. One can see clearly that user's cognitive capacities and social ties are important, but also her/his

[232] Bush, V., 1945. As we may think. The Atlantic monthly, 176(1), 101–108.

[233] Ellis, D., 1989. A behavioural approach to information retrieval system design. Journal of documentation, 45(3), 171–212.

experience in the domain (or area) will influence information seeking activities.

Savolainen[234] used the theory of habitus developed by Pierre Bourdieu[235] as a background for conceptualization of his "Everyday life information seeking" (ELIS), in which he proposes that information seeking is a natural component of everyday life. Habitus is a system of thinking, perception and evaluation that is internalized by the individual, determined socially and culturally. Savolainen put it: *habitus is a relatively stable system of dispositions by which individuals integrate their experiences and evaluate the importance of different choices*. It has dual character; it is *as a generative principle of objectively classifiable judgements* and it is *a system of classification of these practices. In this dual role habitus manifests the incorporation of norms and social expectations within an individual…* and […] *renders a general direction to choices made in everyday life by indicating which choices are natural or desirable in relation to one's social class or cultural group*. Based on these assumptions, Savolainen[236] proposes the concept of a „way of life" that refers to „order of things", based on the choice the individual makes in everyday life:

- ***"Things"*** *stand for various activities taking place in the daily life world, including not only job but also necessary reproductive tasks such as household care and voluntary activities (hobbies).*
- ***"Order"*** *refers to preferences given to these activities. Order of things is determined on both objective and subjective grounds.*
- *As order of things is not reproduced automatically, individuals are taking active care of it, and this activity is called* ***"Mastery of life"*** *that could be active or passive.*
- ***Passive mastery of life*** *is when people are satisfied with seeing that everything goes on as expected, at least on the whole.*
- ***Active mastery of life*** *is associated with pragmatic problem solving in cases where the order of things has been shaken or threatened*.

234 Savolainen, R., 1995. Everyday life information seeking: Approaching information seeking in the context of „way of life". Library & information science research, 17(3), 259–294.

235 Bourdieu, Pierre, 1984. Distinction. A social critique of the judgement of taste. London: Routledge.

236 Savolainen, R.,1995. Everyday life information seeking: Approaching information seeking in the context of „way of life". Library & information science research, 17(3), 259–294.

Understanding differences between those two „modes" (passive and active) of the user using the information system to satisfy his information need could help in the process of designing adaptive functionalities of information systems. The challenge is in how to recognize when the user is in passive or active „mode", as in passive mode he is not acting upon the environment and in active, he does. If it is possible for an information system to distinguish between those two modes, then it could restructure data and present them in a way supporting a particular mode. For example, if an information system could recognize that user needs to act (active mastery of life), then it could send notifications and information objects that are relevant to the user information need (for example, measuring heartbeat rate, the system could tell the users that they are not in the good physical shape and recommend them few links on the YouTube with exercises he could do).

Furthermore, what is important are the experiences that users have as a result of actions taken to solve the problem they are exposed to by satisfying his information need.[237] The feedback from their actions will shape his new actions, and this feedback will be evaluated through the prism of user's experience. As Savolainen[238] put it: *Important factors molding mastery of life are the ways by which individuals orient themselves in (typical) problem situations and seek information to facilitate problem solving*.

This could be analyzed using four types of mastery of life, presented in the center of Figure 17.

[237] Savolainen, R.,1995. Everyday life information seeking: Approaching information seeking in the context of „way of life". Library & information science research, 17(3), 259–294.

[238] Savolainen, R., 1995. Everyday life information seeking: Approaching information seeking in the context of „way of life". Library & information science research, 17(3), 259–294.

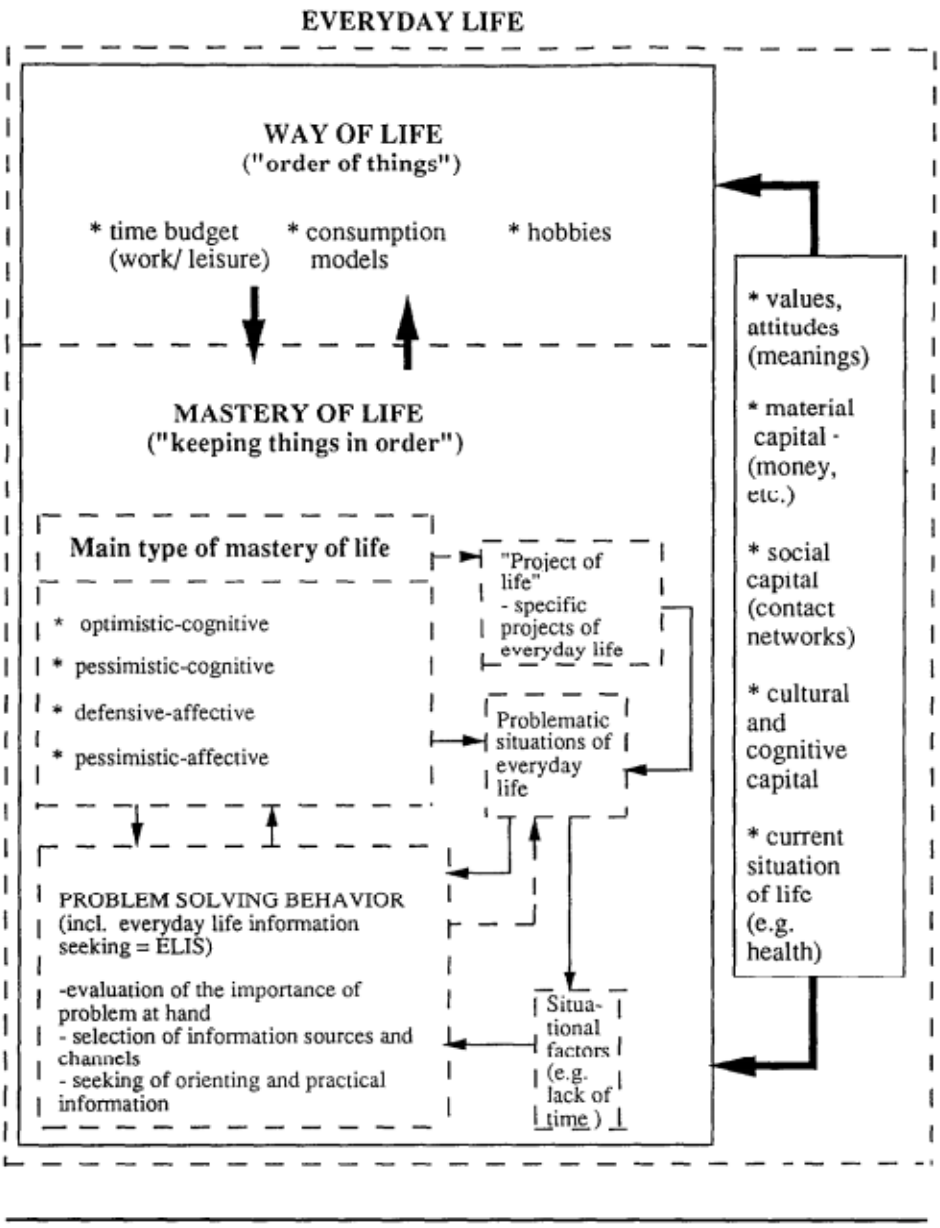

Figure 17 – Basic Components of the Study of ELIS in the Context of Way of life

They could be analyzed as two dimensions that describe qualities of the problem solving behavior. They are:

- **Cognitive versus affective**, degree of rational considerations in a problem-solving situation. *A cognitive orientation emphasizes an analytic and systematic approach to problems whereas the affective orientation refers to its exact opposite: an emotionally*

laden and rather unpredictable reaction to issues at hand.

- **Optimism versus pessimism**, it *describes the expectancy towards the solvability of the problem. This dimension occurs in four classes: unreserved optimism (no setbacks expected in problem solving), reserved optimism (some setbacks anticipated), reserved pessimism (failures anticipated), and unreserved pessimism (failures seen as unavoidable).*

Savolainen's[239] central assumption is that the relatively established style of mastery of life affects the ways by which people approach everyday life problems and seek practical information to facilitate their solving.

Järvelin, K. & Ingwersen[240] proposed a general analytical model of information seeking and retrieval presented in Figure 18.

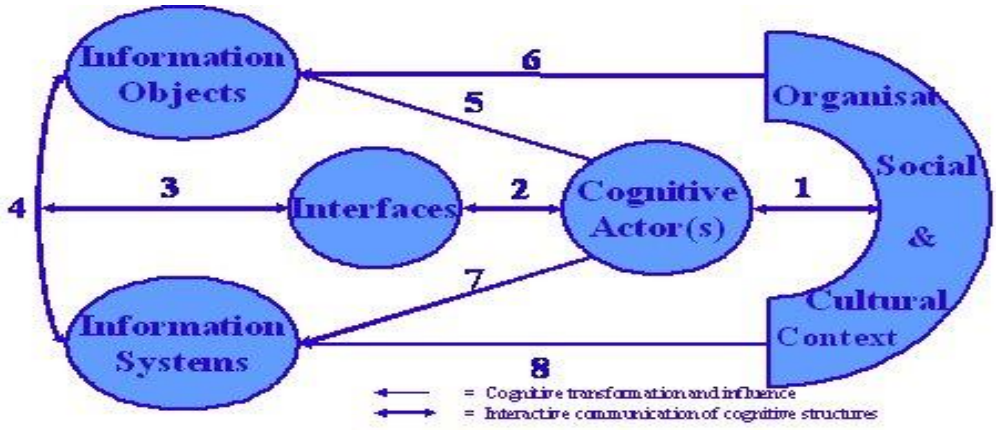

Figure 18 – A general analytical model of information seeking and retrieval (Ingwersen and Järvelin,[241])

239 Savolainen, R., 1995. Everyday life information seeking: Approaching information seeking in the context of „way of life". *Library & information science research*, *17*(3), 259–294.

240 Järvelin, K. & Ingwersen, P., 2004. Information Seeking Research Needs Extension towards Tasks and Technology. Information Research: an international electronic journal, 10(1).

241 Ingwersen, P. & Järvelin, K. (forthcoming). The turn: integration of information seeking and retrieval in context. Berlin: Springer/Kluwer. (recited from Järvelin, K. & Ingwersen, P., 2004. Information Seeking Research Needs Extension towards Tasks and Technology. Information Research: an international electronic journal, 10(1).

This model puts cognitive actors (the users that seek, are about to seek or avoid information) in the correlation with different contexts. They are information objects, information systems, interfaces, social, cultural and organizational affiliations. All these different contexts are interrelated.

Today's real life information seeking is mostly technology driven as a result of introducing more and more communications channels (formal and informal) that are combined into one system as a result of their digitalization. Also, cognitive actors usually operate in a dual context, one related to the information system and the another related to the socio-cultural-organizational. Those two concepts are interrelated and influence each other. Ingwersen and Järvelin propose nine broad dimensions that are involved with information behavior (seeking and retrieval included) and they could be observed. They are already briefly presented in Table 19 above together with Saracevic[242] five relevance frameworks supporting the author's proposed analytical matrix. Those nine dimensions are all related to the context of the actor (user) engaged in the information seeking activities. Actor's dimensions are related to the user's knowledge and skills among personal traits such as motivation and emotions (affective). At the same time, socio-cultural-organizational factors also impact the users's information behavior.

Based on the above presented literature review, it is possible to assume that recognizing user socio-cognitive information experience is something that will influence his information behavior and will trigger information seeking. As information systems are used in the information seeking and searching processes, to better design them, it is important to understand a concept that explains user socio-cognitive information experiences. At the same time, it is important to understand how those systems are designed and how such a design influences user socio-cognitive information experience.

Block 2 – Information seeking

According to Wilson[243], users are in contact with the information system(s) consisting of two

[242] Saracevic, T., 1996, Relevance Reconsidered. In: Ingwersen, P., Pors, N. O. (eds.) Proceedings of the Second Conference on Conceptions of Library and Information Science (CoLIS 2), pp. 201–218. Copenhagen.

[243] Wilson, T. D., 1981. On user studies and information needs. Journal of documentation, 37(1), 3–15.

subsystems, one called mediator (generally a living system such as a human being) and the other technology (*combination of techniques, tools and machines constitute the information-searching subsystem*). They are presented in Figure 19. Arrows in the diagram show different possible search paths available to the user (directly or indirectly) to access information sources. This diagram explains differences between information seeking and information searching as a user has different scenarios to search for information. Wilson also pointed to the difference between applied and basic research in the domain of information behavior. Applied research motive is to investigate information system design and development. Basic research is focused on why an information seeker behaves as he/she does.

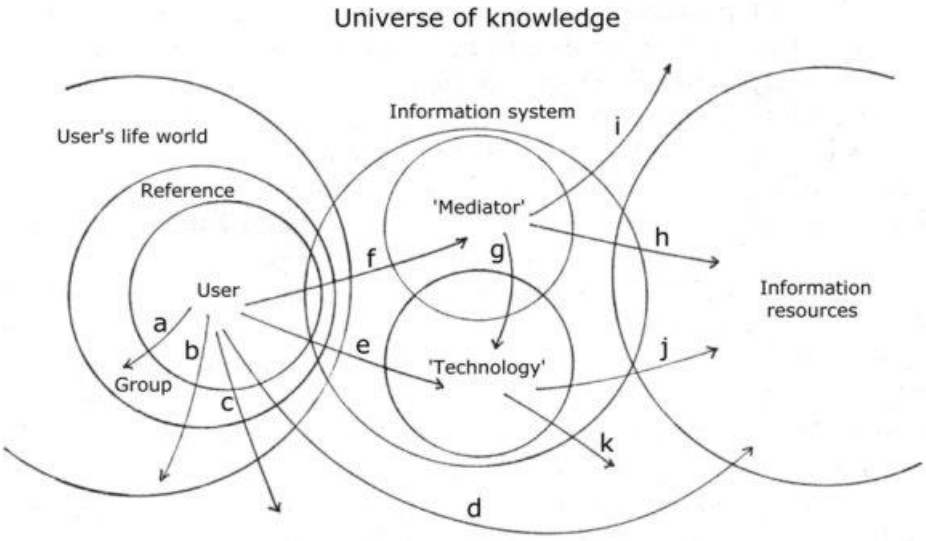

Figure 19 – The context of information seeking[244]

Once the need for information is recognized as a result of information socio-cognitive experience of the agent, engagement in information seeking activities starts. According to Wilson[245], there are potential barriers that influence information seeking activities. They are: personal barriers, social or role-related barriers and environmental barriers. Those barriers will be influenced by different characteristics of the user variables. They are:

[244] Wilson, T. D., 1981. On user studies and information needs. Journal of documentation, 37(1), 3–15.

[245] Wilson, T. D., 1997. Information behaviour: an interdisciplinary perspective. Information processing & management, 33(4), 551–572.

- personal characteristics
- emotional variables
- educational variables
- demographic variables
- social/interpersonal variables
- environmental variables
- economic variables
- source characteristics.

Another important aspect influencing seeking will be *Cognitive dissonance (conflicting cognitions make people uncomfortable and, consequently, they seek to resolve the conflict in one way or another*,[246] as it influences behavior. Users could seek information to support the existing knowledge, values and beliefs or to find a cause to change them. Another aspect is selective exposure explaining that user could tend to expose to the ideas that are in accordance with his interests, needs or the existing attitude and this could be done consciously or unconsciously. [247] At the same time, users in the similar manner could tend to avoid sources of information that are in conflict with his interests needs and attitude.[248] Currently, there is evidence of situations where information systems and recommendation algorithms implemented with them are actually doing those tasks for the user or the group of the user, as their function is to select what is important to the user and what is not. As one could see, clear relationship and feedback from the socio-cognitive experience of the user and the information seeking activities is of high priority to study how those information systems behave. Recently published framework that calls for the research of the mechanism how machines (or information systems) generate behavior, how they develop their behavior, what is the function of such information systems and how they evolve.[249]Figure 20 presents such a framework.

[246] Festinger, L., 1962. A theory of cognitive dissonance (Vol. 2). Stanford university press.

[247] Wilson, T. D., 1997. Information behaviour: an interdisciplinary perspective. Information processing & management, 33(4), 551–572.

[248] Wilson, T. D., 1997. Information behaviour: an interdisciplinary perspective. Information processing & management, 33(4), 551–572.

[249] Rahwan, I., Cebrian, M., Obradovich, N., Bongard, J., Bonnefon, J.F., Breazeal, C., Crandall, J. W., Christakis, N. A., Couzin, I. D., Jackson, M. O. and Jennings, N. R., 2019. Machine behaviour. Nature, 568(7753), p. 477.

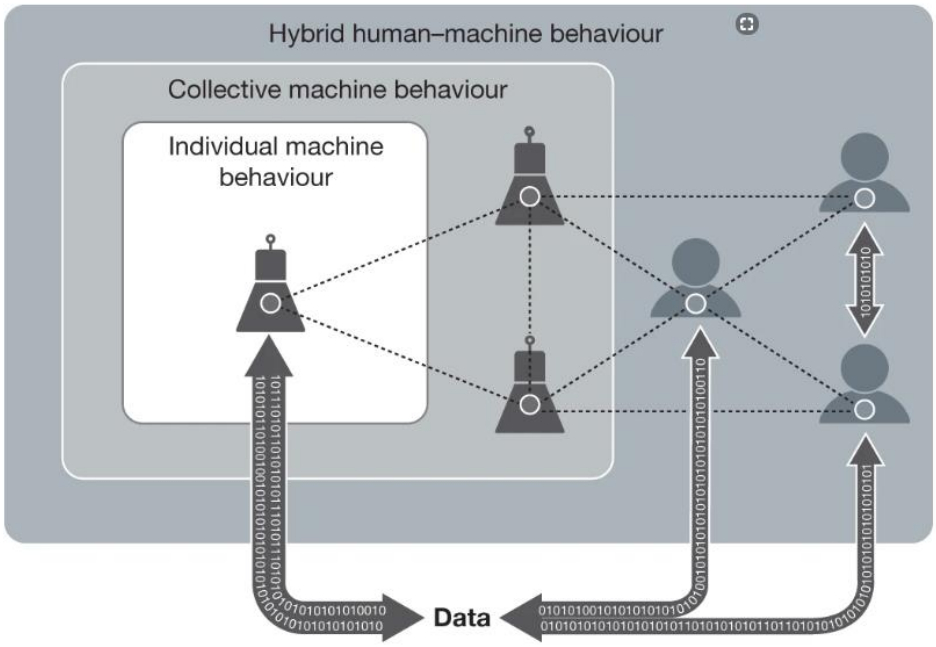

Figure 20 – Machine behavior ecosystem[250]

As mentioned before, Dervin[251] proposed that information seeking and use are constructing activities by which a user creates the sense. Such a proposition gives partially the answer to the basic research direction Wilson proposed (explaining why the user seeking and searching information behaves as he/she does – to make sense). Application of her techniques could lead to a proper understanding of the process of sense making and its wider context. Bates[252] underlined that *information seeking is often quite unself-conscious. People are trying to solve problems in their lives, not „seek information"*. Activities related to the information seeking are sparsely differentiated from other activities taken to solve problems. Such acclaim supports differentiation between information seeking and searching as when a user performs a search, it is conscious activity (such as performing search using Google), while seeking could be unconscious.

250 Rahwan, I., Cebrian, M., Obradovich, N., Bongard, J., Bonnefon, J. F., Breazeal, C., Crandall, J. W., Christakis, N. A., Couzin, I. D., Jackson, M. O. and Jennings, N. R., 2019. Machine behaviour. Nature, 568(7753), p. 477.
251 Dervin, B., 1983. An overview of sense-making research: Concepts, methods and results. Paper presented at the annual meeting of the International Communication Association, Dallas, TX, May.
252 Bates, M. J., 2010. Information behavior. Encyclopedia of library and information sciences, 3, 2381–2391.

According to Ellis[253], information seeking pattern displays the following significant characteristics of information seeking:

- **Monitoring**: maintaining awareness of developments in an area through regularly following particular sources.
- **Differentiating**: employing differences in the nature of the source materials to filter material.

Monitoring and differentiating are two characteristics that define activities that are related to the different sources of the information and are performed over a longer period of time and involve different information retrieval interfaces. For example, a user could monitor different journals or social media to be in sync with the domain he is interested in. Kuhlthau[254] described search process stages. She defines information seeking in the context of Dervin[255], as a sense making process in which a person is forming a personal point of view. She defines Information search process (ISP) as the *user's constructive activity of finding meaning from information in order to extend his or her state of knowledge on a particular problem or topic.*[256] Differentiating seeking and search aspects of information behavior she referenced to the Belkin & Vickery[257], and Borgman[258], pointing to the shift of the emphasis in human computer interaction research in IS from documents and text representation to the users information seeking situations and associated search techniques. To cite her precisely *associated search techniques to the study of users in information seeking situations.* Distinction between search and seeking is clear, as search is a set of techniques applied in information seeking situations.

253 Ellis, D., 1989. A behavioural approach to information retrieval system design. Journal of documentation, 45(3), 171–212.

254 Kuhlthau, C. C., 1991. Inside the search process: information seeking from the user's perspective. Journal of the American Society for Information Science, 42, 361–371.

255 Dervin, B., 1983. An Overview of Sense-Making Research: Concepts. Methods, and Results to Date [on-line] Disponível na Internet na URL http://edfu. lis. uiuc. edu/allerton/96/w1/Dervin83a. html.

256 Kuhlthau, C. C., 1991. Inside the search process: information seeking from the user's perspective. Journal of the American Society for Information Science,. 42, 361–371.

257 Belkin, N. J. & Vickery, A., 1985. Interaction in information systems: A review of research from document retrieval to knowledge-based systems.

258 Borgman, C. L., 1984. Psychological research in human – computer interaction. Annual review of information science and technology, 19, 33–64.

Table 13 – Information seeking process

Stages in ISP	Feelings Common to Each Stage	Thoughts Common to Each Stage	Actions Common to Each Stage	Appropriate Task According to Kuhithau Model
1. Initiation	Uncertainty	General/ Vague	Seeking Background Information	Recognize
2. Selection	Optimism			Identify
3. Exploration	Confusion/ Frustration/ Doubt		Seeking Relevant Information	Investigate
4. Formulation	Clarity	Narrowed/ Clearer		Formulate
5. Collection	Sense of Direction / Confidence	Increased Interest	Seeking Relevant or Focused Information	Gather
6. Presentation	Relief / Satisfaction or Disappointment	Clearer or Focused		Complete

According to her, in the phase of selection the user makes decisions which topic to investigate and how to do that. In summary, the seeking is a set of activities related to finding information that user needs which are influenced by socio-cognitive information experience and include different search techniques. Those search techniques activities are based on the previous experience and associated feelings, thoughts, actions and tasks.

Savolainen[259] pointed in the similar direction saying that in researching everyday life information search (ELIS) the focus could be shifted into two directions:

- *the seeking of orienting information concerning current events*
- *the seeking of practical information which serves as the solution to specific problems.*

Users could seek to orientate their search activities. Both of those activities are related to their socio-cognitive information experience (SCIE) and those activities will influence back their SCIE. Järvelin & Ingwersen[260] pointed to the limitations of information seeking research as those studies provide *only a limited number of empirical answers to research questions that relate characteristics of contexts and situations to characteristics of tasks, actors, information, seeking processes, sources, systems and use of information.* They also point to the problems related to the applications of those findings into information system design. Also, there is an imbalance between understanding *of task requirements and its effects on information seeking* and *the understanding of how to derive and apply design criteria for information (retrieval) systems.* According to them, there is a shortage of studies that relate information retrieval systems features to the features of task/and information seeking process. As a response to this shortage, they argue that it is necessary to extend information seeking research toward task/information seeking and technology. The question they propose as an important *one is: how well current information retrieval systems serve their users in various situations?*

Those arguments are aligned with the proposition of the analytical matrix presented in this chapter. By extending observation lens from information seeking, search and retrieval to the process of information recommendation we could:

- develop interests into their **relationships** (including quantitative explanations of their relationship)
- develop experiments and hypothesis that could be used in the **intervention** (with the aim to test casualties of interest), and based on findings
- develop **instruments** that could be applied in real life cases.

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259 Savolainen, R., 1995. Everyday life information seeking: Approaching information seeking in the context of „way of life". Library & information science research, 17(3), 259–294.

260 Järvelin, K. & Ingwersen, P., 2004. Information Seeking Research Needs Extension towards Tasks and Technology. Information Research: an international electronic journal, 10(1).

In this manner, it is possible to overcome the gaps between behavioral and design science and information and computer science. Such approach could support basic research and/or development of the information systems that are:[261]

- more aligned with **cognitive** capacity of the agents that interact with them (agents could be machine and another IS, or human)
- support better **communications** based on the cognitive processing of the agent,
- resulting in better **co-operations** of the agents involved.

By doing so, it is possible to design information systems that better respond to the challenges coming from the environment. Challenges in this sense could be understood as signals that should be processed with the aim to act and respond to new situations in which we need information. Järvelin and Ingwersen[262] propose three areas of interest extracted from information seeking research that motivate and benefit from information system design. They are as follows:

- *theoretically understanding information seeking in the form of models and theories*
- *empirically describing information seeking in various contexts, and*
- *providing support to the design of information systems and information management*[263]

Authors pointed that pragmatic goal of information seeking research is to support information systems design and information management.

To do so, they offer information seeking and retrieval design and evaluation framework presented in Figure 21. This framework provides a pragmatic goal in practical and utility driven design science in information system research but also in a behavioral (where goal is truth) research[264] *by replacing design and evaluation of information systems to the analysis of social and organizational practices.*

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261 Omazic, M. A., Lugovic, S., 2016. Trust as a layer in semantic web and fundament for development of sociocognitive paradigm in higher education information systems, Chapter 13 in Wankel, C. & Stachowicz-Stanusch, A. (Eds.), 2015. Emerging Web 3.0/semantic Web applications in higher education: growing personalization and wider interconnections in learning. IAP.

262 Järvelin, K. & Ingwersen, P., 2004. Information Seeking Research Needs Extension towards Tasks and Technology. Information Research: an international electronic journal, 10(1).

263 Järvelin, K. & Ingwersen, P., 2004. Information Seeking Research Needs Extension towards Tasks and Technology. Information Research: an international electronic journal, 10(1).

264 Hevner, A. R., March, S. T., Park, J. & Ram, S., 2008. Design Science in Information Systems Research. Management Information Systems Quarterly, 28(1), 6.

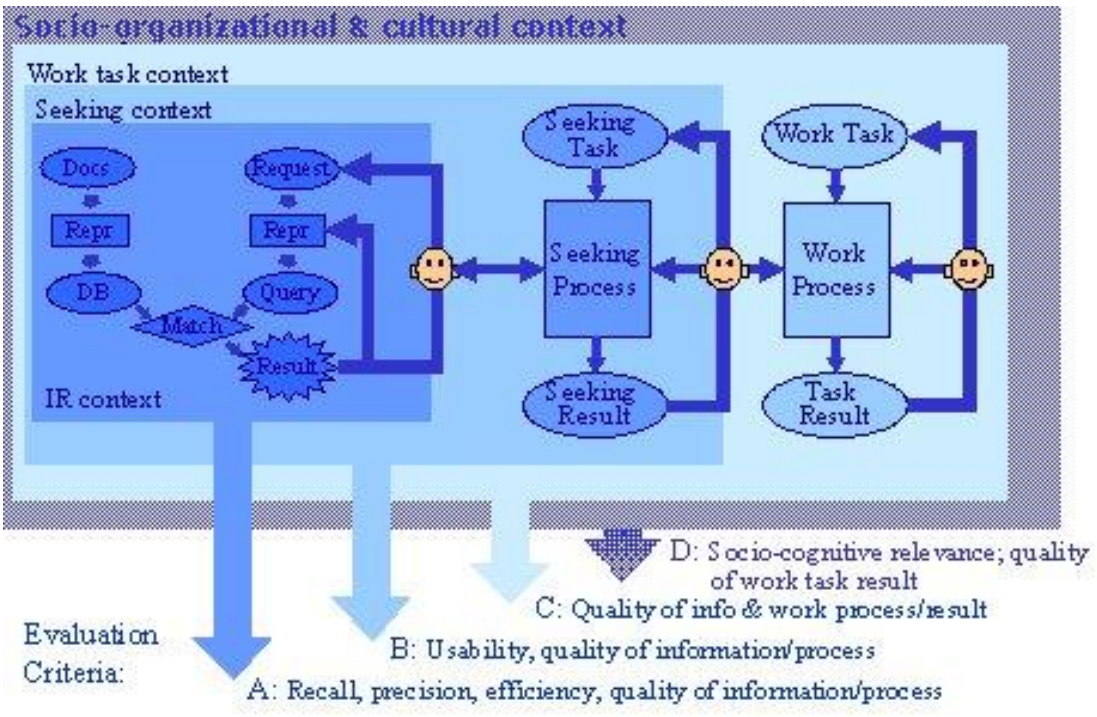

Figure 21 – Information seeking and retrieval design and evaluation frameworks[265]

This framework follows pragmatic goal and approach information seeking and information retrieval system design as integrated contexts of retrieval, seeking, work tasks and interests. Philosophically from the pragmatist point of view perspective truth as justified theory and utility as effective artifacts are two sides of the same coin. [266]

This way strong correlations can be evidenced between the information seeking and information retrieval and information search. But, as most of the above mentioned authors agree, they are a separate set of activities with separated scientific research inquiries. Th interaction between them is a bi-directional process, and the better information system is, the better function of adaptions of each will be. If the information system could recognize patterns of information seeking, then it could adopt its information retrieval functions, but at the same time if the user knows information

265 Järvelin, K. & Ingwersen, P., 2004. Information Seeking Research Needs Extension towards Tasks and Technology. Information Research: an international electronic journal, 10(1).

266 Aboulafia, M. (Ed.), 1991. Philosophy, social theory, and the thought of George Herbert Mead. SUNY Press.

retrieval interfaces that he uses to retrieve information, then the process of information seeking will be more successful. Similar explanation could be made if there are machine-to-machine communications, usually done by using API (Application Programming Interface). To take an illustrative example, if a software agent seeks for information, the better the information retrieval interface is, the smoother and faster the process will take place

Block 3 – Information search and retrieval

By investigating information search process, we could find about information needs of the user and other facts related to the design, development and adaptation of information systems Wilson[267]. Wilson[268] defined ***Information Searching Behavior*** as *the 'micro-level' of behavior employed by the searcher in interacting with information systems of all kinds. It consists of all the interactions with the system, whether at the level of human computer interaction (for example, use of the mouse and clicks on links) or at the intellectual level (for example, adopting a Boolean search strategy or determining the criteria for deciding which of two books selected from adjacent places on a library shelf is most useful), which will also involve mental acts, such as judging the relevance of data or information retrieved.* This definition could be expanded towards machine-to-machine interaction, as in today's information systems some operations and processes related to the data collection and knowledge discovery are implemented without human involvement. This is a particular case in the development of the automated Internet bots[269] as they perform interactions with various other information systems with the aim to find and retrieve data to fulfill determined functions written in algorithms. This could be understood as fundamentals of semantic web.[270] This proposal is aligned with the framework proposed by Järvelin and

[267] Wilson, T. D., 1981. On user studies and information needs. Journal of documentation, 37(1), 3–15.

[268] Wilson, T. D., 2000. Human information behavior. Informing science, 3(2), 49–56.

[269] An Internet bot, also known as web robot, WWW robot or simply bot, is a software application that runs automated tasks (scripts) over the Internet – from https://en.wikipedia.org/wiki/Internet_bot, retrieved 27. 9. 2017.

[270] Omazic, M. A., Lugovic, S., 2016. Trust as a layer in semantic web and fundament for development of sociocognitive paradigm in higher education information systems, Chapter 13 in Wankel, C. & Stachowicz-Stanusch, A. (Eds.), 2015. Emerging Web 3.0/semantic Web applications in higher education: growing personalization and wider interconnections in learning. IAP.

Ingwersen[271], as they call for integrated contexts of retrieval, seeking, work tasks and interests. When it comes to desinging an algorith that retrieves data, records, documents or information, there has to be and understanding why its done (what task or interests should be addressed) but also who will use this retrieved data, records, documents or information (how this fits into the information seeking process).

To be able to design better information systems requires a proper understnading of information retrieval premises or subdivisions. They are: [272]

- **content analysis** *(describing the contents of documents in a form suitable for computer processing)*
- **information structures** *(exploiting relationships between documents to improve the efficiency and effectiveness of retrieval strategies)*
- **evaluation** (measurement of the effectiveness of retrieval).

Wilson[273] offered different concepts related to the information searching and by implementing them into the analysis of information system and/or related basic research we could develop better inquiries. They are as follows:

Sources of information

- **Channel of communication** – relationship between channel through which information is accessed and retrieved and the source of information.
- **Access** – to perform any search requires access to the information and the level of the accessibility will have and impact on information behavior overall.
- **Credibility** – perception of the user and/or algorithmic trust of the source of information will influence information behavior in overall.

Searching and acquisition

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271 Järvelin, K. & Ingwersen, P., 2004. Information Seeking Research Needs Extension towards Tasks and Technology. Information Research: an international electronic journal, 10(1).

272 C. J. Van Rijsbergen, 1979. Information Retrieval 2nd edition, Butterworth-Heinemann Newton, MA, USA, page 5.

273 Wilson, T. D., 1997. Information behaviour: an interdisciplinary perspective. Information processing & management, 33(4), 551–572.

- **Passive attention:** *information acquisition may take place without intentional seeking*
- **Passive search:** *signifies those occasions when one type of search (or other behavior) results in the acquisition of information that happens to be relevant to the individual*
- **Active search:** *where an individual actively seeks out information*
- **Ongoing search:** *where active searching has already established the basic framework of knowledge, ideas, beliefs or values, but where occasional continuing search is carried out to update or expand one's framework.*

All the above concepts will, at the same time, influence information behavior of the user (or machine) and performance of the open system consisting of user and information system, machine and machine, and user and user.

Based on Norman's[274] four stages of interaction between person and machine (intention, selection, execution and evaluation) and Simon's[275] four stages of decision making related information acquisition (*intelligence, design, choice, review*), Wilson proposed a set of stages that could be applied to information behavior in overall, but could also be applied to micro level, or information searching behavior.

Wilson's stages could be extended by adding an execution stage. Those stages are presented in Table 14 along with some practical explanation in the case of DJing as an illustration of the wider context of music-related information behavior. Case of DJing is used as DJ's search and retrieve information through their performance, as they have to select one track after another based on the atmosphere in the club. It also shows how interaction between user and machine is happening in the open system, one in which inputs from the environment impact the sequence of information search (and/or seek).

Table 14 – Stages in information seek (macro) and search (micro) process

		Context of information search and retrieval[276] in the process of DJing as

[274] Norman, D. A., 1984. Stages and levels in human-machine interaction. International journal of man-machine studies, 21(4), 365–375.

[275] Simon, H., 1977. The new science of management decisions. Englewood Cliffs, NJ: Prentice Hall.

[276] Those stages could be used in overall information behavior, including information need, seek, search and use, but at the same time could be used for analysis and basic research related to the information searching and retrieval.

		an illustrative example (based on the author's own experience and other four professional DJs).
Intelligence	„Raw data from the environment are obtained and processed to identify problems", Simon, 1977	DJ is playing in a club, he observes the dance floor, and based on those observations he identifies where he wants to take the crowd further in their musical journey.
Intention, or goal formation	„Mental characterization of the desired goal", Norman, 1984	DJ's music selection could take the crowd in different directions in terms of of mood, intensity, atmosphere and tempo.
Design	Problems are clarified, potential solutions are assessed for feasibility and a course of action is developed, Simon 1997	The DJ makes a decision to increase the intensity of the atmosphere and assess which tracks he or she could use to do so (still mentally).
Choice or selection	Translation of an intention to an action by the selection of one of the available options, Norman, 1984 **feasible solution is selected** and implemented, Simon, 1997	DJ starts searching in his or her playlist the tracks he or she could use and selects a particular track.
Execution	Entering the command selected into the computer system, Norman, 1984 **feasible solution** is selected and **implemented**, Simon, 1997	When the track is selected, the DJ hits the the "play" and blends the new track into the mix.
Information extraction and integration	Working through material in relevant source, Ellis, 1989 Integrated into the individual's overall information seeking patterns, Ellis, 1989	After the track is played to the crowd, DJ gets feedback and integrates this experience into the overall pattern of the music journey he or she prepares for his DJ set.
Review or evaluation	A review of the executed action to direct further activity, Norman 1984	As a result of reviewed actions, he will start the search process of a new track.

One of the starting propositions of this research is that the human and information system could

be understood as an open system that experiences, seeks, searches, recommends and uses information; related principles of General System Theory will be outlined.

The theory tries to show that mechanisms of a feedback nature are the base of teleological or purposeful behavior in man-made machines as well as in living organisms, and in social systems. [277] This statement support thesis that human and information system could be observed as one open system.

Bertalanffy pointed to the two differences between open and closed systems (Von Bertalanffy,[278]) The first is the principle of equifinality. In a closed system, the final state is determined by the initial conditions, while in open systems the *final state may be reached from different initial conditions and in different ways*. The second difference is based on a contradiction between the law of dissipation in physics and the law of evolution in biology. According to the second principle of thermodynamics, the general trend of events in physical nature is towards states of maximum disorder. On the other hand, the living world shows transition towards states of higher order, heterogeneity and organization.[279] So, the change of entropy in closed systems is always positive and order is continually reduced, while in open systems we have production of entropy due to the irreversible process but also the import of entropy, which may be negative. Living systems that maintain themselves in steady states can avoid an increase of entropy and may develop towards the states of the increased order and organization. In order to have an information system that is more reliable and could last longer we have to aim toward the open system concept.

The difference between a closed and open system can be explained in the context of music as follows: CD1 is put into the player and will play from the first till the last track and then finish. If the listener of CD1 is observed as one system, then this system is closed, as it will always come to the final state in the same way (assuming that the CD player does not have random option). After listening is finished, new CD2 has to be put into the player and disintegrate the first system (listener + CD1) and give a new life to a new system consisting of the listener and CD2. When taking the example of YouTube, there is evidence of the living or open system as

[277] Von Bertalanffy, L., 1968. General system theory. New York, 41973(1968), 40.
[278] Von Bertalanffy, L., 1968. General system theory. New York, 41973(1968), 40.
[279] Von Bertalanffy, L., 1968. General system theory. New York, 41973(1968), 40.

recommendation algorithms will always suggest new tracks based on previous music information behavior of the user (what user played and/or liked before) and the playlist will not be the same two times and music will play till listener decides to press the stop button. Also, based on other people's listening habits, the playlist will be changed over the time. The difference is that by listening to YouTube, the listener and machine (from which YouTube is played) are one open system that reaches the same state always in different ways and the more such a system interacts (and more signal from feedback is collected) the better it tends to perform.

In a similar manner, Hughes compared open and closed systems in his work, pointing out that:[280]

- ***Closed systems*** *are "centrally directed" in the sense of having clearly defined goals and values, they operate autonomously without input from the environment.*
- ***Open Systems*** *are loosely-connected and not so controlled because different parts have different goals and values and are subject to influences from the environment.*

He elaborated open/closed dichotomy further[281] pointing out that technological systems tend to incorporate environment into the system eliminating sources of uncertainty. They began as open systems and move towards closed systems as more and more aspects of the environment are brought under control. But with becoming closed they are influenced by new states in the environment making it harder to control internal uncertainty (usually done via bureaucracy, routines, procedures and deskilling).

Wilson[282] proposed a second model of information behavior, presented in Figure 22. The second model is an extension of his first model that is presented in Figure 23.

[280] Hughes, T. P., 1993. Networks of power: electrification in Western society, 1880-1930. JHU Press recited from Shields, W. M., 2007. Theory and Practice in the Study of Technological Systems (Doctoral dissertation, Virginia Polytechnic Institute and State University).

[281] Bijker, W. E., Hughes, T. P., Pinch, T. & Douglas, D. G., 2012. The social construction of technological systems: New directions in the sociology and history of technology. MIT press. recited from Shields, W. M., 2007. Theory and Practice in the Study of Technological Systems (Doctoral dissertation, Virginia Polytechnic Institute and State University).

[282] Wilson, T. D., 1999. Models in information behaviour research. Journal of documentation, 55(3), 249–270.

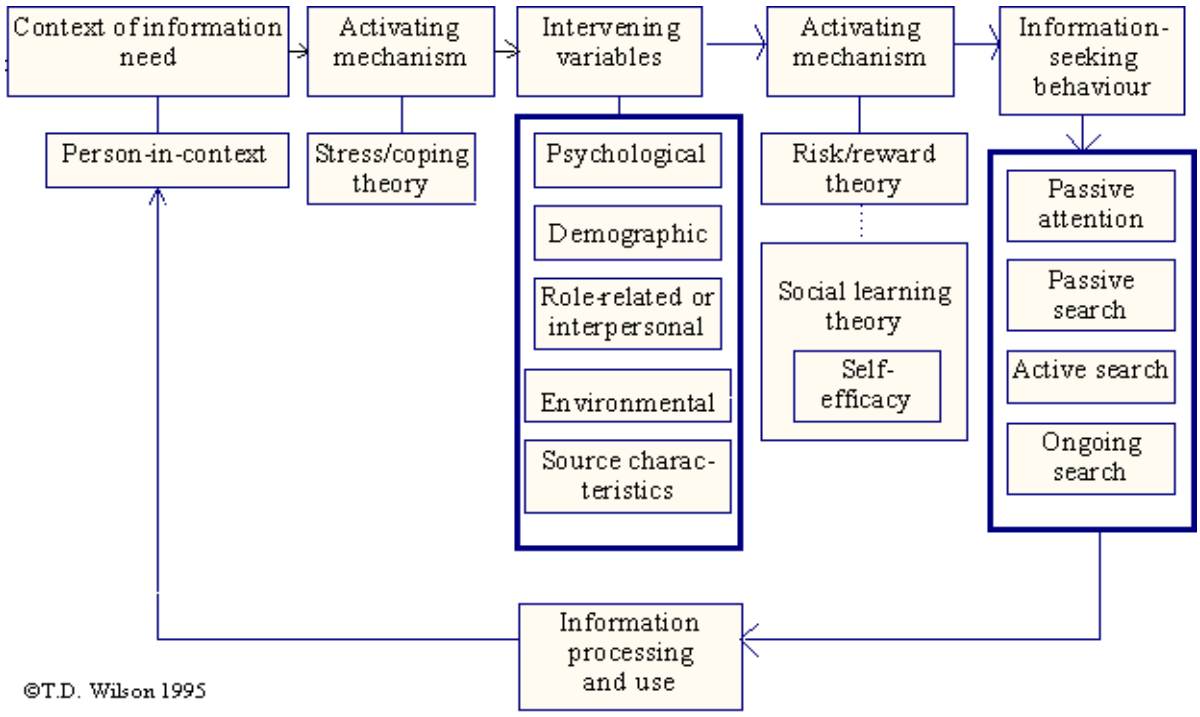

Figure 22 – Wilson's second model of Information Behavior 1996[283]

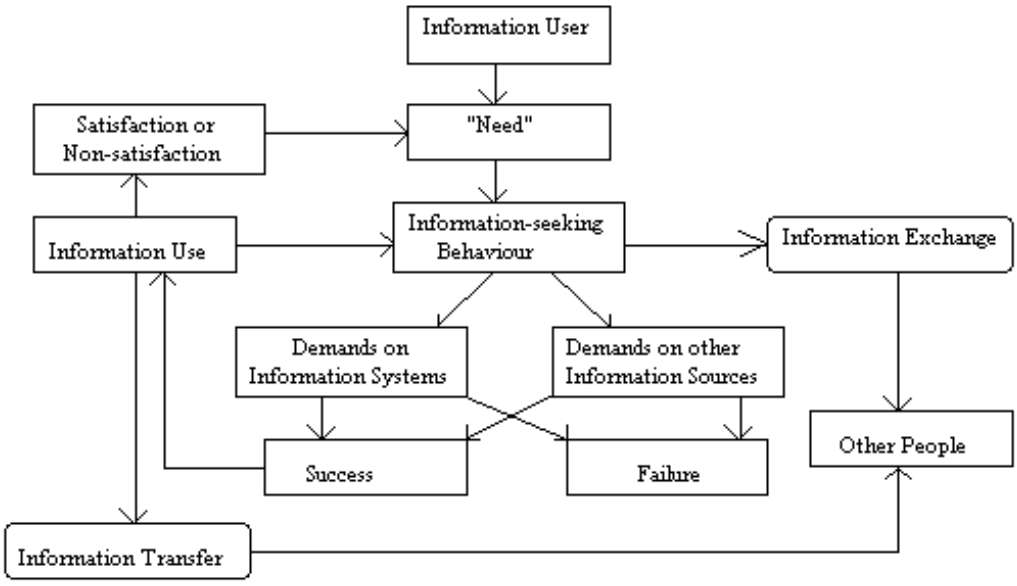

Figure 23 – Wilson's first information behavior model[284]

[283] Wilson, T. D., 1999. Models in information behaviour research. Journal of documentation, 55(3), 249–270.

Information behavior starts with a need for information of the person in the context, which makes an open system. Such a state of the agent triggers the mechanism based on stress and cope theory[285] The agent could be a human, as a machine as well, or to describe it precisely as an algorithm or a set of functions performed by the machine. For example, a thermostat[286] could check the temperature in the room every five minutes (this is information need). Information collected triggers the energy supply to the heating system if needed, based on the functions that determine how much energy should be supplied to the room to achieve wanted temperature (activating mechanism). According to Wilson[287]: *the use of the term intervening variables serves to suggest that their impact may be supportive of information use as well as preventive.* If we follow the process of the thermostat, this could be a function that will check from where energy is supplied into the heating system (as a house could have two sources of energy with different prices that vary over time and availability). If a thermostat could perform such operations, then the next step is to execute risk/reward function that calculates benefits of the switching to the new source of energy, defined by Wilson[288] as *setting out to search for information in any context we may be risking not only financial resources but also psychological and physical resources*), and to do so, depending on the functions implemented into thermostat operations, search could be performed by active searching (if temperature is low and energy is needed, then it searches for prices), passive search (search for the energy prices in other parts of the town, so new prices with current suppliers could be negotiated), ongoing search (check the predefined sources of information about energy prices) and passive attention that happens without intentional seeking (the owner of the flat connects his mobile to thermostat, so automatically it could find more about the latest emails offers received from energy suppliers). Such a search process will not be just related to the risk/reward, but also to the learning (or cognitive) capacity [289] of the thermostat. Wilson described self-efficacy as *the conviction that one can successfully execute the behavior*

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284 Wilson, T. D., 1999. Models in information behaviour research. Journal of documentation, 55(3), 249–270.

285 Folkman, S., 1984. Personal control and stress and coping processes: A theoretical analysis. Journal of personality and social psychology, 46(4), 839.

286 Concept that the thermostat has information behavior is discussed with professor Wilson in private conversation over e-mail.

287 Wilson, T. D., 1999. Models in information behaviour research. Journal of documentation, 55(3), 249–270.

288 Wilson, T. D., 1999. Models in information behaviour research. Journal of documentation, 55(3), 249–270.

289 The social learning theory is derived from the ideas of stimulus response theory (Rosenstock, 1974).

required to produce the desired outcomes.[290] To make decision to search for information about energy prices, thermostat should have evaluated if it is worth it in terms of its resources consumptions and understand if it is capable of doing so (this learning could help over the time as for every search it performed, data are collected, and on those data algorithmic operations are carried out). When a decision is made, data processing starts and, based on information extracted from those processes, the temperature is changed. Later on, new room temperature is measured and process starts from the beginning.

All this happens in the context of information delay. To extract information from data we need time, and time could be calculated. Based on the given function those calculations could be used as a feedback signal. Depending on the situations in which processes are performed, the system will have time or not, to do the processing. And more often than not the best option will be the real time (which is a questionable concept) data processing – as sometimes in different situations there is more time, and if more data is processed, then there is more information and increase the capacity of the system. If – then algorithm will look like this; if *have time,* then *process more data*, if *do not have time*, then *process less data*.

The quotation from the Nest white paper[291] support the above propositions that information behavior model could be used for designing of the intelligent machines and agents, and it is actually used in the context of the thermostat.

Given the importance of behavior in energy savings from thermostats, user satisfaction with the technology and their feeling that their energy savings have not come at the expense of comfort mean that the Nest Learning Thermostat can serve its dual role as a comfort control device and an energy control device without putting those objectives in conflict.

It is important to note that this statement includes the user perspective and his experience of using technology and as such, it supports plea for socio technical perspectives.

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[290] Citated in Wilson, T. D., 1999. Models in information behaviour research. Journal of documentation, 55(3), 249–270 forwarding to Bandura, A., Self efficacy: towards a unifying theory of behavioural change. Psychological Review, 1977, 84, 191–215.

[291] Energy Savings from the Nest Learning Thermostat: Energy Bill Analysis Results https://nest.com/downloads/press/documents/energy-savings-white-paper.pdf (retrieved 23. 9. 2017.).

For the purpose of this research, based on Wilson's second model of Information Behavior [292], the author extracted one hundred ninety seven variables that could be measured and observed. Those variables could be used in the process of observation, evaluation and analysis of the information system, information behavior in general and interaction between the user and the information system. Findings of those inquiries could be applied in the process of design of the IS and in the basic research.

According to Wilson's information behavior, models are, on one hand, dealing with generalized behaviors that trigger information seeking and on the other, expanding the view of the information search to the broader perspective than simply the use of computer-based information retrieval systems[293]. Such views are aligned with Järvelin and Ingwersen views.[294] Models of information behavior could be used to inform the overall design principles of information systems; may support the content developers to design better navigational routes through the system and what type of the content (data, records, documents) should be used.[295] We could further improve information systems; design by including concepts of risk/rewards and self-efficacy into process.[296]

Ingwersen[297] proposed the concept of Poly representation that combines user's cognitive space and the information retrieval system information space representing users information need, problem and knowledge states and work tasks, including the causality in the process of information retrieval, searching and seeking. This could be extended in terms of information avoidance, as sometimes a user does want to avoid the access to the information sources designed in a way to influence his or her behavior. For example, notification on the mobile phone can be turned off or the Internet access switched off to stay focused on the task at hand. Such a view is aligned with the previously proposed view that the user and information system is single open system, as it behaves according to its socio technical features. Ingwersen's empirical research on

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[292] Wilson, T. D., 1997. Information behaviour: an interdisciplinary perspective. Information processing & management, 33(4), 551–572.

[293] Wilson, T. D., 1999. Models in information behaviour research. Journal of documentation, 55(3), 249–270.

[294] Järvelin, K. & Ingwersen, P., 2004. Information Seeking Research Needs Extension towards Tasks and Technology. Information Research: an international electronic journal, 10(1).

[295] Wilson, T. D., 1999. Models in information behaviour research. Journal of documentation, 55(3), 249–270.

[296] Wilson, T. D., 1999. Models in information behaviour research. Journal of documentation, 55(3), 249–270.

[297] Ingwersen, P., 1996. Cognitive perspectives of information retrieval interaction: elements of a cognitive IR theory. Journal of documentation, 52(1), 3–50.

formation of the information need during information retrieval process is important as it evidences that during the process of information retrieval (and information searching) cognitive space and information needs are changed.[298] Further concept of polyrepresentation implies that different representation and information retrieval techniques should be applied to address different cognitive and functional aspects of the user. Or, as already discussed, we have to design information systems that are adaptable to the user's information needs and match his information seeking and searching patterns. It also fits with the socio technical model of information behavior, proposed above in this chapter that calls for a systemic view on socio-cognitive experience, information seeking and searching, information retrieval, recommendation and content use and analysis.

It is based on the feedback loops between different "blocks" and as Ingwersen[299] said: *The goals are to improve the intellectual access to information sources and, simultaneously, to provide the information retrieval system with an enriched contextual platform that can support the user's information seeking.* In other words, if the system is provided with the feedback signal from the user and it adopt accordingly, then this system behaves in terms of information behavior (as discussed in the thermostat information behavior). Ingwersen[300] also pointed to the importance of time in the process of constructing shared objects from the information objects provided by the information system, the user and his or her social ties (defining organizational and situational conditions). This could be explained with the activity theory and concept of shared objects between two activity systems presented in Figure 24.

[298] Ingwersen, P., 1996. Cognitive perspectives of information retrieval interaction: elements of a cognitive IR theory. Journal of documentation, 52(1), 3–50.

[299] Ingwersen, P., 1996. Cognitive perspectives of information retrieval interaction: elements of a cognitive IR theory. Journal of documentation, 52(1), 3–50.

[300] Ingwersen, P., 1996. Cognitive perspectives of information retrieval interaction: elements of a cognitive IR theory. Journal of documentation, 52(1), 3–50.

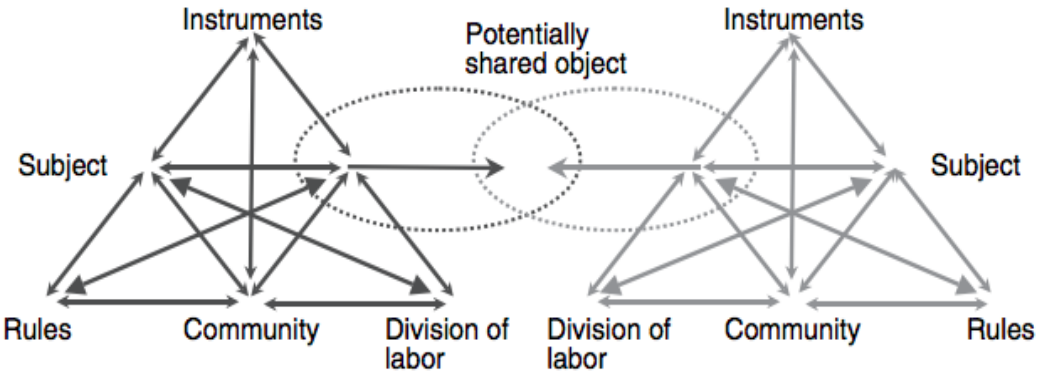

Figure 24 – Two activity systems and potentially shared objects (Engeström, [301])

Time as a variable is important as sometimes there is have plenty of it, but sometimes there is a limit in avaliable time, so output will depend on the time, cognitive capacity of the user and system performance (including environmental conditions). The following is an example of the search for the address to find a university. Student A thinks that he knows where the university is, and student B does not know where the university is. Student A sits in the car and comes near the university but could not find it. He uses his mobile and searches for the images so he could recognize the building. This search (or retrieval) is conditioned by the time available, and he is driving by as he wants to find out what the building looks like as possible. Student B does not know where the university building is, so before leaving his house, he downloads the map and directions to his mobile and drives observing the directions given by machine. The results, at the end, are the same, both students arrive to the university and take exams, but the process of information retrieval is conditioned by time (student A has less time as he is around the university and has to find how building looks like as soon as possible and student B has more time), cognitive state (student A thought that he knew where the building was while student B knew that he did not know where the building was) and the information system supporting their information search process and retrieval of the information was necessary to fulfill the task at hand (as one student use Google Images search, other use GPS map).

This could be explained through the open system theory discussed by Bertalnaffy[302]. He pointed

301 Engeström, Y., 2009. The future of activity theory: A rough draft. Learning and expanding with activity theory, 303–328.

out that: *Even simple open systems show remarkable characteristics. Under certain conditions, open systems approach a time-independent state, the so-called steady state. The steady state is maintained in distance from true equilibrium and therefore is capable of doing work; as it is the case in living systems, in contrast to systems in equilibrium. The system remains constant in its composition, in spite of continuous irreversible processes, import and export, building-up and breaking-down, taking place. The steady state shows remarkable regulatory characteristics, which become evident particularly in its equifinality. If a steady state is reached in an open system, it is independent of the initial conditions, and determined only by the system parameters, i.e., rates of reaction and transport. This is called equifinality as found in many organismic processes. In contrast to closed physico-chemical systems, the same final state can therefore be reached equifinality from different initial conditions and after disturbances of the process. Furthermore, the state of chemical equilibrium is independent of catalyzers accelerating the processes. The steady state, in contrast, depends on catalyzers present and their reaction constants. In open systems, phenomena of overshoot and false start* (Figure 25) *may occur, with the system proceeding first in a direction opposite to that eventually leading to the steady state. Conversely, phenomena of overshoot and false start, as frequently found in physiology, may indicate that we are dealing with processes in open systems.*

[302] Von Bertalanffy, L., 1968. General system theory. New York, 41973(1968), 40.

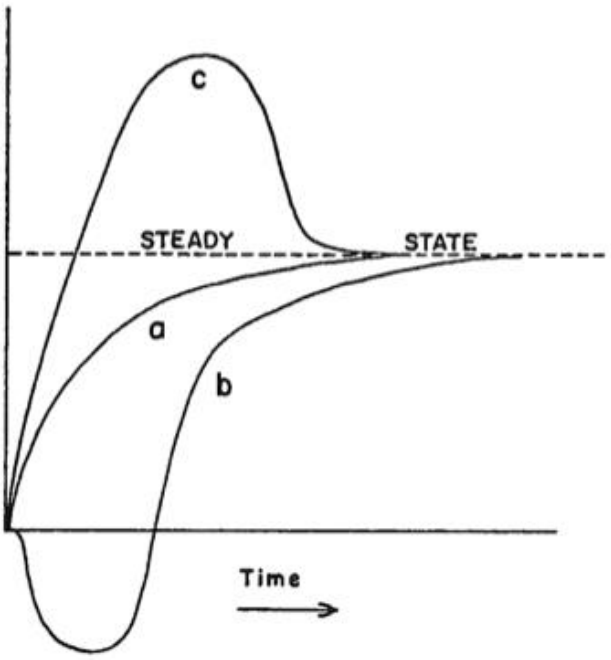

Figure 25 – Reach of the steady state of the open system;[303] Asymptotic approach to steady state (a), false start (b), and overshoot (c)

It could be said that ideal path to the steady state will be that students know where the building is, but according to their circumstances, different information searching patterns happened. If student A and student B are observed interacting with machines as two open systems consisting of a man and an information system, then it follows that to reach steady state (to come to the building to take exams) they have different curves. Both students reach steady state according to their different cognitive information experience (one knows that he does not know, another thinks that he knows) and different information system used to find it (one used Google images other used Google map). If one looks at this from the perspective of thirty students giving exam, they all had to look for information to find a building (assuming that this building is a new one and the exam is there for the first time), have different information behavior patterns but at the end all of them reach the steady state. And this steady state is that they somehow find the information where the building is and could take the exam. Different patterns of information behavior could result in the same steady state of a particular set of different open systems that are selected for

303 Von Bertalanffy, L., 1968. General system theory. New York, 41973(1968), 40.

observation. They are conditioned by the time available, socio-cognitive characteristics of the users and features of the information system they used to find information. Time as a variable could represent situational and environmental conditions of the open systems performing operations (including information behavior) to reach the steady state. And if the steady state is the same for two or more open systems, then they could be compared and analyzed.

The following aspects of such a open system that reaches the steady state could be observed:

- time and pattern how steady state is reached
- change of the information source (such as information system adoption capacity)
- socio-cognitive experience (and its change) of agent searching and retrieving information from that source
- situations and tasks related to the steady state (when the system is capable of doing work), including information processing and use.

An observation of the level at which IS changes while user (or other agent) performing information search and retrieval shows how this system is adaptive. For example, the information system could:

a) Remember the preferred set of data for a particular user and serve it when this user logs in (this is an adaption at the level of data structure).
b) Recommend actions based on the like or dislike of such data set (this is an adaption at the level of generating of new functions).
c) Execute action based on the previous behavior (this is an adaption at the level of new goals).

The principle of triangulation in cognitive and information space could be understood as the principle of triangulation in the design of adoptive information system design based on the assumption that user and information system are one open system aiming at the steady state based on the information need satisfied. This process could be described in terms of patterns of information behavior and they are defined as a time (dependent) sequence happening between the moment a user experiences information, i.e., when structured data become information and the information seeking process starts, until the moment the user stops interacting with the information source as the user satisfies his information needs. Such a process can occur in social

and technical domains.[304]

Patterns of information behavior are representation of a behavior of open system of interest, consisting of information system behavior and affective, behavioral and cognitive features of user interaction with the information system.

Information behavior is influenced by affective and behavioral features, not just cognitive aspects. There is evidence development of the affective, behavioral and cognitive computing sub disciplines in the computer science domain.

Cognitive computing is about the development of a coherent, unified, universal mechanism that is inspired by the mind's capabilities. Instead of assembling a collection of piecemeal solutions, in which various cognitive processes are designed as independent solutions, we have to search for computational theory based on how minds work. [305]

Detailed elaboration of affective, information behavioral and cognitive computing is presented in Table 15:

Table 15 – Affective, Behavior and Cognitive computing

Affective computing	Affective computing *relates to, arises from, or influences emotions.* With the help of the affective computing paradigm, machines can assist humans in their task, increase performance, and develop additional abilities to make correct decisions (Tao and Tan,[306]). The data may be collected with a number of wearable sensors and non-invasive techniques such as video and audio channels and face and speech emotion estimation.[307] Sentiments are also detectable through text analysis of popular social networks.[308]

304 S. Lugović, I. Dunđer and M. Horvat, 2015. Patterns-based information systems organization, Proceedings of the 5th International Conference: The Future of Information Sciences (INFuture), pp. 163–174.

305 Modha, D. S., Ananthanarayanan, R., Esser, S. K., Ndirango, A., Sherbondy, A. J. & Singh, R., 2011. Cognitive computing. Communications of the ACM, 54(8), 62–71.

306 Tao, J. & Tan, T., 2005, October. Affective computing: A review. In: International Conference on Affective Computing and Intelligent Interaction (pp. 981–995). Springer Berlin Heidelberg.

307 Kukolja, D., Popović, S., Dropuljić, B., Horvat, M. & Ćosić, K., 2009. Real-time emotional state estimator for adaptive virtual reality stimulation. Foundations of Augmented Cognition. Neuroergonomics and Operational Neuroscience, 175–184.

308 Dunđer, I., Horvat, M. & Lugović, S., 2016. Word occurrences and emotions in social media: Case study on a Twitter corpus. In: 39th International Convention on Information and Communication Technology, Electronics and Microelectronics MIPRO 2016.

Information behavior computing	Information behavior is *behavior in relation to sources and channels of information.* [309] Information can be purposely sought (macro level) to satisfy goals and searched for (micro level) in the process of interacting with the information sources.[310] When found, information can also be incorporated into the information system and affect its behavior. Behavior computing supports explicit, implicit and quantitative behavior analysis by observing patterns and impact of the behavior (by observing changes). It includes data representation, modeling and construction, impact and pattern analysis, simulation, and presentation of the behavior and its use. By applying behavioral computing into the information behavior, we could categorize information behavior into symbolic behavior (*social activities recorded into computational systems, which present as symbols representing human interaction and operation with a particular object or object system*).[311]
Cognitive computing	Cognitive computing supports users' goals and achievements, adopting along the way to the users' learning curve and redefined goals by computing information resources, influencers, context and insights. An output is describing what's best rather than what's right in terms of prescription, suggestions, and instructions. To do so, systems have to be adoptive, interactive, iterative, and contextual so they can play the role of the user's assistant or coach but also autonomously solve emerging problem-solving situations. It seeks to integrate computing closer to the human natural states. [312],[313],[314], [315]).

By using an observation lens of one open system that is aiming towards a steady state consisting of user(s) and a machine, and implementing triangulations, Larsen and Ingwersen proposed applying the results of such observations to the design of information systems or other machines. It is important to say that by intervention in the information spaces of the user, social structures could also be designed, but it opens up ethical considerations. Thera re numorous examples of

309 Ford, N., 2015. Introduction to Information Behaviour. London: Facet Publishing.

310 Wilson, T. D., 2000. Human information behavior. Informing Science, 3(2), 49–56.

311 Cao, L., 2010. In-depth behavior understanding and use: The behavior informatics approach. Information Sciences, 180(17), 3067–3085.

312 Coccoli, M., Maresca, P. & Stanganelli, L., 2016. Cognitive computing in education. Journal of e-Learning and Knowledge Society, 12(2).

313 Gudivada, V. N., 2016. Cognitive computing: Concepts, architectures, systems, and applications. Handbook of Statistics, 35, 3–38.

314 Wang, Y., 2006, July. Cognitive informatics: Towards future generation computers that think and feel. In: 2006 5th IEEE International Conference on Cognitive Informatics. 1, 3–7.

315 Rozenblit, J. W., 2005. Cognitive computing: Principles, architectures, and applications. In: Proceedings of the 19th European Conference on Modelling and Simulation (ECMS).

this in the „fake news" phenomena, but this is not the focus of this thesis. Below are listed some empirical findings from Allcott and Gentzkow[316] to support thesis that social system could be designed by intervening into their information space (by interventions into information space we influence on socio-cognitive space that is a part of the proposed model, defined in the Block 1):

- 62 percent of the US adults get news on social media[317]
- the most popular fake news stories were more widely shared on Facebook than the most popular mainstream news stories[318]
- many people who see fake news stories report that they believe in them[319]
- the most discussed fake news stories tended to favor Donald Trump over Hillary Clinton[320]

According to the suggestion of commentators of the political reality in the US, Donald Trump would not have been elected president were it not for the influence of fake news. [321],[322]; [323])

In addition to the Facebook experiment already mentioned by Kramer, Guillory and Hancock,[324] it could be clearly stated that by influencing the information space of the user socio-cognitive space could be designed as well. And this is happening in the process of information searching and retrieval.

316 Allcott, H. & Gentzkow, M., 2017. Social media and fake news in the 2016 election (No. w23089). National Bureau of Economic Research.

317 Gottfried, J. & Shearer, E., 2016. News use across social media platforms 2016. Pew Research Center, 26.

318 Silverman, C., 2016. This analysis shows how viral fake election news stories outperformed real news on Facebook. Buzzfeed News.

319 Silverman, C. & Singer-Vine, J., 2016. Most Americans who see fake news believe it, new survey says. BuzzFeed News.

320 Silverman, C., 2016. This analysis shows how viral fake election news stories outperformed real news on Facebook. Buzzfeed News.

321 Parkinson, H. J., 2016. Click and elect: how fake news helped Donald Trump win a real election. The Guardian.

322 Read, M., 2016. Donald Trump won because of Facebook. New York Magazine.

323 Dewey, C., 2016. Facebook Fake-News Writer: 'I Think Donald Trump is in the White House Because of Me'. The Washington Post.

324 Kramer, A. D., Guillory, J. E., Hancock, J. T., 2014. Experimental Evidence of Massive-scale Emotional Contagion Through Social Networks. In: Fiske, S. T. (ed.) Proceedings of the National Academy of Sciences, vol. 111(24), pp. 8788–8790. Princeton University, Princeton, http://www.pnas.org/content/111/24/8788.full.pdf.

Ingwersen[325] pointeded out the following two fundamental aspects of IR:

- *the uncertainties and unpredictability inherent in information retrieval interaction*
- *any presuppositions, meaning and intentionality underlying the communicated messages are vital but constantly lost.*

Those two factors associated with the interpretation of the retrieved data to reach cognitive, communication and/or cooperation level[326] are applicable to the human and information system (or other information processing machines). In terms of human interpretation, this act demands more than encoding and decoding. It requires common semantics, too. Intentionality, presumptions and meaning are essential properties for the perception and understanding of message and their loss is crucial in the process of information retrieval.

Those two features of IR are the major reason for: *inter-indexer inconsistency, inconsistent assessments of 'relevance', searcher differences for identical queries, and the different results obtained by the variety of IR techniques.*[327]Ingwersen[328] pointed to the two different levels of information retrieval, direct and real information retrieval and text retrieval performed at lower level. They are presented in Figure 26.

325 Ingwersen, P., 1996. Cognitive perspectives of information retrieval interaction: elements of a cognitive IR theory. Journal of documentation, 52(1), 3–50.

326 Hofkirchner, W., 2008. Web 3.0 Philosophy: Internet in the perspective of a unified theory of information. Trent University. Recuperado el, 26.

327 Ingwersen, P., 1996. Cognitive perspectives of information retrieval interaction: elements of a cognitive IR theory. Journal of documentation, 52(1), 3–50.

328 Ingwersen, P., 1996. Cognitive perspectives of information retrieval interaction: elements of a cognitive IR theory. Journal of documentation, 52(1), 3–50.

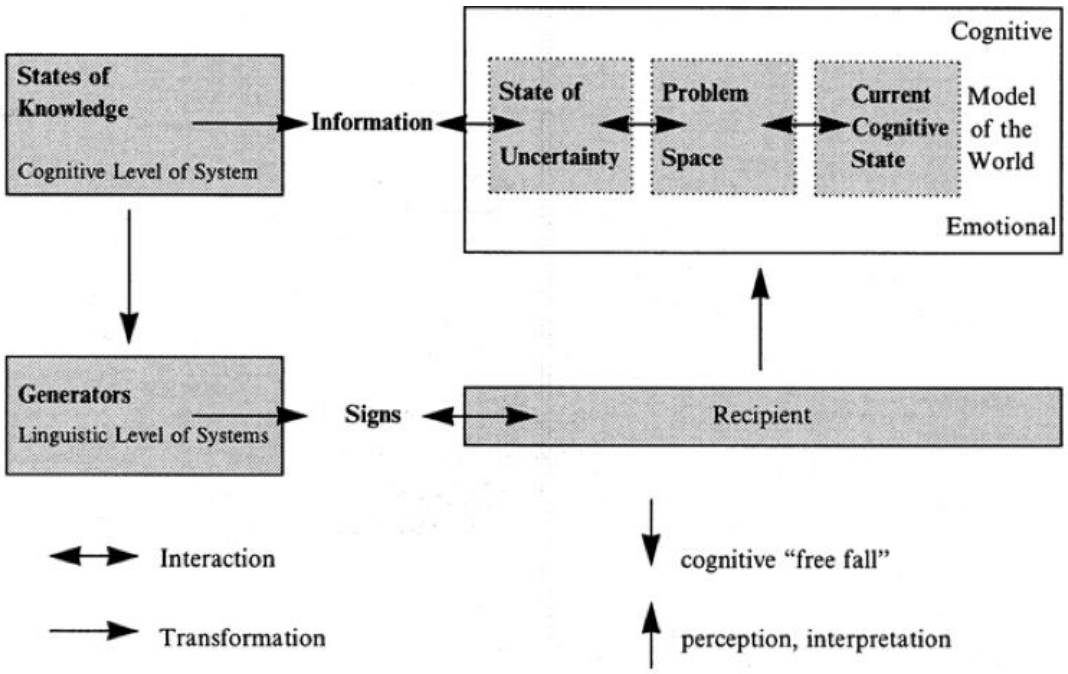

Figure 26 – The cognitive communication system for information science and IR (Ingwersen, [329])

According to Ingwersen[330], in information science cognitive viewpoint that information processing (perceptual or symbolic) is mediated by the categories and concepts that for the agent (human or machine) constitute the world model.[331]

Figure 27 presents polyrepresentation nature of the cognitive space and the interaction of different elements that result in the change of cognitive space, could be spaces to be intervened in the experiments and could rise the interest of the researcher and analysis.

329 Ingwersen, P., 1996. Cognitive perspectives of information retrieval interaction: elements of a cognitive IR theory. Journal of documentation, 52(1), 3–50.

330 Ingwersen, P., 1992. Information retrieval interaction. London: Taylor Graham.

331 De Mey, M., 1980. The relevance of the cognitive paradigm for information science. Theory and application of information research. London: Mansell, 48–61.

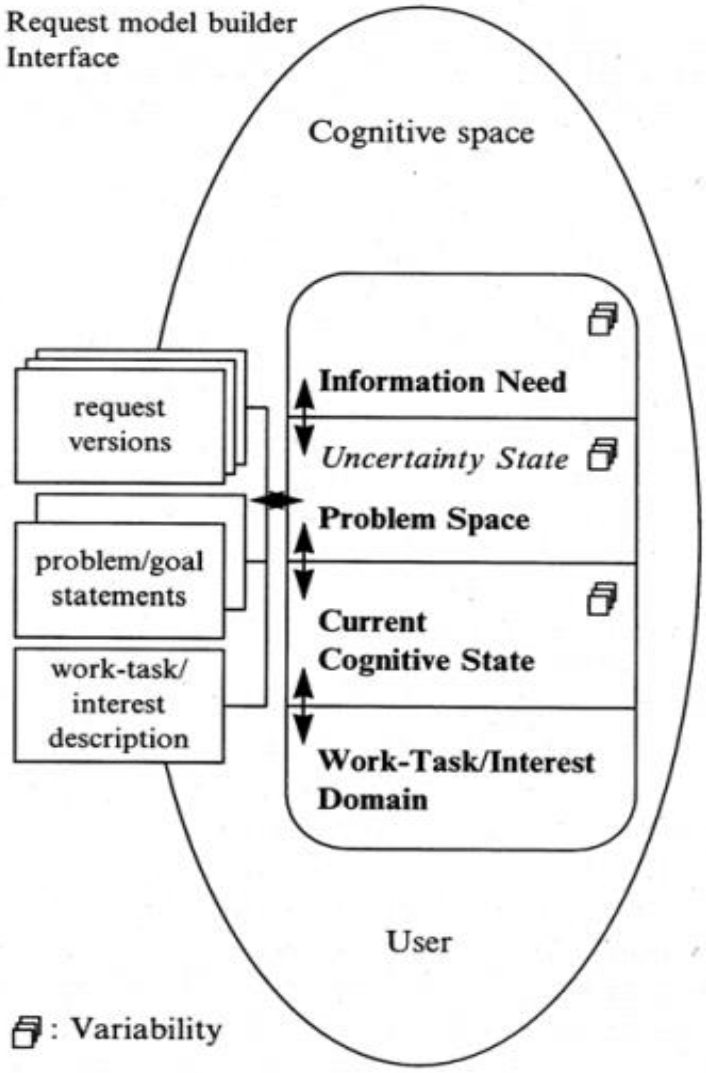

Figure 27 – Polyrepresentation nature of the cognitive space[332]

Figure 28 presents Ingwersen's cognitive model of information retrieval interaction. This model could be used as a framework to develop basic research questions and a hypothesis and support the process of information system (including information retrieval system) design. As such, it could also support inquiries related to observation of an open system consisting of user and machine.

[332] Ingwersen, P., 1996. Cognitive perspectives of information retrieval interaction: elements of a cognitive IR theory. Journal of documentation, 52(1), 3–50.

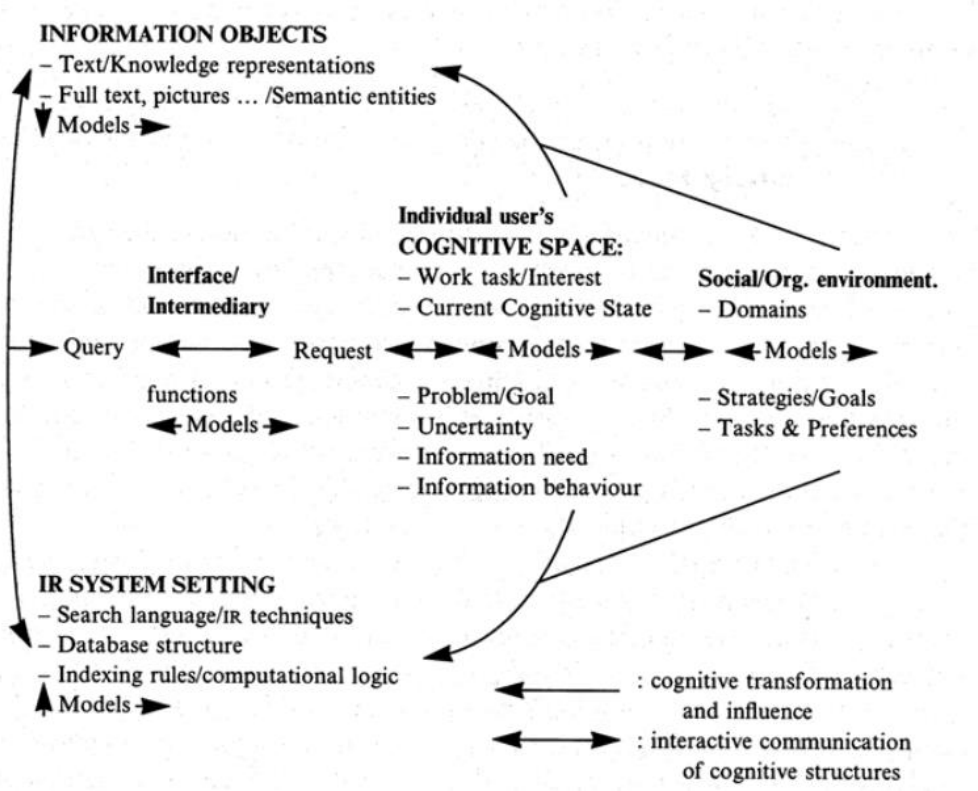

Figure 28 – Ingwersen's cognitive model of IR interaction[333]

Open systems emerge and disintegrate in the process of information behavior. One set of interactions in the open system of interest could be described in terms of information searching. If the process of satisfying information need requires the emergence of more than one open system, then we could explain those in terms of information seeking. In this way, a higher granularity of the research inquiry could be developed, as in searching searching interactions are observed that occur in the open system (conditioned by the environment).

Those who are interested in seeking can observe interactions of two or more open systems and their environment. It is important to note that seeking is happening in the longer time span and accordingly, the dynamics of the environment will be more complex and as variable more

[333] Ingwersen, P., 1996. Cognitive perspectives of information retrieval interaction: elements of a cognitive IR theory. Journal of documentation, 52(1), 3–50.

demanding to quantify. This is aligned with the thoughts of Hjørland[334], differentiating cognitive (*study knowledge by studying the individual*) and socio-cognitive view (*individual knowledge in a historical, cultural, and social perspective*). Observation of the open system interactions and its environment offers an insight into how steady state (that could be understood as knowledge too, as knowledge is needed to be able to act) is reached from the lens of its properties, characteristics and features. By careful observation of the emergence and disintegration of more than one open system a lot of knowledge can be gained about historical, cultural and social aspects or signal processing between those open systems.

For example, if somebody wants to find recommendations where to eat tonight, first, the user is engaged in a conversation with a colleague over the telephone, and then engaged with the Trip Advisor application, and then lookat the Google map how to find a restaurant. Information needs are always the same – to find enough information to have good dinner, but to satisfy it, the user is engaged in the process of information seeking. Three open systems are created in this process, one with the colleague, one with the Trip Advisor application and one with the Google map application. In each of those three open systems of emergence and disintegration the user was going towards the steady state of the open system (user and machines) to be able to have dinner. Or as Bates put it: […] *the searcher typically finds information a bit at a time, uses a variety of sources* (Bates, [335]) such a process is presented in Figure 29:

[334] Hjørland, B., 2002. Epistemology and the socio- cognitive perspective in information science. Journal of the Association for Information Science and Technology, 53(4), 257–270.

[335] Bates, M. J., 2002. Toward an integrated model of information seeking and searching. The New Review of Information Behaviour Research, 3, 1–15.

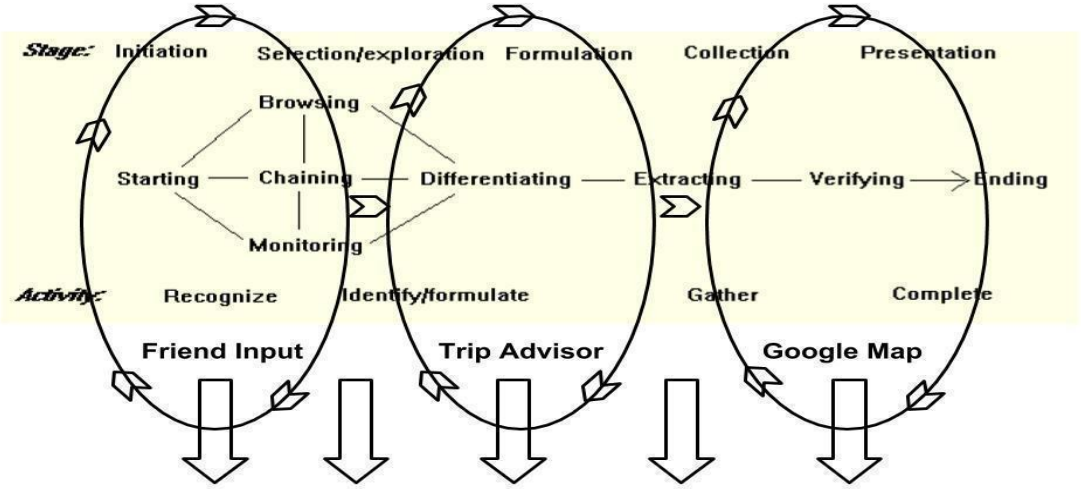

Figure 29 – Three searching loops of information seeking process

There could be observations of affects and feelings of the user and performance of the information system (including information retrieval systems) supplying the user with information while performing search operations. Three open systems are created in the process of satisfying information needs. Moreover, interactions between those open systems could also be observed. For example, Tripadvisor application is better integrated with the Google map than it is telephone conversation with Tripadvisor. For this reason, questions could be asked if the quality of the integration between Tripadvisor and Google map has an impact on its use or there could be a question on user satisfaction with Tripadvisor queries. Also, there is a technical aspect of the inquiry, we could be interested in how Trip Advisor IR system collects data from the interaction and improves its algorithms (cognitive) and what security procedures are implemented in the communication between Trip Advisor and Google map applications (socio-cognitive).

The Activity theory could be used here to support those claims presented in Figure 30.

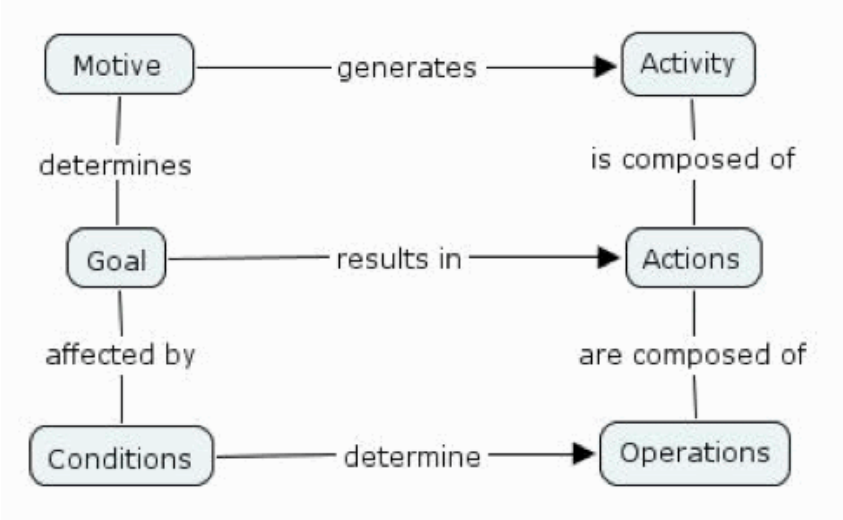

Figure 30 – Activity, actions and operations [336]

To satisfy information needs (that is activity) we engage in different actions, those actions could be understood as information seeking. Those actions consist of operations determined by conditions, and they could be viewed as engagement of the user (or the machine) in the information searching activities. If there is a need to design adaptive information systems, then a deeper understanding of the user information needs is required, as well as the user's information seeking activities and how he performs the search. Signal used to trigger the adoption process could be extracted from the open system aiming towards steady state and at the same time from the interactions between open systems that emerge and disintegrate in the process of satisfying information needs. As Spink put it: *Each search strategy may consist of one or more cycles. Each cycle may consist of one or more interactive feedback occurrences. An input may also represent a move within the search strategy... and may be regarded as a search tactic to further the search.... Each move consists of a user input or query requesting a system's output.*[337] Bates[338] pointed to

[336] Wilson, T. D., 2006. A Re-Examination of Information Seeking Behaviour in the Context of Activity Theory. Information research: an international electronic journal, 11(4), n4.

[337] Spink, A., 1997. Study of interactive feedback during mediated information retrieval. Journal of the American Society for Information Science, 48(5), 382–394.

[338] Bates, M. J., 1990. Where should the person stop and the information search interface start? Information Processing & Management, 26(5), 575–591.

the “move” as the basic unit of analysis in the information search behavior, and defines it as a small action or identifiable discrete thought.

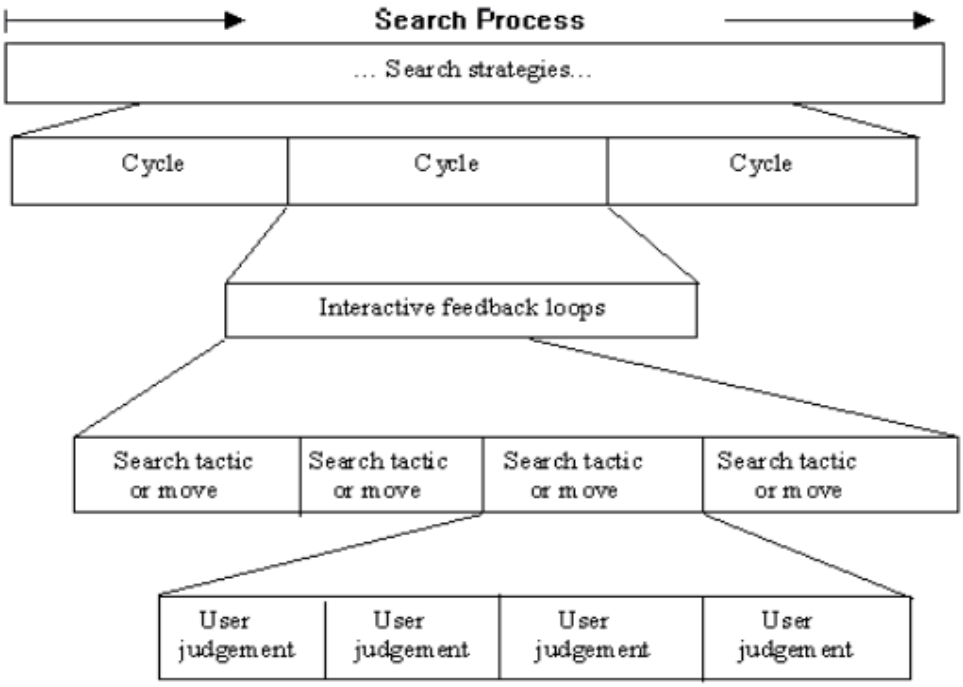

Figure 31 – Spink's model of the search process[339]

Studying and observing a human and an information system as an open system that is aiming towards the steady states, we could get insights into the performance of such a system, its dynamics and how it acts (and changes) the environment. Information searching and retrieval are central in such inquiry as in this „block” happens direct interaction between a human and an information system. By observing how results of information search and retrieval influence behavior of the user, it is possible to implement adoptive functions of the information system based on the user feedback. But we have to be aware that user behavior could be influenced by the information retrieved from the information system. And this could be done intentionally and unintentionally. In this day and age when information systems are becoming ultra large and serve almost the entire global population (such as Google and Facebook) and are designed and owned

339 Spink, A. & Losee, R. M., 1996. Feedback in information retrieval. Annual review of information science and technology, 31, 33–78.

by a few, there is a pressing need for another observing mechanisms that could signal potential moral and ethical threats. To do that, observing a man and a machine as one open system is one of the potential solutions. Also, in this chapter particular focus was shifted towards the analysis of differences and similarities related to the information retrieval and information search and based on this analysis it is possible to say that those two terms should be researched in a holistic way. This is the reason why those two are combined as one "block" of the proposed socio-technical information behavior model.

Block 4 – Recommendation

Wilson[340] pointed to the several forms of information behavior, one, when user accesses information system (such as libraries, on-line services or information centers), another when user accesses the systems that perform information functions as secondary functions supporting his tasks, e.g., when estate agents or car sales agencies look into the information system to find a property or a car to sell. Their primary function is to sell and to do so, they have to inform themselves and customers about the availability of properties or cars. Alternatively, the user could ask other people (rather than the information system). Output from all activities mentioned above is related to capacity to recommend and not just provide the user with the information he or she searches for (and/or retrieves). Except to retrieve information as it is, user could also ask for advice or opinions.[341] Both advice and opinions will influence the user's further information search. We could separate recommendation from the search for the purpose of better analysis and observation. Recommendation as such, could be implemented by a machine (some kind of information system) or a human. Those agents that recommend could also be understood as a bottleneck in the process of finding information to satisfy information need,[342] as there are established patterns in the social systems, and they could act as barriers in information seeking and searching activities. Those patterns do not reduce much uncertainty and could be understood as a weakness of any socio-technical system in terms of reaching the steady state needed to get the jobs done. This could be overcome with the design of recommendation systems that ingest

340 Wilson, T. D., 1981. On user studies and information needs. Journal of documentation, 37(1), 3–15.
341 Wilson, T. D., 1981. On user studies and information needs. Journal of documentation, 37(1), 3–15.
342 Wilson, T. D., 1997. Information behaviour: an interdisciplinary perspective. Information processing & management, 33(4), 551–572.

serendipity in the process of information behavior (including information seeking and searching). Implementation of such functions in the process of design of recommender systems is a regular practice.

In Bandura's[343] *Social Cognitive Theory,* he proposes four phases of diffusion efforts. They could be used as such in design and/or fundamental research related to how recommendation systems could impact the process of information need satisfaction and socio-cognitive information experience. Those are: selection of an optimal setting for introducing innovation (recommend new content when the user is not doing some critical task), creation of the necessary preconditions for change (link to the recommended content), implementation of a demonstrably effective program (share the rating of other users), dispersion of the innovation to other areas (suggest other people in the organization). There is a great research opportunity in the application of information behavior models in the observation of innovation processes.

Ellis's[344] elaborates different behaviors features involved in information seeking, provides an insight into the features features important for recommendation system, as follows:

- ***Differentiating:*** *using known differences in information sources as a way of filtering the amount of information obtained.*

For example, if the differences in information sources can be understood, different information objects could be recommended accordingly, such as video to the tablet and not to the mobile phone of the user.

- ***Chaining:*** *following footnotes and citations in known material or 'forward' chaining from known items through citation indexes.*

Footnotes and citations could be used as a trigger to design recommendation; it is common today at the ResearchGate.net website.

- ***Starting:*** *the means employed by the user to begin seeking information, for example, asking some knowledgeable colleague.*

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[343] Bandura, A., 1986. Social foundation of thought and action: A social-cognitive view. Englewood Cliffs.

[344] Ellis, D. and M. Haugan, 1997. Modelling the information seeking patterns of engineers and research scientists in an industrial environment. Journal of Documentation, 53(4), p. 384–403.

Talking in terms of serendipity the starting phase could be used to ingest some unexpected information object, much like forbes.com is does, offering the daily quote when user log into the system. Wilson[345] pointed out that in information seeking studies personal networks have an important role in the information behavior and that information retrieval system designers could implement such functionalities into the systems they build. Information becomes agreed upon over the time frame and becomes a fact.[346] If time is needed for data to become fact, knowing how much time is available, the recommender system could be adjusted so that ingests recommendations in the process of information search and retrieval depending in time availability. For example, a user could state how much time he or she has to find something, or such predictions could be made by the information system itself if some advanced functions are implemented in its design. If a system could understand how much time is at disposal for the user (or agent that is not human), then it could process more data (if there is enough time) or it could process less data (if there is no time). This is aligned with Dervin[347] assumptions *that sense-making behavior is responsive to and mandated by changing situational conditions*. One of the properties of such conditions is time available. In order to design better recommendation systems, there should be interest in the situations and changes, user demographics and the time available to perform information seeking, search or retrieval related activities. Ingwersen[348] calls for applying different methods of representation and a variety of information retrieval techniques of information objects. It calls into question where the space is where the selection of those methods and techniques occurs. By applying the proposed socio-technical information behavior model paves the way for an analysis in the "block" that is related to the recommendation activities. Mechanics implemented to the system is based on the feedback from the block describing information search and retrieval (what people searched for) and the block dealing with content (that could be information objects, data, records…) and analysis of its use (what is used and how often). There are two acts of information processing, one perceptual (how the user experiences information) and another symbolic (what data are processed to create information). Each of them is mediated by a system of categories and concept that constitute the world model, either for a

345 Wilson, T. D., 1999. Models in information behaviour research. Journal of documentation, 55(3), 249–270.

346 Dervin, B., 1983). An overview of sense-making research: Concepts, methods, and results to date. The Author.

347 Dervin, B., 1983. An overview of sense-making research: Concepts, methods, and results to date. The Author.

348 Ingwersen, P., 1996. Cognitive perspectives of information retrieval interaction: elements of a cognitive IR theory. Journal of documentation, 52(1), 3–50.

man or the machine as information processing device (Ingwersen, [349]). Difference lies in that in automatic (symbolic processing) the world model is dynamic but self-contained and consisting of the human cognitive structures embedded in the system prior to processing.[350] In human information processing (perceptual) the world model is built based on dynamic and interchangeable cognitive structures that shape perception and processing of external input during communication and information retrieval.[351]

On the one hand, there is a symbolic system embedded into the structure of information system providing user with the information, while on the other hand, there are cognitive structures of the user that are dynamic and are influenced by other external inputs during interaction with socio-technical system (as information could be searched by technical means such as information system or the social means such as user personal social network. The fact is that users interacting with such a socio technical system is movment towards a steady state (to do some job or handle the situation). To design an information system that supports a more efficient process of achieving steady state, one can step back and observe the user and the information system as one open system. To achieve a steady state, both symbolic systems and cognitive structures will be important. For example, if the user does not understand the language (symbolic system) which the information system uses, then it is not of use to him. Or, if the system provides information about properties and the user is searching for a car, then again, there is not much use in it. According to Ashby[352], feedback is not enough to understand such complex systems, but behaviors have to observed (that are goal seeking and occur in complex patterns). Collecting log data of users interacting with the system and data describing their socio-cognitive characteristics is a step closer to behavior quantification. Access to a separated set of variables related to the "block" of information search and retrieval and "block" of recommendation provides substantial data that could be conducive to describing such complex behavior. For example, if a user is searching the music on YouTube and if YouTube will know how the user was affected by results retrieved (by using emotion recognition software), then the recommender system could improve

[349] Ingwersen, P., 1996. Cognitive perspectives of information retrieval interaction: elements of a cognitive IR theory. Journal of documentation, 52(1), 3–50.
[350] Ingwersen, P., 1996. Cognitive perspectives of information retrieval interaction: elements of a cognitive IR theory. Journal of documentation, 52(1), 3–50.
[351] Ingwersen, P., 1996. Cognitive perspectives of information retrieval interaction: elements of a cognitive IR theory. Journal of documentation, 52(1), 3–50.
[352] Ashby, W. R., 1961. An introduction to cybernetics. Chapman & Hall Ltd.

its results based on those data (if algorithm A is making people happier than algorithm B, then use algorithm A). Or, if there is a corporate reporting information retrieval system that also uses the recommender system to provide managers with the reports, and the system stores logs about who on who clicked which report, then the recommender system could evaluate its outputs based on the type of information objects used (e.g., charts or table). As a result, we are reducing subsystems complexity and we could come to the data structures that could be easier for analysis and the concept of feedback becomes of interest as it could be used to handle such lower complexity of the system. Bates[353] pointed out to the long tradition of the information science and IT discipline interactions in terms of implementing information technology innovations into design features of information systems that are user friendly, improve search success, information access improvements and optimal implementations of those innovations. She also pointed to the "Big Science" during the WW2 period when the government leaders saw the opportunity in improving the distribution and transfer of information about new discoveries between separated teams of engineers and scientists. As distribution and transfer between users in this case was made through governmant intervention, it means that they were trying to develop recommender systems that would help to find information and a better use of it. Kuhlthau[354] invited for innovations in filtering, transmitting and distribution of information based on the analysis of the role and practice of intermediaries involved in information objects acquisitions. Intermediaries have roots in the bibliography, collecting and classifying texts and developing retrieval strategies. Expertise and patterns of intermediaries could be observed and learned about while they were interacting with the users and such findings could help in the design of the recommendation systems. As studies of information behavior rarely include information retrieval system design features into their research inquires, information management and information system design may be the weakest contribution to the information-seeking domain so far (Järvelin and Ingwersen,[355]). The issue raised by Järvelin and Ingwersen[356] is important because information retrieval features are not well researched, they could not be communicated to other fields dealing

353 Bates, M. J., 2010. Information behavior. Encyclopedia of library and information sciences, 3, 2381–2391.

354 Kuhlthau, C. C., 1991. Inside the search process: Information seeking from the user's perspective. Journal of the American society for information science, 42(5), 361.

355 Järvelin, K. & Ingwersen, P., 2004. Information Seeking Research Needs Extension towards Tasks and Technology. Information Research: an international electronic journal, 10(1), n 1.

356 Järvelin, K. & Ingwersen, P., 2004. Information Seeking Research Needs Extension towards Tasks and Technology. Information Research: an international electronic journal, 10(1).

with information systems design. This issue could be extended towards the putting the recommender systems analysis and design as a part of information behavior research in overall, covering the process of satisfying information needs.

Block 5 – Content use and analysis

Information becomes "used" and evaluated in a relationship to the information needs of the user.[357] It could satisfy (or not) the user needs but could also be evaluated in terms of potential relevance to another user and could be transferred to that person.[358] This is evidence of a clear link between the use and recommendation. Information processing and use is something happening beyond information seeking and is an essential component in the feedback loop from a person in context and his or her information needs. Information processing and use obtained by the user during the process of satisfying an information need[359] could be described quantitatively as patterns of information behavior (of a human and information system) by analyzing logs collected through the process of information seeking and searching. There is a clear distinction between information processing and information use, where the former could be described as incorporation of the information into the user's knowledge framework, beliefs or values and the latter explaining situations when the user changes state of knowledge, behavior, values and beliefs.[360] In both cases, user fills the cognitive gaps, changes affective states supporting him or a group which he was involved with, their values and beliefs.[361] Also, it could influence and/or support changes of the structure and relationship between information objects based on the logs collected and analyzed. This is particularly important in the current trends of distributed computing and social media, when a large number of end users process and use the same source of information but in a personalized way (such as Facebook) or a large number of users who share a single database (such as Blockchain technology). Observing a user and an open information system requires a proper understanding of the ways how information is processed on

357 Wilson, T. D., 1981. On user studies and information needs. Journal of documentation, 37(1), 3–15.

358 Wilson, T. D., 1981. On user studies and information needs. Journal of documentation, 37(1), 3–15.

359 Wilson, T. D., 1997. Information behaviour: an interdisciplinary perspective. Information processing & management, 33(4), 551–572.

360 Wilson, T. D., 1997. Information behaviour: an interdisciplinary perspective. Information processing & management, 33(4), 551–572.

361 Wilson, T. D., 1997. Information behaviour: an interdisciplinary perspective. Information processing & management, 33(4), 551–572.

the side of the information system from which information is retrieved. By doing so, it might be possible to overcome challenges related to observation of information need (in terms of limitations related to observations as they are of subjective nature). Since their relationship with the information behavior is casual, observing changes in the information system accessed by users paves the way for gaining insights into their information needs of the user and the way in which users process information. For example, knowing what somebody is searching forgives rise to insights into their information needs. Another aspect is that information processing and use is related to learning (as it changes state of the knowledge). Observing such changes of knowledge, it is possible to observe behavior in longer periods of time using quantitative methods explaining social network properties, characteristics, dynamics and formation of the new functions and goals. If new goals or tasks at hand are created, then new types of information need will appear and by analyzing interaction logs the system will be aware of it. Therefore, data could be collected from the user's side and by observing changes that happen in the information systems (or other machines) the user interacts with. It is aligned with the call of Wilson[362] to use more social research methods (quantitative and qualitative) to explore social and organizational contexts based on the theories and philosophical stances from communication and social sciences. To support users information need, there should be an information system that could adapt automatically based on the user needs.

On the grounds of the information used and processed, innovation in the social systems takes place. Its diffusion will not happen only because of the new information is used, information need satisfied, and the state of knowledge changed, but as a result of effectively designed phases of innovation programs.[363] By acknowledging that such programs could intervene in the diffusion of innovation, we also acknowledge the interest in such programs, resulting in their instrumentalization (most of today's business organizations have whole departments dealing with innovation). So, there is a clear connection with the information behavior and social structures and their dynamics.

362 Wilson, T. D., 1981. On user studies and information needs. Journal of documentation, 37(1), 3–15.

363 Wilson, T. D., 1997. Information behaviour: an interdisciplinary perspective. Information processing & management, 33(4), 551–572.

Saracevic[364] pointed out that a user interacts with the output of the system and evaluates the outputs in relation to the initial problem. We could understand this process as an open system reaching a steady state, being able to fulfil a task at hand or a situation. Dervin[365] describes the information use through the way in which a user makes sense of it and such information could help and hurt (or support or change beliefs, task or situation). So, collecting feedback on the information provided to the user is the essence of the adaptive information system design.

Ingwersen[366] described information processing as the act of reception and the generation of information and it is related to the world model of the agent that retrieves information (human and/or machine). In fact, information is not stored in the system but emerges when the user is connected to the system which is processing structured data in the system, or as he puts it: *real information is understood as a result of human interpretation of data sources during communication and information interaction*. Analyzing the user interaction with the information system could shed light on how structured data becomes information with regards to the user and the information system or someother information-processing machine. By analyzing how the user processes and uses information could explain how the users act upon the environment they are in. For example, an observation could be conducted to monitor how users A and B access the same report, for how long they process it and how they acted after processing data from the same report. User A could move report to read e-mails folder and he spends one minute reading report while User B could start to call his associates in relation to the results from the report (which took him twenty minutes to read). If Ellis's model is understood as a process happening in time[367], information use as a trigger that changes the state of the user. After "extracting", the user will use information extracted and start to verify it before being able to stop the search by "ending" it. If the information system knows that information is used, it could trigger (semi)automatically a new sequence of information seeking. Once the process of information seeking comes to an end, it could be predicted that the open system of the user and the machine reached a steady state in which the job or the task at hand could be completed.

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364 Saracevic, T., 1996. Modeling interaction in information retrieval (IR): a review and proposal. In: Proceedings of the ASIS annual meeting (Vol. 33, pp. 3–9).

365 Dervin, B., 1983. An overview of sense-making research: Concepts, methods, and results to date. The Author.

366 Ingwersen, P., 1996. Cognitive perspectives of information retrieval interaction: elements of a cognitive IR theory. Journal of documentation, 52(1), 3–50.

367 Ellis, D., 1989. A behavioural approach to information retrieval system design. Journal of documentation, 45(3), 171–212.

In a similar way, the information search process defined by Kuhlthau[368] could be explained. Its decomposition to the affective (feelings), cognitive (thoughts) and physical (actions) dimensions of the process can even provide deeper insight into the process of information processing and use. Within this analytical framework, changes between different stages could be described with richer data sets. This is important as sensors could be used to detect brain waves describing what is happening in terms of cognition, a video signal of the user's face to detect affect of the user and observe what types of documents or data the user actually accessed in the process. In most cases, the relevance of different information sources and channels is evaluated on the basis of their familiarity and effectiveness in information use situations.[369] This is aligned with the DeLone and McLean IS system success model[370] indicating that user satisfaction and willingness to employ IS are related to the information, system and services qualities of IS.

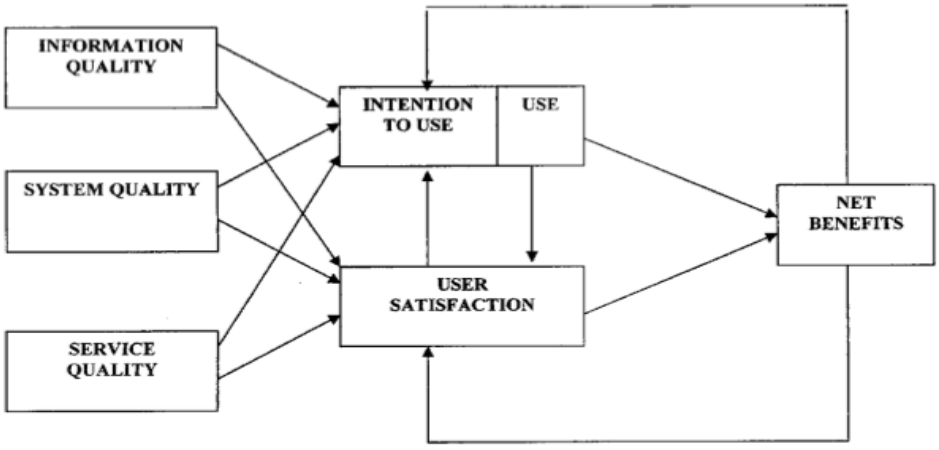

Figure 32 – Updated D&M IS Success Model[371]

Savolainen[372] further elaborated that mastery of life is a problem solving activity in which

368 Kuhlthau, C. C., 1991. Inside the search process: Information seeking from the user's perspective. Journal of the American society for information science, 42(5), 361.

369 Savolainen, R., 1995. Everyday life information seeking: Approaching information seeking in the context of „way of life". Library & information science research, 17(3), 259–294.

370 Delone, W. H. & McLean, E. R., 2003. The DeLone and McLean model of information systems success: a ten-year update. Journal of management information systems, 19(4), 9–30.

371 Delone, W. H. & McLean, E. R., 2003. The DeLone and McLean model of information systems success: a ten-year update. Journal of management information systems, 19(4), 9–30.

information seeking is an integral activity. It could be said that except for information processing and use, the user could act upon the environment based on the information. Information processing is incorporating retrieved data into existing structure of knowledge, values and beliefs. User could change any of those while acting upon the environment as a result of information use. One of the goals of information seeking research is to support the design and evaluation of IS and/*or the analysis of social and organizational practices, with related construction of meaning, if not feeling in a task or leisure activity setting.*[373] *Bearing this in mind could generate interest between users and the inform*ation system working together as an open system aimed to reach a steady state. The question is what could be observed to learn more about how those open socio-technical systems reach the steady state. For example, how users finds information for the purpose of incorporating it into their own systems of beliefs and values (i.e., read the comments below the article to support his attitude toward the content in the article), changee their state of knowledge, beliefs and values (i.e., reads the article and learn something new and change their state of knowledge) and/or acts upon the environment by using the information found (i.e., contact the author of the article and share some more data related to the topic of such an article). Incorporation, change and act could be understood as already proposed three dimensions of socio technical information behavior model. So, any socio technical information behavior system could have three purposes, or better to say, reasons why somebody engages in the process of satisfying information needs. Those purposes are presented in Table 16.

Table 16 – Three modes of engagement in information seeking and searching resulting in information behavior

Incorporation	*cognitive processing*	*interests*
Change	*communications*	*intervention*
Act	*co-operation*	*instrument*

372 Savolainen, R., 1995. Everyday life information seeking: Approaching information seeking in the context of „way of life". Library & information science research, 17(3), 259–294.

373 Järvelin, K. & Ingwersen, P., 2004. Information Seeking Research Needs Extension towards Tasks and Technology. Information Research: an international electronic journal, 10(1), n 1.

Patterns of information behavior of such an open system could be observed for the purpose of learning how a human and a machine reach a steady state to process, use or act upon the environment based on the information. Focus is on those patterns that are dynamic and are emerging based on the information seeking behavior. Those patterns that are static and do not change do not convey much information. For example, if end user follows the same pattern when selecting a movie on Netflix (i.e., he selects an action movie one after another and this happens twenty times in a row), then the recommender system "knows" that its algorithms are satisfying the needs of the user. However, if after twenty action movies user tries to find a romantic drama and could not find the right one and starts to browse through the interface in different patterns, then this is a signal for the recommender system that something changed. This new pattern of information behavior is a result of internal properties of the open system of a man and a machine. A different romantic drama will be selected by different users and how such a system reflects on the environmental circumstances based on the signal received from such an environment.[374] The change in the pattern is related to:

a) agent (human or artificial) properties and features (such as cognitive capacity, affect, social and technical aspects)
b) properties and features of information system from which it retrieves information
c) environment in which information seek and search is happening
d) how signal from the environment is processed by agent and information system, and
e) how much time is at disposal to find information.

Change could happen at the three levels (reference to table above):

1) processing (incorporate into belief or values)
2) use (change the state of knowledge)
3) act upon (solve problems).

And two types of experience could happen by doing so, according to John Dewey[375]:

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374 Lugović, S., Dunđer, I. & Horvat, M., 2015, January. Patterns-based information systems organization. In Proceedings of the 5th International Conference: The Future of Information Sciences (INFuture) (pp. 163–174).

375 Dewey, J., 1929. Experience and nature. London, UK: George Allen & Unwin, Ltd, Available at https://archive.org/stream/experienceandnat029343mbp/experienceandnat029343mbp_djvu.txt, (retrieved 10. 10. 2017.).

a) primary
b) secondary.

Dewey differentiated between two types of experience, primary experience and secondary or reflective experience pointing that: *Contrast between gross, macroscopic, crude subject, matters in primary experience and the refined, derived objects of reflection in secondary experience*.

Differences between two types of objects of experience are presented in Table 17:

Table 17 – Primary and Secondary Experiences by John Dewey[376]

Primary Experience = Processing	**Secondary Experience = Use**
gross, macroscopic, crude subject- matters	refined, derived objects of reflection
primary experience sets the problems and furnishes the first data of the reflection	explain the primary objects, they enable us to grasp them with understanding, instead of just having sense-contact with them
in immediate contact	what is experienced gains an enriched and expanded force because of the path or method by which it was reached
	the meaning is contained in a whole system of related objects
	they are rendered continuous with rest of nature
	take on import of the things they are now seen to be continuous with

We could understand that primary experience is related to information processing, as structured data is experienced and incorporated as information into the existing values and beliefs

[376] Dewey, J., 1929). Experience and nature. London, UK: George Allen & Unwin, Ltd, Available at https://archive.org/stream/experienceandnat029343mbp/experienceandnat029343mbp_djvu.txt, (retrieved 10. 10. 2017.).

framework of the user (processing). Secondary experience is related to values, knowledge and beliefs that are changed (use). Act upon environment happens when the system reaches a steady state as a result of incorporating information into beliefs and value system (processing) and the state of the knowledge is changed (use), or it could be defined as a function of primary and secondary experiences. This function is represented by a dynamic emergence of information behavior patterns over time. Those patterns are represented in the information seeking and searching interaction logs collected. And by processing and analyzing logs the information system has means to adapt to the user information needs including environment, task and social network he is operating in a particular moment in time.

Challenge is in the amount of information and noise in the signal. For example, if we observe a pattern in a closed system (user interacting only in the YouTube environment or searching one particular website), then by observing the time needed for a user to select the movie, the quality of the algorithm. Time and data describing behavior could give information about the user and about the system. It is similar if logs are used to analyze the online user behavior on a particular website. Time as a variable is rich in terms of information/noise ratio as space where it all happens (YouTube or website) is determined and does not ingest much of the noise into the calculation process. But on the other hand, insight generated from such analysis is of little value, as it is related to predefined closed system of a particular domain (YouTube or website).

Open questions could be what the user has done before this interaction with the system, what he has experienced in the environment, how he processes it, how his characteristics change, how his affective states change, who he or she is interacting with, by using which devices, who recommended him a particular movie, how the film watched will influence his further information seeking behavior, etc. A shift from the the observing close system (user interacting with YouTube) to the open system in which the user has socio-cognitive experience, seeking for information through different sources, searches and retrieves it from particular system that recommends it and at the end, he or she could process it, use it or act upon, then there is a a richer signal with more information, but there is much more noise in such a signal. There is challenge how to reduce it and extract information that could be the trigger for some functions. Time variable is present in both cases; the space variable is a constant in the closed system analysis but not determined in the open system analysis. In order to address / tackle /avoid such issues in the

analysis, a larger number of users could be observed interacting with the system and the total space of all of them could be defined, as conducted in the experiment showcased in the next chapters of this thesis. A large number of users were given the task to search for information without time and source constraints (so they could search for relevant information whenever they wanted using the internet browser without time limitations). Even in such space there is primary and secondary experience of every open system (consisting of a user and information system he is using) reaching a steady state. It could be understood that user A searching Google and user B searching Google are two different open systems. But both will steer towards the steady state that will be reached based on their socio-cognitive experience and the quality of their laptop. For example, the user B has a slower laptop but knows much more than user A, but eventually user A will take less time to reach a steady state. It is important to try to understand technical and social aspects of such an open system to be able to figure our what influences behavior. Such a system could be explained using the terminology of system dynamics, which describes a system as a set of causal loops diagrams. They could be called causally closed system (as the causes that trigger particular behavior are inside the system), but they are still open as they are capable of receiving disturbance, energy, material and inputs outside of the system boundaries (Forrester,[377]) The system is open in terms of exchange of energy and information from the environment, but the causal loops between entities are defined. User(s) is one entity while socio-technical system (including information system) is another entity. Those entities could be defined as a single set of causal loops. For example, when somebody searches for music on YouTube, its recommendations will change over time. Another set of causal loops could be found between the "blocks" in the information behavior process. Different socio-cognitive experience will result in different information seeking patterns and engagement with different socio technical sources to do so. Different information seeking strategies could lead the user to different information searching interfaces with different information retrieval mechanisms, different information searching and retrieval activities could have different recommendations system implemented and different recommendations techniques could result in different information processing and use, which in turn, is a trigger for different recommendations, different search and retrieval interfaces, different seeking strategies and new socio-cognitive information experience. The literature abounds in classifications that fit the above elaborated differentiations of processing, use and

[377] Forrester, J. W., 1994. System dynamics, systems thinking, and soft OR. System dynamics review, 10(2–3), 245–256.

acting upon environment.[378] In Tables 18, 19, 20 illustrate different frameworks related to the information followed by a synthesis of those frameworks comparing them:

Table 18 – Deacon's three types of information [379]

Type of information	**Underlying theories**	**Focus on**	**Semiotics perspectives**
Information 1	Shannon	Data, pattern, signal, data communications	Syntax (what it exhibits)
Information 2	Shannon + Boltzmann	Intentionality, aboutness, reference, representation, relation to object or referent	Semantics (what it conveys)
Information 3	Shannon + Boltzmann + Evolution	Function, interpretation, use, pragmatic consequence	Pragmatics (what it is for)

Table 19 – Three different types of system formation[380]

Type of the system	**Evolution of sign processes**	**System formations: from patterns to new goals**
Self-restructuring systems	Reflective pattern formation in dissipative systems – emergence of signs	Forming patterns is the way self-restructuring systems reflect some changes in the conditions in the environment of the system.
Self-reproducing systems	Intelligent symbolization in autopoietic dissipative systems – emergence of symbols	Self-reproduction requires structures to be functionalized for survival. Functionalized structures are not plain

[378] Lugović, S., Dunđer, I. & Horvat, M., 2015, January. Patterns-based information systems organization. In Proceedings of the 5th International Conference: The Future of Information Sciences (INFuture) (pp. 163–174).

[379] Dodig Crnkovic, G., 2012. Physical computation as dynamics of form that glues everything together. Information, 3(2), 204–218, citing Deacon, T. W., 2011. Incomplete nature: How mind emerged from matter. WW Norton & Company.

[380] Hofkirchner, W., 1999. Towards a Unified Theory of Information – The Merging of Second-Order Cybernetics and Semiotics into a Single and Comprehensive Information Science. In 15e Congrès International de Cybernétique, Namur 1998, Namur 1999, 175–180.

		patterns anymore, but something that contains meaning.
Self-determining systems	Conscious formation of ideas in re-creative autopoietic systems – emergence of goals (ideas)	Systems which do not merely (re)produce themselves and strive for survival, but in doing so seek additional goals, which they are committed to and which they have chosen on their own. There are three steps of idea formation: 1. Perception of signals from outside the system resulting in modification of the system structure; 2. Interpretation of the perceptions by which a system is modified; 3. Evaluation of the interpretations modifying a system by affecting behavior.

Table 20 – The Tripartite Scheme[381]

Knowledge about	**Description**
Cooperativities	The emerging patterns or modes to which they give rise
Set of primitives	The interacting elements themselves
Boundary conditions	The parameters acting on the system

Crnkovic pointed that: *Reality for an agent consists of structural objects (informational structures, data structures)* with *computational dynamics (information processes) that are adjusted to the shared reality of the agent's community of practice.*[382] In this sentence we could recognize processing (*structural objects and data structure*), use (*computational dynamics*) *and acting upon environment* (*community of practice*). A synthesis of the above framework is

[381] Kelso, J. S., 1997. Dynamic patterns: The self-organization of brain and behavior. MIT press, page 4.

[382] Dodig-Crnkovic, G., 2014. Info-computational constructivism and cognition. Constructivist Foundations, 9(2), 223–231.

presented in Table 21:

Table 21 – Different explanations of three modes of steady state

Wilson/ Savolainen	**Dodig - Crnkovic**	**Hofkirchner**	**Kelso**	**Deacon**	**Dewey**	**Leont'ev** [383]	**Lugovic**
Processing	Informational and data structure	Self-restructuring systems / Cognitive	Boundary	Information 1 – Syntax (what it exhibits?)	Primary Experience	Operations	Structure
Use	Computational dynamics	Self-reproducing systems / Communication	Set of primitives	Information 2 – Semantics (what it conveys?)	Secondary Experience	Actions	Functions
Solve problems (Act upon environment)	Community of practice	Self-determining systems / Cooperative	Cooperativities	Information 3 – Pragmatics (what it is for?)	Function of Primary and Secondary Experience	Activity	Goals

It is possible to define three modes of the steady state, the first mode is when the system reaches the steady state and a new structure of the system emerges, the second mode is the one when the steady state is reached and the system is able to perform a new function (based on new data structure) and the third mode, when the steady state is reached and new goals resulting in the acting upon the environment (based on the new functions). It could be concluded that the world is understood as three dimensional, so the message resonates in those three dimensions, but observing feedback signals that make a difference opens up the fourth dimension, the dimension

[383] Leont'ev, A. N., 1978. Activity, consciousness, and personality. Retrieved 23 August, 2012 from http://www.marxists.org/archive/leontev/works/1978/index.htm (Archived by WebCite® at http://www.webcitation.org/5IWYmOhTm).

of information.

RESEARCH METHODS IN INFORMATION BEHAVIOR – A SYSTEMATIC REVIEW

This chapter presents a quantitative and qualitative literature review on research methods in the field of information behavior, with a specific emphasis on log analysis as the main data collection technique used in this PhD thesis. It is as an extension of the analysis done by Greifeneder[384]. She analyzed the published papers from 2012 to 2014 in three major journals: *the Journal of the Association for Information Science and Technology* (JASIST), *the Information Research*, the *Journal of Documentation* (JDoc). She also analyzed the papers published in the iConference proceedings. Those publications include leading scientists and have rigorous double blind review, low acceptance rate and a large number of published papers. For the purpose of this dissertation, focus is only on the journals while iConference proceedings are not analyzed. Journals were searched by keyword „information behavior" for the years from 2014 to 2016. In total, for a more in-depth analysis 100 papers were selected from the *Information Research*, 55 from the *Journal of Documentation* and 452 from the *Journal of the Association for Information Science and Technology*. Not all the papers are available to the author and some are left out of the scope of the analysis because they did not have people as a subject of the study included in the scope of their research. For the purpose of this systematic review, 97 papers from the *Journal Information Research*, 39 from *Journal of Documentation* and 268 *from the Journal of the Association for Information Science and Technology* were selected for analysis.

The first part presents a quantitative analysis and the second part gives a qualitative analysis of the articles that used logs analysis as a method. They are elaborated and placed in the context of the conceptual framework presented in Chapter 3.

Quantitative analysis

384 Greifeneder, E., 2014, December. Trends in information behaviour research. In: Proceedings of ISIC: the information behaviour conference (No. Part 1).

Based on the analysis of 404 papers, Table 23 presents how many methodologies are used in the research.

Table 22 – Number of articles analyzed

Name of the Journal	Number of articles analyzed
Information Research	97
Journal of Documentation	39
Association for Information Science and Technology	268
Total	**404**

Table 23 – Number of Methodologies used (Quantitative and Qualitative or Both)

Number of methodologies	One Methodology	Two Methodology
Information Research	91	6
Journal of Documentation	37	2
Association for Information Science and Technology	243	25

Table 24 – Type of the results when one method is used[385]

Type of the results when one method is used	Quant.	Qualit.	Mix (results)
Information Research	42	43	5
	46.67%	47.78%	5.56%
Journal of Documentation	11	26	0
	29.73%	70.27%	0.00%
Association for Information Science and Technology	166	72	2
	69.17%	30.00%	0.83%

[385] Means that data collection is based on Mix qualitative data, but results are presented in quantitative terms.

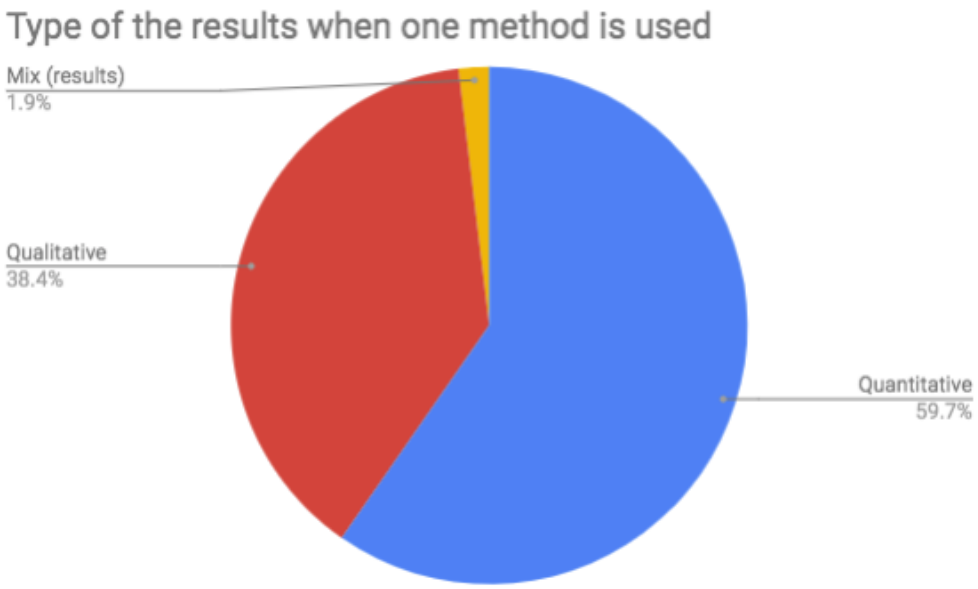

Figure 33 – Type of results when one method is used

Table 24 and Figure 33 present the distribution of the types of the results (qualitative or quantitative) is presented. Mix results mean that data collection is based on qualitative data, but results are presented in quantitative terms, but quantitative results prevail (59.7%). The journals have different research method approaches. In the *Information Research* results are distributed evenly, while qualitative results prevail in the *Journal of Documentation* (70.27%) and quantitative (69.17%) prevail in the the *Association for Information Science and Technology*.

Next step in the analysis is related to the methods used. Table 25 presents a list of the methodologies used in the analyzed corpus and how they are distributed across the three journals.

Table 25 – Type and number of methodologies used in research per different publication

Methodologies used	**Information Research**	**Journal of Documentation**	**Association for Information Science and Technology**	**Total**
Literature Review	6	7	14	**27**
Theory review	9	10	24	**43**

Diary	2	1	5	**8**
Observation	14	3	11	**28**
Survey	33	7	63	**103**
Draw & Write	1	0	2	**3**
Interview	28	8	38	**74**
Photo	1	0	0	**1**
Photovoice	1	0	0	**1**
Content analysis	11	2	58	**71**
Laboratory	8	3	51	**62**
Logs	4	2	19	**25**
Bibliographic	1	1	9	**11**
Case Study	4	1	12	**17**
Think-aloud	2	0	6	**8**
Web analytics	2	0	2	**4**
Longitudinal study	0	2	1	**3**
Collaborative review	0	0	1	**1**
Schema testing	0	0	1	**1**
User Studies	0	0	6	**6**
InBox usage data	0	0	1	**1**
Usability tests	0	0	4	**4**
Field study	2	0	1	**3**
Biofeedback	4	0	6	**10**
Narrative inquiry	0	0	1	**1**
Policy capture	0	0	1	**1**
Prototyping (evaluation)	1	0	3	**4**
Social network Analysis	0	0	3	**3**
Online Experiment	0	0	1	**1**
Focus Group	1	0	1	**2**
Card-sorting exercise	2	0	0	**2**
Documentary analysis	1	0	0	**1**
Total	138	47	345	**530**

The most popular research method is survey (103), followed by interviews (74) and content analysis (71). It is also interesting to see that the laboratory method is often used (62).

This analysis follows the previous research approach by Greifeneder[386], which groups the research into three main categories, first one is „how", addressing how people interact with information, the second is „who", addressing who was looking for information, and the third category is „where", addressing where the information is looked for. One research could address more than one category. Once the papers are analyzed, when more than one topic were researched, each one was counted toward the overall number. All papers are analyzed in terms of those categories of the research aims or the hypothesis and were given one point for addressing how, who and where. At the end of the analysis those points are summarized and presented in Table 26.

Table 26 – Overview of the areas of interest of analyzed papers

How, Who and Where analysis			
Information Research	**How**	**Where**	**Who**
Total	90	45	51
Percentage	48.4%	24.2%	27.4%
Journal of Documentation			
Total	37	10	17
Percentage	57.8%	15.6%	26.6%
Association for Information Science and Technology			
Total	226	149	142
Percentage	43.7%	28.8%	27.5%
All journals together			
Total	353	204	210
Percentage	46.00%	26.60%	27.40%

Table 27 – Overview of the number of questions the research paper was addressing (How, Where, Who)

	All three	**Two**	**One**
Information Research	20	53	20
Journal of Documentation	3	21	13
Association for Information Science and Technology	82	108	55
Total	105	182	88

386 Greifeneder, E., 2014, December. Trends in information behaviour research. In: Proceedings of ISIC: the information behaviour conference (No. Part 1).

Table 28 – Distribution of research interest when two questions were studied

Information Research	**How & Who**	**How & Where**	**Who & Where**
	49	43	6
Journal of Documentation	**How & Who**	**How & Where**	**Who & Where**
	17	10	3
Association for Information Science and Technology	**How & Who**	**How & Where**	**Who & Where**
	129	135	90
Total	**How & Who**	**How & Where**	**Who & Where**
	195	188	99

Table 28 gives the summary of all papers in terms of their research interests (how, where and who). It is valuable to understand what is researched to realize which areas are still in need of further study. It is particularly interesting to note which of those questions together are studied and if behavior is understand as a function of an agent in the environment. An appreciation of information behavior requires the awareness of who, where and how searched, which could shed more light on information behavior. But out of 404 papers only 106 researched all three questions together. Furthermore, the analysis shows that most of the papers covered the "how" question, explaining how people seek and search for information, but this is not enough. In order to make sense of information behavior, there should be an observation and an attempt to figure out why somebody seeks and searches information, where it happens and who the agent is who does that. As information behavior changes, the state of the agent changes (as he reduces information need, he could act based on the retrieved information, finish the task and move to a new one), state of the environment changes (agent acts upon environment) and state of his social environment changes (form groups, change the social structure of the groups, influence group behavior). More could be learned about information behavior only if the answers are pursued in all three aspects. Such an approach is very important at this day and age when humans are exposed to a large

amount of data and artificial agents have functions to give recommendations on what to read, watch or listen to. From that perspective, human behavior could be understood as artificially influenced. And if it is understood only how humans behave, there is no understanding why they behave in such a way. In music related information seeking and searching it is particularly important to understand what triggers the music related information behavior and how different triggers influence different segments of music consumers. Large number of how – shows that behavior happens between the information system and user where the environment is. This research covers all three aspects: who is searching (by survey), where (which websites), and how (pattern of behavior).

Qualitative literature review

This section gives an overview gives an overview of the selected research articles that used log analysis as a method, as this research is based on the same method. It has two main aims, one aim is to analyze similar studies that used log analysis as a research method, but at the same time to use the five blocks concept of information behavior presented in the previous chapter. So, the articles are analyzed in terms of the socio-cognitive user experience resulting in information need, information seeking, information searching, recommendation and the actual use of information. In total, 20 papers are analyzed. Table 29 presents a review of how many papers addressed the research of particular information behavior blocks.

Table 29 – Number of articles addressing each of the blocks

Articles per block	
Socio-cognitive experience	18
Information seeking	13
Information search and retrieval	16
Recommendation	14
Information use	8

Table 30 – Numbers of papers analyzing different "blocks"

Number of "blocks" analyzed	
5	3
4	4
3	12
2	1
1	

It is interesting to see that only three papers in their scope of analysis studied all five blocks. It could be argued that the proposed concept of five blocks covering different aspects of human information behavior could be used in future research as an analytical framework that provides a better understanding how users experiences information, about their socio-cognitive properties, how they seek, search and retrieve information, what rules, algorithms and procedures used to recommend information and actually which particular information is used and how often. This could show that a user's socio-cognitive experience and information search are most often the area of interest. It could be explained that researchers are interested in who is searching and how. It is not aligned with the results of the whole corpus presented above, where only 27.4 % papers analyzed who is searching for the information. It could be explained that most of the papers that used the log analysis tried to connect users' characteristics and their information behavior and try to find interplay and causality between these two. It could also be explained that such information behavior could be observed only through the data collected from the process of how actual users interact with information systems or other information sources. Since log analysis as a method is used in approximately five percent of the whole analyzed corpus, it could be understood that this type of research is quite novel and still requires further improvements in future. But as computational power and methods to collect data about users and how they interact with the information system will improve, it is fair to guess that they will be increasingly used, developed and standardized. A look outside of the academic world shows that the largest companies such as Amazon, Facebook and Google are building their business models on the data collected from their users interactions with their information systems. The music industry has seen the rise of YouTube as the ultimate music source and growth in popularity of streaming subscription services such as Deezer and Spotify. All mentioned businesses thrive on the recommendation algorithms that facilitates users in finding faster and better music that matches their taste. It is

aligned with the areas researched in these twenty articles, as the recommendation block comes in the third place of interest (14 papers were interested in recommendation block of information behavior). In most papers there is an overlap between search and seek and information retrieval. This was discussed and elaborated in the previous chapter in more depth. But it proves that discussion is needed, and a common understanding of the terms should be the end goal of the academic community in the domain of information behavior. The research results will be presented as follows: for each block the comments will be made on what papers addressed and how it relates to the proposed concept of five blocks of information behavior and a brief summary. Table 31shows that the analyzed papers are listed and marked according to their covering or not covering a particular block of information behavior (number one means that in the paper a particular block was addressed by the researcher). It also give a total number of blocks for each paper covered.

Table 31 – Total number of "blocks" of each paper

	Experience	Seeking	Search	Recommendation	Use	Total
O'Brien, H., Freund, L., & Westman, S., 2014. What motivates the online news browser? News item selection in a social information seeking scenario. Information Research, 19(3).	1		1	1	1	4
Rutter, S., Ford, N., & Clough, P., 2015. How Do Children Reformulate Their Search Queries?. Information Research: An International Electronic Journal, 20(1),	1	1	1	1		4
Berget, G., & Sandnes, F. E., 2015. Searching databases without query-building aids: implications for dyslexic users. Information research, 20(4).	1	1	1			3
Xie, I., Babu, R., Joo, S., & Fuller, P., 2015. Using Digital Libraries Non-Visually: Understanding the Help-Seeking Situations of Blind Users. Information Research: An International Electronic Journal, 20(2),	1		1	1		3
Wu, D., & Cai, W., 2016. An empirical study on Chinese adolescents' web search behavior. *Journal of Documentation*, *72*(3), 435–453.	1	1	1			3
Yuan, X., & J. Belkin, N., 2014. Applying an information-seeking dialogue model in an interactive information retrieval system. *Journal of Documentation*, *70*(5), 829–855.		1	1	1		3
Choi, E., & Shah, C., 2015. User motivations for asking questions in	1	1		1		3

online Q&A services. Journal of the Association for Information Science and Technology.						
Mohammad Arif, A. S., Du, J. T., & Lee, I., 2015. Understanding tourists' collaborative information retrieval behavior to inform design. Journal of the Association for Information Science and Technology, 66(11), 2285–2303.	1	1	1	1	1	5
Cleverley, P. H., Burnett, S., & Muir, L., 2015. Exploratory information searching in the enterprise: A study of user satisfaction and task performance. Journal of the Association for Information Science and Technology.	1		1		1	3
González- Ibáñez, R., Shah, C., & White, R. W., 2015. Capturing Collabportunities: A method to evaluate collaboration opportunities in information search using pseudocollaboration. Journal of the Association for Information Science and Technology, 66(9), 1897–1912.		1		1	1	3
Ren, Y., Tomko, M., Salim, F. D., Ong, K. & Sanderson, M., 2015. Analyzing Web behavior in indoor retail spaces. Journal of the Association for Information Science and Technology.	1	1			1	3
Shah, C., Hendahewa, C. & González- Ibáñez, R., 2015. Rain or shine? forecasting search process performance in exploratory search tasks. Journal of the Association for Information Science and Technology.	1	1		1	1	4
Williams, P. & Hennig, C., 2015. Effect of web page menu orientation on retrieving information by people with learning disabilities. Journal of the Association for Information Science and Technology, 66(4), 674–683.	1		1			2
Liu, J., & Belkin, N. J., 2015. Personalizing information retrieval for multi- session tasks: Examining the roles of task stage, task type, and topic knowledge on the interpretation of dwell time as an indicator of document usefulness. Journal of the Association	1	1	1	1	1	5
Viejo, A., & Sánchez, D., 2014. Profiling social networks to provide useful and privacy- preserving web search. Journal of the Association for Information Science and Technology, 65(12), 2444–2458.	1		1	1		3
White, R. W., 2014. Belief dynamics in Web search. Journal of the Association for Information Science and Technology, 65(11), 2165–2178.	1	1	1	1	1	5
Lopatovska, I. (2014). Toward a model of emotions and mood in the online information search process. Journal of the Association for Information Science and Technology, 65(9), 1775–1793.	1	1	1			3
Torres, S. D., Hiemstra, D., Weber, I., & Serdyukov, P., 2014. Query recommendation in the information domain of children. Journal of the Association for Information Science and Technology, 65(7), 1368–1384.	1		1	1		3

Kinley, K., Tjondronegoro, D., Partridge, H. & Edwards, S., 2014. Modeling users' web search behavior and their cognitive styles. Journal of the Association for Information Science and Technology, 65(6), 1107–1123.	1	1	1	1		4
Aloteibi, S., & Sanderson, M. (2014). Analyzing geographic query reformulation: An exploratory study. Journal of the Association for Information Science and Technology, 65(1), 13–24.	1		1	1		3

Socio-cognitive information experience

A variety of users' features are taken as a starting point for the papers reviewed, all coming from different users' features are taken. They come from different socio-cognitive or psychology-related domains. They are as follows: prior experience, learning-effects, feelings, lose courage, self-esteem, cognitive styles, grades and needs, motivation, tensions, personal knowledge, satisfaction, mental models, information overload, attention, metacognitive processes, social relationship, social context, affects, rational behavior, cognitive features, learning disabilities, established beliefs, primary and secondary emotions and mood. Numerous studies take information need as their starting point and some of them observe the social context in which information appears. Different cognitive styles, features or properties of the users were observed in relation to information retrieval, search or seek. Particular user group features were studied (children, blind people, dyslexics) as a primary object of the research, or how those groups behave when exposed to a task to find information. Additioanly, emotions and moods were viewed as a factor influencing information behavior. User's existing beliefs about the topic or the outcome of information seeking and searching were included in the study and monitored how they shape information behavior through the process of finding information. In one research, a user profile is created by computation based on their information behavior and data collected through the process of finding information. Information needs are detected and categorized into groups such as a problem to solve, a goal to attain and/or work task. Experience related to search task were were examined including how it impacts user information behavior. One research based on the experiment calls for extraction of cognitive features, motivation, rationality of behavior, as retrieved results influence performance in the process of finding information based on agents of different cognitive or motivational-related properties. Social context and situation turned out to be an important factor in defining information behavior. Organizational setting is looked upon as a trigger and factor related to information behavior including satisfaction with

search results, self-reported expertise, organization level of understanding what is known, complexity of the tasks, attention, motivation, mental models and metacognitive processes. There was also research addressing how information need is created and how this information need is presented in natural language, cognitive styles, interaction with other people (social aspects) and motivational factors. Also, there was interest in how information was validated according to agent cognitive features. Some experiments intentionally created situations to take on the appearance of an information need and then examine information behavior as a result.

Information Seeking

One of the first things coming out of the analysis is that some papers blur the distinction between information seeking and information searching. This brings up the question whether those two terms should be separated and used as a definition of the process of finding information that could be macro and micro or or more precision and rigor is required in order to define them. Such a discussion is not a part of this study, and it should be investigated further in future studies of information behavior. The analysis indicates that user's socio-cognitive information experience is related to information seeking and that different properties of the user influence how he seeks information. In terms of the research design, the tasks given to the participants were assigned in such a way that researchers could monitor how users fulfill the given task, collect data from that process and try to establish causality between the different users' characteristics and information seeking process. It also shows that different information seeking processes could be categorized and segmented by the time frame, type of information need, the context where and why it happened and by the assignment of different information seeking patterns to different social groups. A very promising and interesting research angle is observation of groups' information seeking behavior. As more and more people are connected through social media, findings from such research could shed more light on different ways how people together seek information. In most papers where information seeking behavior was observed, users were asked to seek on the internet using different sources. However what will bring the additional insights into the process of information seeking is including offline sources of information in the observations, as well.

Information Search and Retrieval

Since for this research the time needed to find the information was an important variable in the experiment, analysis of other papers using log analysis showed that time was rarely observed as a variable. Another finding is that other researchers used search engines results as retrieval systems. But it is challenging, as researchers do not have access to retrieval algorithms of those engines. As search engines behave under the coded rules and algorithms, it is hard to clearly understand which algorithm or rule is connected to human information behavior including searching and retrieval of information. Some experiments created new retrieval systems for their research and in some cases different presentation rules and algorithms were created. One research created two different retrieval systems; other research created different queries retrieval presentation algorithms. Those approaches are encouraging and important as they lay the foundation for future research where behavior is related to the algorithms used for information retrieval. The order of the retrieved information by which search results appeared was observed in terms of how it influences human information behavior. In different experiments the search result page was examined in terms of information searching, while in another similar approach it was viewed from the information retrieval perspective. But the experiments are similar, as well as their research questions, reflecting a need for a more profound common understanding of the notion of information search and retrieval as discussed in the previous chapter. Different search tasks that were categorized and how they influence searching behavior were the object of the study stressing the importance of insights into how human and information the system behave as one. One experiment built up an interface where people could build teams and later go to seek information in other sources. This approach is interesting as it demonstrates how information systems influence groups and team formation. It is very relevant in this day and age of giant social media sites, owned and controlled by others, and no knowledge about social network formation, behavior and activities could be generated from the outside observers but all that knowledge stays inside those organizations being used for the business objectives of those companies. The logs could facilitate detecting and observing that behavior and could be detected and observed and as such, it is important to use this methodology more often. In some experiments, a particular website was given as an artifact in which people performed their search tasks and retrieved the information.

Recommendation

In today's world, in most of the large systems we use on a daily basis, information is served to us based on the recommendation algorithms, but unfortunately, in the selected papers recommendation of the information is most often briefly mentioned and included in the research and experiment design. In the music information behavior, it is of high importance as music is served to a user from ultra large information systems such as YouTube, Spotify and Deezer, and whole business models of those systems are based on the recommendation algorithms. Information recommendation is mentioned in several papers of papers, but it was not a subject of the study that could provide some good starting points for future research and experiment design where different variables could be defined in the domain of information recommendation. Likewise, observing information recommendation could help to bridge a gap between information systems and information behavior research as some of the analyzed papers have done. This approach allows for a clear view into the link between human information behavior and information recommendation capabilities of the information systems where information seeking, searching and retrieval takes place. Moreover, observing how humans and machines behave as a single system could be achieved using logs that describe behavior and capture user profiles based on such interaction. Social context is also important as it gives a better insight into human information behavior.

Information Use

In the analyzed papers some findings indicate that there is no direct connection between the user and the content they looked for, which comes as a surpris. It could be explained that in the design of the experiment, all five blocks of information behavior are not used as a framework and as such, those relationships were not detected. Some researchers express an interest in suggestions for further research, which provides evidence that the analysis of how and what information is used and by whom, where and why is important for a better understanding of human information behavior. In some experiments, participants were given the sources of information to look for as a task – but actual use of information was not analyzed. Information use is the least "block" covered in search log analysis papers. Also, there are no studies that analyze how information behavior is related to the type of the content and use in the analysis. In some experiments, users have to rate/categorize information retrieved after the search and retrieval was performed and this process was a subject of the study. Understanding how different users rate and categorize content

and what they do later is the key to understanding how differences between types of users or social groups behave in terms of information seeking, searching, retrieval and use.

This Chapter presents a systematic overview of the literature that addresses human information behavior. It is based on the analytical framework of the previous research. Thus, it offers an insight into how the discipline developed over time in terms of the methodologies used in research. As it is based on the leading journals in the domain, it also sheds light on different editing policies in terms of preferred methods used. It identifies a wide range of different methodologies used and the frequency of their use. It also used the framework of three main categories, one is "how", addressing how people interact with information, another is "who", addressing who was looking for information, and finally „where", addressing where the information is looked for. After analyzing a large corpus of papers, those in which log analysis is used as a method are selected and given the quantitative and qualitative analysis of those with the aim to find if five blocks of information behavior concept proposed in the previous chapter could be detected. The results showed that different blocks were found in most papers. As many as seventeen out of twenty papers approached research and experiment design with three or more blocks proposed. On top of that, in the presentation of the qualitative results of each block, a suggestion was made on how to develop further research that could advance a deeper understanding of human information behavior. It is of a particular interest to understand the whole process, from the moment the information need is created based on socio-cognitive user experience, information seeking, searching and retrieval, information recommendation to how information is used, to include all five blocks. Only three of the papers included all five blocks in their research design.

METHODOLOGY AND RESEARCH RESULTS

The research is based on a quantitative quasi-laboratory experiment. The methods used are surveys and an analysis of logs collected through the interaction between users and a computer. The participants of the experiment are students who are selected in order to represent different fields of science. Before the main experiments, a test experiment was cunducted to test the information technology infrastructure in the lab and information searching tasks that are given to the users and structure of data collected. It was done on a smaller sample of users, more precisely, on only nine students. This test experiment helped to improve the search tasks, as in the test experiment the instructions for one task were not clear enough to some participants and one task did not yield the data in a way that analysis could be done, or better to say, data could be better structured if the given task was refined. The real experiment was done in the Polytechnic of Zagreb computer lab in the period of two weeks in a way that participants were randomly selected into ten groups for each working day. It is based on 160 participants (the initial number was 172 but some participants did not finish all the tasks given and some did not follow the procedure so that collected results were not good for analysis. Out of 160 participants 75 percent of the participants were female and 25 percent were male. There were 12,5 percent of participants who were younger than 20, 75 percent were between 21 and 25 years old, 11,9 percent were between 26 and 30 and only one participant was older than 30. Table 32 presents descriptive data related to the areas of study programs that students attended.

Table 32 – Descriptive data representing the area of the participants' study program

	Frequency	Percentage
Natural science	28	17.7%
Technical science	35	22.2%
Biomedicine and health science	19	12.0%
Social and humanistic sciences	52	32.9%
Art studies	13	8.2%
Business studies	11	7.0%
Total	158	100.0%

No answer	2	
Total	160	

Table 33 – Descriptive data describing the size of the town where a participant was born and raised

	Frequency	Percentage
Larger than 100,000 citizens	72	45.6%
Smaller than 100,000 participants	86	54.4%
Total	158	100.0%
No answer	2	
Total	160	

On average, most participants spent 983 seconds to complete the four tasks assigned ranging from 307 to 2530 seconds. The average number of steps (defined as the opening of the new web page) was 60 varying from 9 to 274 steps, going through the 7 to 37 domains (different web pages defined as steps could be inside of the one web domain).

Research design and instruments

The research analyzes the process of searching music information and finding music tracks. This process is reflected in the logs collected through a computer when searching websites to find the information given for four tasks. The logs are collected by the existing computer program that was made for this purpose. For each new visit to a page, the log contains the identifying tag of the user who visited that site, the link to that page, the time the page was loaded, and the time the page was left.

The link can be used to identify the domain of a website and the key words that the user used while searching (if they were used). At the same time, each user has their own unique characteristics that influence the information behavior and those data were collected by the survey that each experiment participant fills in before the tasks to find information were given. The experiment itself consists of the following parts.

1. All participants are given a survey to fill in, in order to collect data about their characteristics.

2. The participants of the experiment are presented with two tasks to search for a music track, and two tasks to find information about buying tickets for a music event.

3. Each participant of the experiment logs on to the computer with the unique username and password and accesses the given tasks or starts looking for information in accordance with the given tasks.

4. After completing each individual task, the participant logs on to a particular web link in order to divide the collected logs for each task in a later analysis of the data.

5. After the searches have been made according to the given tasks, the user logs out of the computer, and the computer program that generates the logs creates a file that records all the steps.

The data are collected about which websites each individual participant of the experiment visited, when they accessed them and when they left them. In this way, the acquired data reflect the information behavior of the user, quantitatively and objectively describing each step in the process of searching information.

The data collected by the survey describe:

- needs through the subject and contents of the search key words, by the function of looking for (e.g., home entertainment or new discoveries)
- the nature (e.g., criticism or historical facts), the complexity of the source of the information itself (daily newspapers or specialized journals)
- the point of view or influence of the objectivity of the source of information
- quantity and quality of information
- timeliness, geographic location of the source and the importance of the format presented
- personal characteristics
- demographic data
- emotional and educational influences
- economic dimensions related to the search and music consumption
- social / interpersonal and situational variables
- attitudes towards the sources of information.

When designing the questionnaire for the needs of classifying the characteristics of users, two other theoretical bases were considered:

1. Big Five personality test[387]
2. The model of classification of music users in four categories presented in Celma[388]

Since the socio-cognitive aspects were examined that affect the way information is searched, the chosen theoretical frameworks for the purpose of this research (information needs and the research of social characteristics of users) provide the possibility of collecting the most relevant data. The collection of these two sets of data provides:

- The data that characterize the socio-cognitive characteristics of the information behavior of each individual user that can be compared.
- The data that quantitatively describe the times and pages when the user visited them.

After collecting the data in a laboratory, the data were subsequently cleaned and the users who did not complete their tasks were excluded, as well as their related data, including those who failed to do the required tasks, those who did not fill in the survey in its entirety, or those who did not follow the instructions to complete the tasks of searching information, or collected logs were not appropriate for processing due to technical mistakes upon their collection. Such cleared data, divided into two sets (user characteristics and information search logs) were statistically analyzed for the purpose of finding the correlations and predictive values of the collected data. Cross-validation of the data is used for the purposes of proving the correlations of these predictive value variables. The research is conducted using a sample of students from Zagreb, who were selected by non-probabilistic sampling techniques. The independent variables are the information seeking tasks of music. The dependent variables are patterns of searching information. The intervention variables are the characteristics of the students.

If it is possible to identify characteristics of users and their information needs by means of machine observation of the information search form, then we can state that the information search logs collected become an input signal that the information system can use to adapt to the user.

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[387] Barrick, M. R. & Mount, M. K., 1991. The big five personality dimensions and job performance: a meta-analysis. Personnel psychology, 44(1), 1–26.

[388] Celma, O., 2010. Music recommendation. In: Music recommendation and discovery, pp. 43–85. Springer, Berlin, Heidelberg.

Objectives and hypothesis of the research

The aim of the research is to explore the ability to identify user information behavior through information search patterns on music and music records.

The research hypotheses are:

a) *different user information needs will result in different proprietary information search patterns*
b) *the user environment affects information search patterns*
c) *based on the records generated by machine observation of the information search process, characteristics of the user who searches the information can be predicted.*

Data analysis was conducted in two iterations with the aim to test different hypotheses. Hypotheses A and B are tested based on the exploratory factor analysis and regression analysis, while algorithms are used to test hypothesis C regression, AUROC and LASO.

Test of Hypotheses a & b:

a) *different user information needs will result in different proprietary information search patterns*
b) *the user environment affects information search patterns*

The first task of the analysis is to gain exploratory insights into socio-cognitive characteristics of users that search for information based on the exploratory factor analysis. Exploratory factor analysis (EFA) is used to identify the relationship between measured variables in cases when there is a large number of variables. It provides an insight into how such a large set of variables create the factors built on top of them, how particular factors emerge from those variables and how new constructs become observable. So, every factor is a new construct that could be analyzed later in the process.

The survey is structured as follows:

- variables 1 – 4 describe basic demographics of the users that search for information
- variables 5 – 16 describe user information need

- variables 17 – 30 describe personal characteristics, emotional and educational characteristics of the user
- variables from 31 to 35 describe economic barriers that influence information behavior
- variables from 36 to 39 describe social and interpersonal barriers that influence information behavior
- variables from 40 to 45 describe environmental and situational barriers that influence information behavior.

Table 34 presents a cleaned factor structure without particles with disproportionately small i.e., evenly distributed saturations on factors (therefore, it cannot be said that they belong to a particular dimension).

Table 34 – Factor structure

Variable	Factor1	Factor2
6_3 I search and expand my knowledge about a particular music genre or a musician	0.7327	
7_2 I search music: through historical facts about a musician	0.6033	
7_3 I search music: through the texts describing a musician	0.5782	-0.1178
6_4 I search and expand my knowledge about music genre or a musician beyond my primary interest	0.5211	0.1567
27_5 I can never get enough information on what I like to listen	0.4799	
34_2 Free time I dedicate to music is spent on: getting information on music	0.4591	0.2134
40_4 I will get informed on music regardless of the conditions		0.636
RECODE OFV40_1 430_1 If I do not have time, I will not start searching		0.5799
33_ How much time weekly is available for your searching new music?	0.1021	0.4881

(blanks represent abs (loading) <.1)		

Variable 6.3 & 6.4 describe how often and why the user engages in information seeking and searching, where 6.3 is related to the music that the user is interested in, and 6.4 is related to the music the user is not interested in. **Variables 7.2 & 7.3** explain the nature of information need, where 7.2 is related to the historical facts about musicians and 7.3 is related to the texts that describe musicians of interest. **Variable 27.5** is related to the personal characteristics of the user, especially how much information is enough about the music the user likes to listen to.

Variable 34.2 is related to how the user spends available free time devoted to the music, particularly information seeking and searching through various sources such as magazines and internet portals. Table 35 shows the results of the factor analysis related to particular constructs that are of interest for the purpose of this research.

Table 35 – Factor analysis

Variable	Factor1
6 3 I search and expand my knowledge about a particular music genre or a musician	0.7364
6 4 I research and expand my knowledge about a particular music genre or a musician beyond my primary interest	0.6226
34 2 Free time I dedicate to music I like to listen	0.6095
7 2 I search music through historical facts about a musician	0.6042
RECODE of v40 1 If I do not have time, I will not start searching	0.4957
33 How much time weekly is available for your searching new music?	0.4923
40 4 I will get informed on music regardless of the conditions	0.4774
27 5 I can never get enough information on what I like to listen	0.4725
7 3 I search music: through the texts describing a musician	0.4547

(blanks represent abs (loading) <.1)	

The second factor is based on the following variables: **Variable 40.1** is related to the environmental and situational barriers that influence information behavior, especially how available time at disposal will impact the user information seeking and searching behavior. **Variable 33** is related to the amount of time users have per week to searching for new music while **Variable 40.1** describes the user attitude toward conditions that could influence music information behavior, particularly stating that users will engage in information seeking and searching regardless of the conditions.

Table 36 – The ONE-FACTOR solution, obtained by the GUTTMAN-KAISER criterion of extraction

Variable	Factor1
6 3 I search and expand my knowledge about a particular music genre or a musician	0.7364
6 4 I search and expand my knowledge about a particular music genre or a musician beyond my primary interest	0.6226
34 2 Free time I dedicate to music I like to listen	0.6095
7 2 I search music through historical facts about a musician	0.6042
RECODE of v40 1 If I do not have time, I will not start searching	0.4957
33 How much time weekly is available for your searching new music?	0.4923
40 4 I will get informed on music regardless of the conditions	0.4774
27 5 I can never get enough information on what I like to listen	0.4725
7 3 I search music: through the texts describing a musician	0.4547

(blanks represent abs(loading)<.1)	

Moreover, it should be emphasized that, for theoretical reasons, we arbitrarily looked for two extracted components, instead of using some objective criterion for factor extraction (e.g. Guttman-Kaiser criterion which extracts factors whose eigenvalue of matrix correlation is higher than 1). WHen the G-K criterion was applied, only one dimension was extracted, when saturation and commonalities of particles which presumably relate to the work concept of External information engagement/time consumption in the total period of time (40_1, 40_4, 33), were slightly lower, but EFA does not have the option of testing construct validity (separation) of concepts in the strict sense.

First factor explanation

First factor is based on the following variables. Variables 6.3, 6.4, 7.2, 7.3 are related to the information need, especially to the function (6.3, 6.4) and nature (7.2, 7.3) of information needs. According to Nicholas[389], characteristics of information needs related to function, are based on the premise that every individual (and community) puts information to work in different ways. People need information in five broad functions so as to:

- provide answers to specific questions (**fact finding function**)
- keep up to date (**the current awareness function**)
- investigate new fields of interest in depth (**the research function**)
- obtain a background understanding of an issue or topic (**the briefing function**)
- provide ideas or a stimulus (**the stimulus function**).

The first factor construct demonstrates that the user will engage (or not) in information seeking and searching based on his information needs. To do so, he or she could use historical facts about a musician of interest and the available texts that he or she could find in a range of various sources such as journals and Internet portals. And if user like the music of particular musicians, then they will never have enough information about his music.

[389] Nicholas, D., 2003. Assessing information needs: tools, techniques and concepts for the internet age. Routledge. 2nd edition.

Second factor explanation

The user music information behavior will be defined by the time avaliable to seek and search for music related information, while other conditions that could impact music information behavior will not be the barrier to engage in information seeking and searching. Available time is defined by the user environment.

The next step in the analysis, by means of confirmatory factor analysis, tests the validity of constructs. The results are presented in Figure 34.

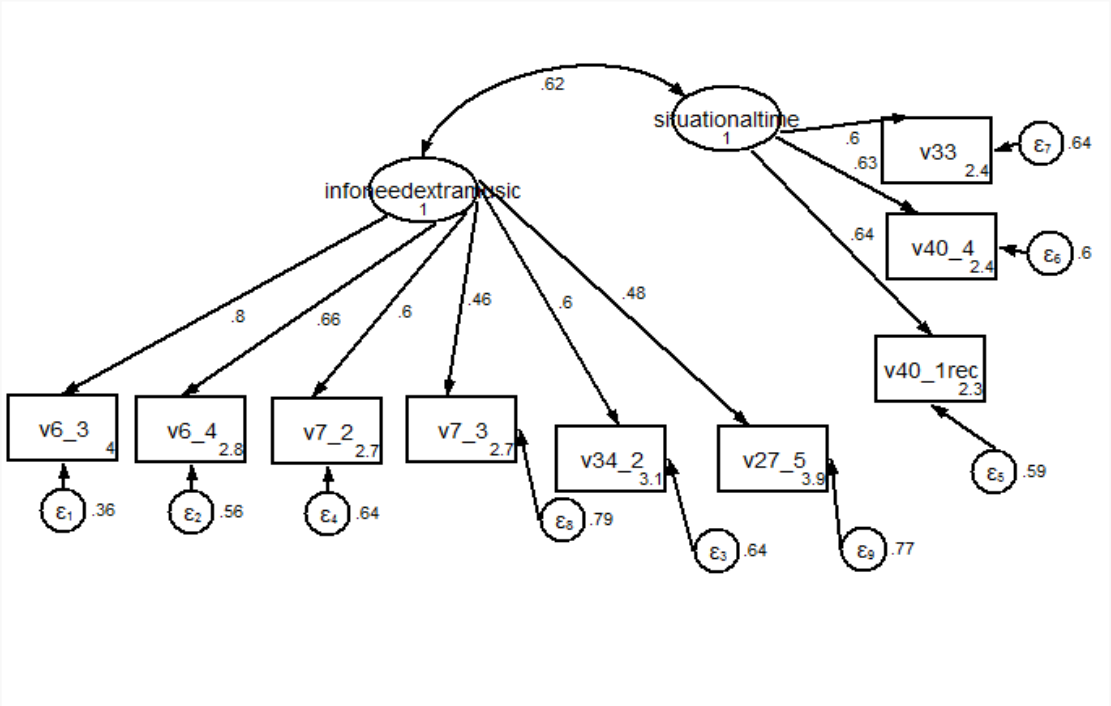

Figure 34 – Diagram of the confirmatory factor for „Internal information engagement/time consumption in the total period of time" and „Eternal information engagement/time consumption in the total period of time"

This clearly shows the validity of constructs and the two factors are aligned with the hypothesis A (information need impact to the information searching patterns) and B (the impact of the environment on the music information behavior of the user).

Table 37 – Results of the Cronbach Alpha test that measure internal consistency of the variables providing an insight how closely variables are related and show us reliability of selected variables

			Cronbach
Item	Obs		**alpha**
v6_3	159	+	0.6958
v34_2	157	+	0.736
v7_2	159	+	0.7328
v7_3	159	+	0.7584
v6_4	158	+	0.7398
v27_5	158	+	0.7652
Test scale			**0.7725**

According to the criteria of internal consistency, Cronbach Alpha above 0.7 justifies the use of the variables as additive scales. It is generally recommended that no more than five variables be employed, according to standard approaches. As a result, Variable 27.5 will be left out of any future regression analysis. Variable 27.5 is also less dependent on other variables, but it also stands out from other variables as it is the only one that describes the personal characteristics of the user.

Table 38 – The results of Cronbach Alpha test

Item	Obs		alpha
v40_4	158	+	0.4703
v40_1rec	158	+	0.5242
v33	159	+	0.5924
Test scale			**0.6221**

Table 38 presents the results of Cronbach Alpha test of the variables included in the second factor. Here we could see a noticeably lower result of the Cronbach Alpha test showing the values below 0.7 thresholds. The lower number of variables that were tested for consistency could explain these lower values. But according to the literature, it is possible to lower the threshold to 0.6[390].

For the purpose of evaluating those user's socio-cognitive characteristics that could be found in the construction of factor 1 and factor 2, regression analysis will be carried with the information searching patterns. Because of the asymmetric distribution of dependent variables that describe information searching patterns and not the existence of zero value for the variable (as the task

390 "Nunnally (1978) recommended calculation of coefficient alpha (also known as Cronbach alpha) in order to assess the reliability of a multiple-item variable. Churchill and Peter (1984) suggested an accepted level for the alpha coefficient. According to them a value of alpha below 0.60 is undesirable. Nunnally (1978; 1988) indicated that newly developed measures can be accepted with an alpha value of 0.60, otherwise, 0.70 should be the threshold. However, considering the use of these scales for the first time in a new culture, the cutoff value for the alpha coefficient was set up for 0.60 for all the scales (self-developed scales)."

given to the users was not possible to complete in zero seconds, domains or steps) linear regression is not suitable.

Poisson regression is not useful in this analysis, either, as dependent variables representing information searching patterns are dispersed in terms of arithmetic medians (*over dispersion relative to conditional mean values and variances of dependent variables*). Instead of linear or Poisson regression analysis, zero-truncated negative binomial regression will be used as it does not assume the distribution of count having variance equal to its mean.

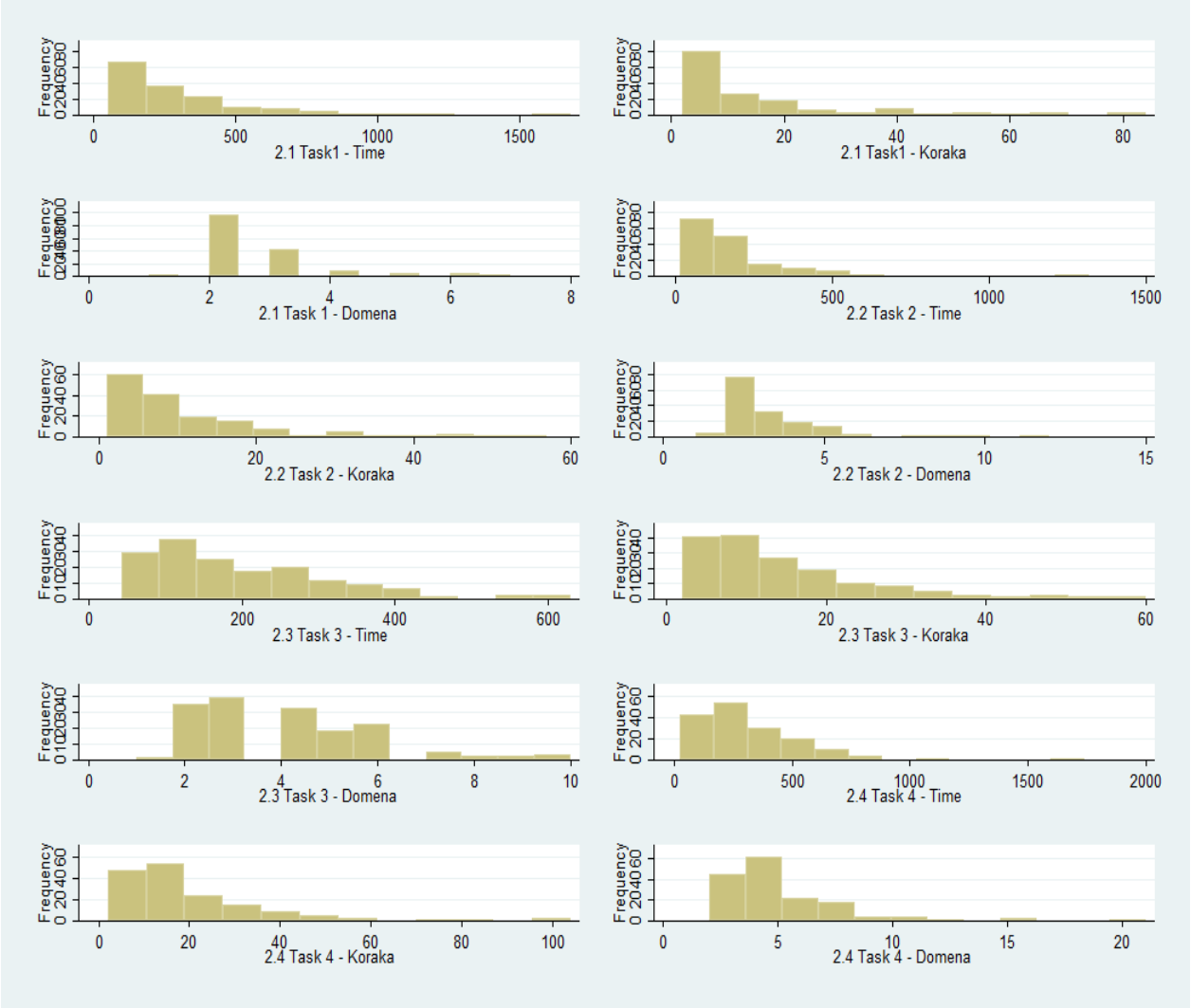

Figure 35 – Distribution of quantitative indicators of information searching patterns. Dependent variables in regression. X-axis represents the number of steps, time or domains, Y-axis is frequency (the number of users)

Zero-truncated negative binomial regression is used to model count data for which zero value cannot occur and when there is evidence of overdispresion.

H1 – different user information needs will result in different proprietary information search patterns

Factor 1 is constructed about the variables that are related to the information need. We could see that there is dependence between the task 3 and factor 1, particularly in the total time, the number of steps and number of domains.

H2 – the user environment affects information search patterns

Hypothesis 2 explores how the user environment influences the information searching patterns.

Factor 2 is constructed around time available for music related information searching. There is no dependence between Factor 2 and variables related to the given tasks. But there is dependence between the type of the university which users attend, and the number of steps needed to complete the second task, time, number of steps and the number of domains for the fourth task.

There is also dependence between the size of the town the experiment participants are from and the information searching pattern, especially between the size of the town and the number of steps needed to complete task 1. The size of the town and the type of the university are clearly environmental factors that we could confirm in the second hypothesis.

To confirm the third hypothesis:

- Information search indicators are used as explanatory variables (features), and users' socio-cognitive characteristics as response variables, based on a larger number of information search indicators relative to the number of users' socio-cognitive characteristics.
- This enabled achieving a bigger predictive performance of statistical models and more compelling feature selection than in the opposite case, which would be using socio-

cognitive characteristics as features and information search indicators as response variables.

In order to construct a set of indicators that are used as explanatory variables as exhaustively as possible, the indicators of information search patterns were diversified along several dimensions:

1. By aspect of internet browsing:
    - number of times spent per task
    - number of steps the user took to complete the task
    - number of unique domains the user visited to complete the task.
2. By task/total
3. Absolute/relative measure
4. By domain classification (visited domains are categorized in 8 categories):

- Domain categories were assigned by the author to each unique domain that appeared among the Internet browsing steps in the dataset.
- Domain categories were ranked by the number of how many users visited a particular domain in total.
- The top eight domain categories were chosen that combined account for about 95 percent of all internet browsing steps in the dataset, ranging from about 53 percent of the steps taken on "Key Domains" (this category encompassed *Google* and *YouTube* domains) to roughly 1 percent of steps taken on „Artist web-sites" (see Results section for details).
- This gives 264 indicators of music-related information search.
- Keyword search indicators were created in addition to these 264 indicators.
- Time and steps pertaining to keyword search, by task and total, measured in absolute and relative terms (20 additional indicators).
- In total, there are 284 initial explanatory variables or features of information search.

The exploratory purpose of the study:

- The primary aim of the analysis was feature selection. For each of the socio-cognitive characteristics, an optimal combination of explanatory variables (information search pattern indicators) needed to be found, in terms of predictive performance achieved.

- The secondary aim of the analysis was to obtain estimates of the explanatory variables' association with socio-cognitive characteristics which are as unbiased as possible, in order to enable interpretations (comparisons) of the associations' sizes. The secondary aim of the analysis is important in terms of drawing conclusions about the most crucial aspects of information search patterns that are related to users' socio-cognitive characteristics.

The presence of collinearity in data deserves special emphasis, as there is collinearity "by design" relative measures within the same finite quantity (e.g., proportions of the user's internet browsing steps or time spent on different domain categories) are correlated by definition.

Another aspect of collinearity that is "built into" the indicator set are inevitable correlations between relative and absolute measures of the same attribute (e.g., absolute and relative user's time spent for a certain task). Besides collinearity, there is one more general challenge to meet: sparse data, reflected in a larger number of a candidate's features than there are observations (units).

Analytical techniques and the algorithm

Continuing on the issues of automated feature selection stated previously, we point to one analytical technique that is used to avoid the pitfalls of step-by-step feature selection:

The least absolute shrinkage and selection operator (LASSO)[391]

LASSO includes a built-in feature selection; it shrinks parameter estimates and performs well in presence of sparse data (**N number of features exceeding**) as well as in presence of collinearity relative to other methods.[392]

391 Tibshirani, R., 1996. Regression shrinkage and selection via the lasso. Journal of the Royal Statistical Society: Series B (Methodological) 58, no. 1, 267–288.

There are no absolute rules for discarding some predictors as noise and retaining others as a signal. This must be determined in relative terms and in the context. However, there are routines helping in feature selection and parameter estimates' interpretation. Namely, one performs dividing the sample in the training and calculates some predictive performance benchmark across a grid of values.

The results of this procedure can serve a two-fold purpose in our context of multiple dependent variables (models) to consider for interpretation:

- We have to (1) choose dependent variables (users' socio-cognitive characteristics) for which there is a substantial prediction by independent variables (music-related information search indicators),
- (2) We have to select the features (predictors) of all those present that substantially contribute to prediction and that lend themselves to interpretation.
- Validation can serve the first task by providing us with a single, optimal value – where the prediction error in the test sample is smallest, or where the chosen predictive performance metric satisfies some threshold.
- Performance metrics with absolute thresholds serve this task better than the ones without such properties, since the decision made is binary (to consider or not to consider some socio-cognitive characteristic as substantially predicted by music-related information search indicators).
- After this decision, another validation can also solve the second task: selection of features for those dependent variables (models) selected. Now estimating parameters in the full sample (since the selection of particular features within a single model, i.e., the dependent variable is the task, not feature-outcome sets selection.
- Cross validation can be used to determine some narrower range where the ratio of the number of features and prediction error is optimal.
- To be more precise, validation aims to determine the range of values and therefore parameter estimates when predictive performance metric peaks before a final sharp decline preceding the point when all predictors reach zero.

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[392] Oyeyemi, G. M., Eyitayo, O. O. and Adeyinka I. F., 2015. On performance of shrinkage methods – a Monte Carlo Study. International Journal of Statistics and Applications 5, no. 2, 72–76.

- If there is a sharp difference in the performance metric that is confined to a certain range of values, there is certainty to feature selection (retaining predictors with non-zero parameter estimates).
- And this is then the range of non-zero parameter estimates where they should be interpreted.

As stated, **LASSO** has a built-in feature selection: this is reflected in parameter estimates reaching zero.

The reason why **LASSO** tends to ameliorate the big issue of collected data, which is a feature of multi-collinearity, which is being minimized in **OLS** (ordinary least squares) or any other parameter estimation method, expands the parameter space and therefore reduces estimation uncertainty arising from feature inter-correlations.

- Although employing **LASSO** in a single step, whereby all candidate features would be included in the specification for each response variable, is appealing. This approach is not applicable to this study.
- First, the collected data is sparse (284 indicators on 155[393] respondents).
- Second, collinearity "by design" is not tolerable.
- To return to this latter point: it is not possible, for example, to include proportions of steps taken within any of the tasks by domain categories, as they sum up to something close to 1 by definition.
- Another collinearity "by design" is expectedly high correlations between absolute and relative measures of the same indicator (for example, between the count of steps and the proportion of steps taken within a certain task within a certain domain category).

Both issues (sparse data and collinearity by design) can be addressed by a cautious introduction of stepwise selection – to be more precise, by an introduction of a single initial step of eliminating "noise" features.

[393] In the process of undertaking the second part of the statistical analysis, five more participants data were excluded from analysis because of the incomplete data.

To avoid issues otherwise pertaining to stepwise selection as much as possible, it was decided that the first step should, for each response variable, consist of estimating univariate models for each candidate feature (284 univariate models for each response variable). A comparison of the null model (without any parameters other than the constant) with the univariate model (with a feature included) can be based on Akaike information criterion[394], which is equivalent to the comparison of deviance in the case of univariate models. One can declare the fit of the null model (without predictors) and the fit of the univariate model (with a feature included) as indistinguishable if the difference of the two models' deviance (-2LogLikelihood_0 - (-2LogLikelihood_1) does not exceed the value of 2. This is the same as saying that the information contained in the feature regarding its association with the response variable is redundant, and this feature can therefore be excluded from further selection. This procedure for univariate linear models is equivalent to eliminating those features whose estimates' p-values in univariate models do not fall below 0.157.

After considering everything that has been discussed so far, the new analytical algorithm can be described as follows:

For each response variable

1. estimate univariate models for each candidate feature (logistic or OLS regression – depending on whether the response is binary or continuous/interval) in the training sample
2. among models estimated in step 1, select those features with substantial contribution to the explanation of the response variable ($|\text{AICc}_{\text{null-model}} - \text{AICc}_{\text{univariate model}}| > 2$)
3. estimate LASSO regression with features selected in step 2
4. perform cross-validation (k-fold) of LASSO solutions from step 3 within training sample and determine lambda with smallest prediction error as the optimal value of lambda
5. from the model obtained in step 4, predict the response variable in the test sample and calculate Area under Receiver Operating Curve (AUROC) at the optimal value of lambda determined in the previous step
6. rank the response variables by AUROC of their final models in the test sample

394 Akaike, H., 1979. A Bayesian extension of the minimum AIC procedure of autoregressive model fitting. Biometrika 66, no. 2, 237–242.

7. estimate parameters in the full sample only if the solution of the model identified in step 4 resulted with AUROC in step 6 (within training sample) that exceeded some (conventional) critical value for substantial predictive performance, most likely value of 0.7
8. plot estimates from the solution identified in the previous step, with the same axes as in the left panel of Figure XY in the previous section.

Outcomes of the final step (results) are meant for human interpretation, after the outcome of step 7, which is relatively straightforward and can be left to the machine: AUROC value below 0.7 means poor prediction or no prediction whatsoever compared to random allocation of cases to one or the other predicted class (0 or 1) in binary classification problems such as the ones we are dealing with, while AUROC value above 0.7 means substantial prediction. Moreover, AUROC is a better benchmark of predictive performance than other commonly used indices in binary classification, such as percent cases correctly predicted, percent false positives or percent false negatives, simply because AUROC unifies information on all three of the latter indices at the entire possible range of predicted probability cut-off points which delimit 0 and 1 predicted class, instead of choosing the cut-offs arbitrarily unlike the three aforementioned single indices. Receiver operating characteristic curve plot has as its x-axis the expression (1-Specificity), i.e., (100% - % correctly predicted 0s), along with the predicted probabilities (ranging from 0 to 1), and as its y-axis Sensitivity (% correctly predicted 1s) along with the predicted probabilities as well. This means that the larger the area under the curve is for a particular classifier (i.e., for predicted probabilities obtained from a particular statistical model), the smaller both the percentage of false positives and the percentage of false negatives over the entire classifier range. All analyses were performed in R statistical environment[395], using packages *glmnet*[396] for LASSO estimation, *plotmo* (by Stephen Milborrow) for LASSO estimates plots and package *pROC* for AUROC calculation[397].

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395 Team, R. Core, 2017. R: A language and environment for statistical computing. R Found. Stat. Comput. Vienna, Austria .

396 Friedman, J., Hastie T. and Tibshirani R., 2001. The elements of statistical learning. Vol. 1, no. 10. New York: Springer series in statistics.

397 Xavier, R., Turck N., Hainard A., Tiberti N., Lisacek F., Sanchez J. A. and Müller, M., 2011. pROC: an open-source package for R and S + to analyze and compare ROC curves. *BMC bioinformatics* 12, no. 1, 1–8.

Table 39 – Student sample descriptive

	Frequency	**Percentage**
Male	40	25.0%
Age		
20 years or less	20	12.5%
21 – 25 years	120	75.0%
26 – 30 years	19	11.9%
31 years or more	1	0.6%
Study field		
Natural sciences	28	17.7%
Technical sciences	35	22.2%
Biomedicine & health	19	12.0%
Social sciences & humanities	52	32.9%
Art	13	8.2%
Business school	11	7.0%
No answer	2	1.3%
„City I grew up in" > 10,000 people	72	45.6%
N	**160**	**100 %**

Table 39 presents descriptive probabilistic sample of Zagreb University students that participated in the laboratory experiment. The sample was representative at the level of study fields at Zagreb University.

Natural sciences and art students were overrepresented in the sample, their population shares at the time being 6 and 2 percent, respectively. The recruitment process involved rewards valued at HRK 50 (about 8 U.S. dollars). The students filled out the questionnaire and performed the web-search exercise at the premises of Zagreb Polytechnic.

The experiment participants were asked to do four tasks to search for the music related information searching. Task 1 consisted of finding music for user's own house party, task 2 was to find music for a birthday party of one of the user's parents, task 3 entailed finding a concert or clubbing event for a night out in the user's city of residence (Zagreb), and task 4 was to find a concert or clubbing event in London. Users indicated completion of each task by visiting the university's domain. Data on information search patterns obtained from the participants' web-exercise consisted of time spent at each step of the search (between each distinct URL visited) within each task, as well as the number of steps and distinct domains corresponding to the URLs, as described in the previous section.

A questionnaire on users' socio-cognitive features was designed to cover broad areas of users' information behavior (based on the Wilson 2nd model) and information needs based on the Nicholas framework. All the item scales were Likert-type (5 degrees, with a neutral middle category, two positively and two negatively formulated degrees).

Descriptive statistics

Table 40 shows descriptives for questionnaire items. As all the questionnaire items had a 5-degree scale, and data were sparse, a decision was made to approach the analysis as a binary classification problem (logistic regression) for each considered response (questionnaire item), coding the two positively formulated degrees as a single predicted class, for reasons of comparability of predictive performance across dependent variables (questionnaire items). On the same grounds, it was decided to omit the questionnaire items with less than 20% or more than 80% positive answers (predicted class) from the analysis, since severely unbalanced response variables are at the onset less likely to produce meaningful results or perform well in prediction.

Table 40 – Descriptives of socio-cognitive characteristics (questionnaire)

Socio-cognitive characteristic	Mean	SD	% choosing two positive scale degrees
Keywords important	3.9	0.7	78.1
Reason for searching music: special occasions (house parties, birthdays)	3.7	1.0	49.0
Reason for searching music: following musical trends	3.1	1.1	32.9
Reason for searching music: expanding knowledge about genre or musician of interest	3.9	1.0	64.5
Reason for searching music: stimulation while engaged in other activities	4.0	1.0	67.1
Frequent information source: Listening to music	4.2	0.9	78.1
Often spending more time on music information search than planned	3.5	1.0	58.7
Reputation and quality of music information sources are important	3.1	1.0	41.9
Up to date information is important (1)	2.8	1.2	32.5
Up to date information is important (2)	3.7	1.0	67.1
Timeliness of music information important	2.7	1.2	30.3
Information format is important (text, video)	3.2	1.0	44.5
Self-assessed "musicality"	3.9	1.0	76.1
Influence of music's emotional impression on information search	3.9	1.0	76.6
High-quality information on music from friends	3.3	0.9	47.1
Friends important as music information source	3.2	1.1	49.7
Self-assessed critical perspective on music information sources	3.2	1.0	46.5
Self-assessed knowledge about favorite music genre (2)	3.6	0.8	49.4

"I can never get enough information about music I like to listen to"	3.9	1.0	70.8
Self-assessed knowledge about favorite music genre (1)	3.6	0.8	63.6
Self-assessed knowledge on music in general	3.4	0.8	52.6
Frequent music sources: Radio	3.3	1.0	37.0
Frequent music sources: Online Radio	2.8	1.1	23.4
Frequent music sources: Mobile phone	3.9	1.3	71.4
Frequent music sources: downloaded music	3.6	1.3	55.8
Frequent music sources: links from friends on social networks	3.2	0.9	33.1
Weekly time for music searching: 2 hours+	3.7	1.6	50.3
Free time spent on music: clubs & concerts	3.6	1.1	63.9
Free time spent on music: information from various sources	3.0	0.9	26.8
Free time spent on music: Listening to music in company	3.8	0.9	67.7
Free time spent on music: sharing links with music on social networks	2.6	1.2	25.8
Friends influence music information search	3.3	1.0	53.2
Music information sources different from friends' sources	3.2	0.9	48.7
"If I don't have time, I will not start searching"	3.2	1.2	47.4
“In a bad set-up (slow internet, weak lighting) I will not search information”	3.8	1.1	66.2
"I will search information regardless of the conditions"	2.6	1.1	22.7
Long-term perspective in life is more important	3.8	0.9	62.3
Uncertainty avoidance	3.0	1.2	42.9
Material possessions important	3.0	0.8	31.2

Table 40 shows domain categories ranked by the frequency of search steps in the sample, with percentages of users that visited each of the domain category by task, as well as with the percentage of time spent browsing through each domain category within each task (in

parentheses). Key domains (Google, YouTube) were visited by virtually every user in the sample in each of the tasks.

As was expected, in addressing tasks 3 and 4 (finding a music event in Zagreb and in London), a larger share of users visited "listing", "media", "ticketing" and "venue" domains[398] than in dealing with tasks 1 and 2 (finding music for one's own, and for a parent's party). In terms of browsing time, domains belonging to „ticketing" and "venue" categories surpass the key domains within tasks 3 and 4 only when those two domain categories are combined. Noting that social media domains were in general relatively less popular among users (music information searchers), it is worth nothing that social media domains (Facebook, in particular) were visited by by a proportionally bigger number of users when it came to finding a music event for a night out in Zagreb. Within the latter task, about 6 percent of total browsing time was spent on social media. A comparably smaller share of users visited music content domains and artist websites. Music content domains were more relevant (for a larger number of users) in tasks 1 and 2 than in tasks 3 and 4, while artist websites were more relevant in tasks 2 and 4 (finding music for a parent's birthday party and finding a music event in London) than in tasks 1 and 3 (finding music for one's own party and finding a music event in Zagreb).

Table 41 – Percentages of visiting users by domain categories ranked by frequency of steps in total (categories chosen for indicator construction in italic)

	Task 1	**Task 2**	**Task 3**	**Task 4**	**Steps frequency**
Domain Category	% users (% browsing time within task)				n
Key Domain	100.0	100.0	98.7	99.4	5299
	(70.9)	(52.1)	(30.8)	(24.8)	
Listing	5.8	7.7	22.6	75.5	1362
	(0.0)	(0.4)	(7.3)	(20.0)	
Media	16.8	37.4	55.5	51.0	1143
	(4.3)	(16.2)	(14.7)	(12.6)	

[398] Those domains are based on previously mentioned classification of different types of the domains a participant visited.

Ticketing	8.4	14.2	74.2	66.5	955
	(0.0)	(0.3)	(24.6)	(16.3)	
Venue	6.5	6.5	31.0	31.6	334
	(0.0)	(0.1)	(9.6)	(10.0)	
Social Media	6.5	9.0	29.0	6.5	231
	(0.6)	(1.3)	(6.2)	(1.4)	
Music Content	12.3	14.8	3.2	3.9	190
	(5.7)	(8.4)	(0.7)	(0.7)	
Login-Google	22.6	6.5	0.6	0.0	87
	(14.4)	(2.6)	(0.0)	(0.0)	
Artist WebSite	2.6	5.8	1.9	9.0	80
	(1.1)	(2.4)	(0.4)	(1.6)	
Wikipedia	2.6	11.0	1.9	2.6	73
	(0.0)	(8.4)	(0.5)	(0.6)	
Classified Ads	0.6	0.6	0.0	9.7	44
	(0.0)	(0.0)	(0.0)	(2.8)	
Festival Website	0.6	2.6	3.9	4.5	36
	(0.0)	(0.2)	(1.3)	(1.2)	
Tourism	0.0	0.0	0.0	7.7	31
	(0.0)	(0.0)	(0.0)	(1.7)	
Other	1.9	1.3	2.6	4.5	20
	(0.6)	(0.3)	(1.0)	(1.0)	
Music Shop	0.6	2.6	2.6	0.0	18
	(0.0)	(0.9)	(0.8)	(0.0)	
Music Lyrics	0.6	3.9	0.0	0.0	15
	(0.0)	(2.6)	(0.0)	(0.0)	

Login-YouTube	1.3	5.2	0.6	0.0	11
	(1.9)	(0.5)	(0.3)	(0.0)	
Login	0.6	0.6	1.3	4.5	10
	(0.0)	(0.0)	(0.5)	(1.2)	
Music Label	0.0	2.6	0.6	0.0	8
	(0.0)	(1.1)	(0.4)	(0.0)	
Music Online Bookstore	0.6	0.6	1.3	0.0	7
	(0.0)	(0.0)	(0.3)	(0.0)	
Services Agency	0.0	0.0	0.0	1.9	7
	(0.0)	(0.0)	(0.0)	(1.1)	
Search Engine	0.0	0.6	1.3	0.6	6
	(0.0)	(0.2)	(0.2)	(0.1)	
Google Play	0.6	0.6	0.0	0.0	5
	(0.3)	(0.3)	(0.0)	(0.0)	
Post office	0.0	0.0	0.0	0.6	5
	(0.0)	(0.0)	(0.0)	(0.3)	
Company Website	0.0	0.0	0.0	2.6	4
	(0.0)	(0.0)	(0.0)	(1.1)	

Of all the 42 socio-cognitive characteristics of users that we predicted, only two of them came out with AUROC value in test sample (algorithm step number 5) above 0.7 that is deemed „fair" by common rule-of-thumb.[399] It was one of the two questionnaire items about user's self-assessed knowledge on their favorite music genre and the item that aimed to tap into importance that the information about their favorite music has for the user ("I can never get enough information

[399] Swets, J. A., Robyn M. D. and Monahan, J., 2000. Psychological science can improve diagnostic decisions. Psychological science in the public interest 1, no. 1, 1–26.

about the music I like to listen to"). The initial number of parameters was not correlated with the AUROC of the final models at optimal lambda values, i.e., lambda value for each model (predicted characteristic) with minimum prediction error in terms of AUROC in 10-fold validation estimation ($r = -.08$; $p > 0.05$). This means that the initial selection at step 1 of the algorithm had no influence on predictive performance, and thus selection, at the later stages of the algorithm, which is a favorable argument for the proposed procedure.

Table 42 – Users' socio-cognitive characteristics sorted by Area Under Receiver Operating Curve of the corresponding final LASSO models (at optimal value of λ in the training sample

	no. of parameters	$\lambda_{optimal}$	**AUROC**
Self-assessed knowledge about favorite music genre (1)	**29**	**0.116**	**0.726**
"I can never get enough information about music I like to listen to"	**44**	**0.000**	**0.714**
Material possessions important	25	0.000	0.671
Self-assessed „musicality"	19	0.120	0.629
Free time spent on music: clubs & concerts	41	0.001	0.605
Self-assessed knowledge about favorite music genre (2)	34	0.137	0.601
Reason for searching music: stimulation while engaged in other activities	36	0.061	0.600
High-quality information on music from friends	18	0.017	0.598
Long-term perspective in life is more important	14	0.038	0.595
Self-assessed critical perspective on music information sources	21	0.000	0.593
Friends influence music information search	24	0.049	0.592
Reputation and quality of music information sources are important	40	0.003	0.591
Uncertainty avoidance	32	0.007	0.586
„If I don't have time, I will not start searching"	12	0.029	0.576

Reason for searching music: special occasions (house parties, birthdays)	21	0.078	0.574
Information format is important (text, video)	30	0.129	0.571
Reason for searching music: expanding knowledge about genre or musician of interest	44	0.105	0.559
Up to date information is important (1)	27	0.083	0.554
Frequent music sources: Online Radio	29	0.077	0.551
Keywords important	15	0.035	0.546
Free time spent on music: Listening to music in company	26	0.005	0.538
„I will search information regardless of the conditions"	40	0.007	0.535
Up to date information is important (2)	27	0.009	0.530
Influence of music's emotional impression on information search	27	0.043	0.523
Frequent music sources: links from friends on social networks	28	0.027	0.518
Free time spent on music: information from various sources	18	0.071	0.518
„In a bad set-up (slow internet, weak lighting) I will not search information”	17	0.058	0.513
Music information sources different from friends' sources	49	0.005	0.513
Timeliness of music information important	35	0.000	0.512
Often spending more time on music information search than planned	27	0.000	0.511
Frequent music sources: Radio	10	0.045	0.500
Frequent music sources: Mobile phone	19	0.071	0.500
Frequent information source: Listening to music	57	0.023	0.496
Weekly time for music searching: 2 hours+	42	0.050	0.488
Frequent music sources: downloaded music	23	0.053	0.479
Self-assessed knowledge on music in general	28	0.092	0.474

Free time spent on music: sharing links with music on social networks	41	0.027	0.469
Friends important as music information source	46	0.070	0.464
Reason for searching music: following musical trends	29	0.000	0.431

Results of a 10-fold cross-validation of the best performing feature-outcome set, where dependent variable is one of the two questionnaire items that aimed at measuring users' self-assessed knowledge about his or her favorite music genre. Vertical dashed lines demarcate the range of log-lambda values where the predictive performance peaks before it sharply declines – here is where the predictors that are non-zero, or that are relatively further from zero in a more stringent feature selection, should be selected and interpreted as final features. Following the latter result, a minimum subset of the LASSO estimates of music information search indicators' relationship with users' self-assessed knowledge on favorite music genre that includes the range of optimal lambda values demarcated, in the full sample (test and training samples combined). The vertical grey line marks the optimal lambda value in the 10-fold model validation within the full sample, at which the predictors' coefficients should be foremost interpreted (but not exclusively). Indicators that can be considered as substantial predictors, and thus interpreted, are labelled in Figure 37. The remainder of the 29 predictors that entered the equation at step 2 of the algorithm ($p > 0.157$ in univariate logistic regressions of this questionnaire item on all of the 284 indicators), the majority of whom are not shown in Figure 36, were shrunk to zero due to **LASSO** penalty and can be discarded as noise predictors without further consideration. By far the strongest (negative) predictor of responding positively to the statement "I know much about my favorite music genre" was the share of domains categorized as "Listing" (e.g., *Songkick*, *Allgigs.London*, *London.Eventful*) within the total number of domains visited. A larger share of such domains within the number of domains visited by the user was a "flag" for a user that was not likely to claim knowledge on his or her favorite music genre. To a much lesser extent, similar can be said about the share of steps that entailed keyword search and the share of domains visited that were categorized as "Media" within task 2 (finding music for a parent's birthday party). However, if we are after a maximally parsimonious final feature specification to be interpreted, even the latter two could be considered as noise and omitted from the interpretation. The only positive predictor of claiming knowledge on one's favorite music genre, that can be considered as

a signal, was the share of steps taken in task 1 (finding music for one's own party) within the total number steps taken in all tasks.

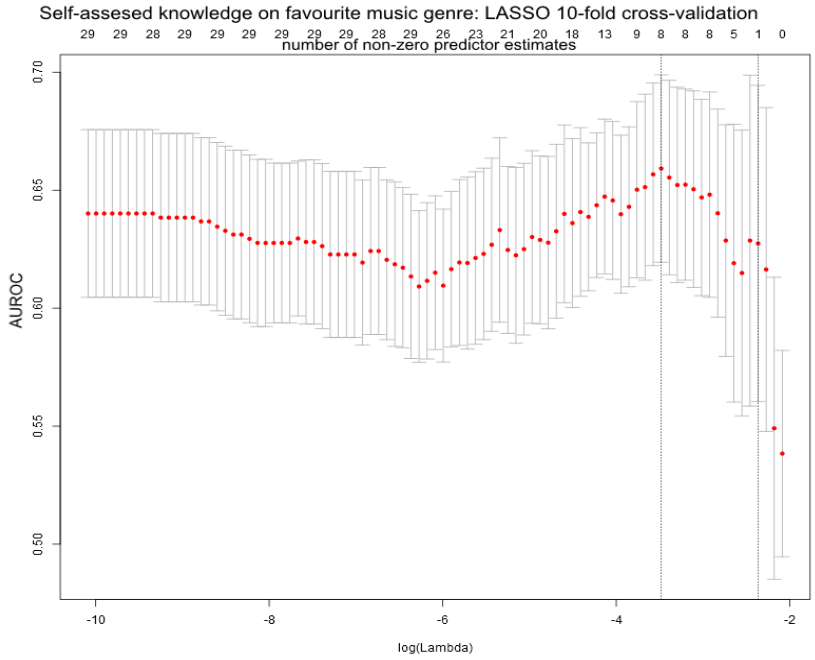

Figure 36 – Predictive performance metric (AUC) in 10-fold validation of prediction of the user's self-assessed knowledge on favorite music genre

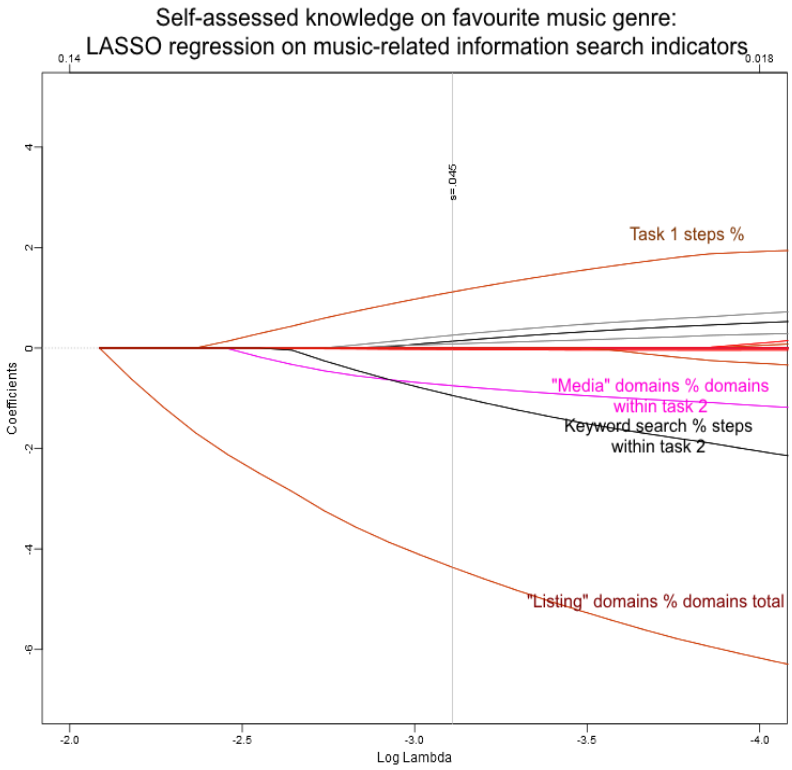

Figure 37 – A subset of LASSO estimates of the music information search indicators' relationship with the user's self-assessed knowledge on favorite music genre

The second socio-cognitive characteristic item that was substantially predicted by music-related information search indicators aimed to tap into users' engagement with music-related information, i.e., into importance that such information has for the user. Figure 36 shows that the predictive performance within 10-fold cross-validation sharply declined after log-lambda value of about 3.7, where there were around 12 non-zero predictors. Figure 37 depicts the estimates around the optimal lambda value from the cross-validation (marked by the vertical grey line). One feature clearly distinguishes itself by contribution to prediction. Larger share of browsing steps taken on "Music content" domains (consisting mostly of *Last.fm*, *Deezer*, *Soundcloud*) within the total number of steps made by the user was the most substantial predictor of responding positively to the statement "I can never get enough information on music I like to listen to". On the other hand, share of time spent on "Ticketing" domains (mostly *Eventim.hr*, *Ticketmaster.uk*, *Viagogo.uk*) within task 1 (finding music for one's house party), was negatively associated with the alleged importance that the music-related information has for the user. A

negative predictor closely related in content to the latter, but weaker, was the share of total browsing time spent on "Listing" domains (e.g., *Songkick*, *Allgigs.London*, *London.Eventful*). However, if we take a more stringent approach to feature selection, all the negative predictors shown in Figure 39 (below the horizontal line) could be discarded as noise, as they reach zero still within the optimal lambda value range which is demarcated in Figure 37. Two relatively much weaker positive predictors of music-related information's importance for the user, were the share of distinct domains visited in task 2 (finding music for a parent's birthday party) and the share of browsing steps taken on domains categorized as „Venue" within task 4, which consisted of finding a music event to visit in London (websites of clubs and concert halls in London).

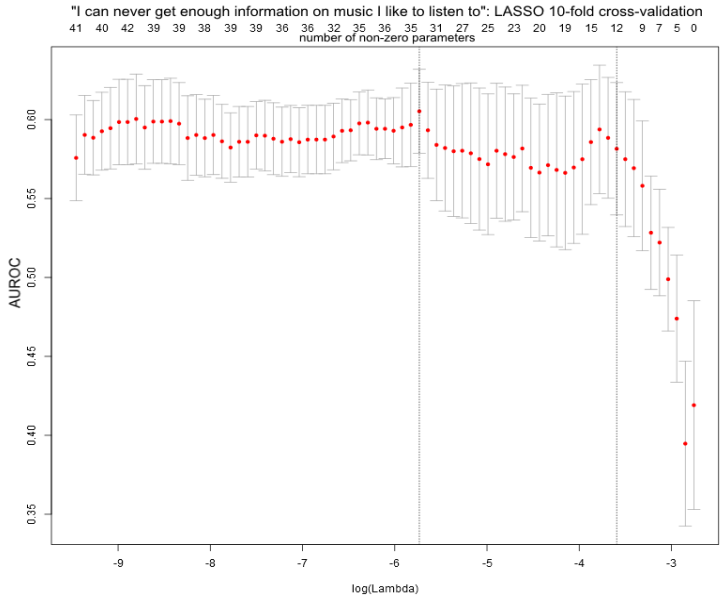

Figure 38 – Predictive performance metric (AUC) in 10-fold validation of prediction of the users's engagement with music-related information search

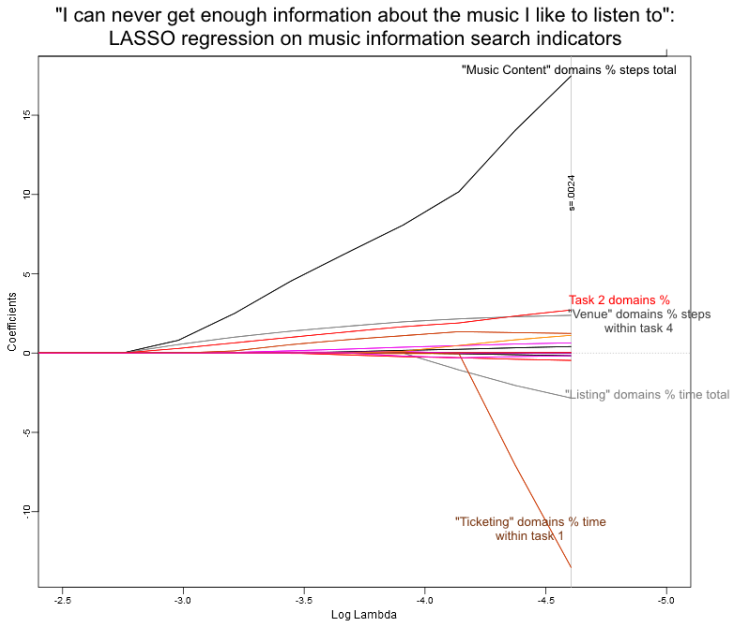

Figure 39 - Recognition of user information behavior through music-related information searching patterns

Further optimal lambda values are from zero, the closer is the solution chosen to the original logistic regression solution (without penalization). However, in the case of user's engagement with music-related information as the predicted socio-cognitive characteristics, even the small penalization (optimal lambda values range close to zero) can have large consequences for feature selection (nullifying the parameter estimates).

H3 – based on the records generated by machine observation of the information search process, characteristics of the user who searches the information can be predicted.

Hypothesis 3 is confirmed as it is possible to predict user characteristics based on the logs collected through the user search patterns. Two characteristics; a) *Self-assessed knowledge about favorite music genre* and b) *I can never get enough information about music I like to listen to* sorted by Area Under Receiver Operating Curve of the corresponding final LASSO models have predictive values.

Results' Highlights and discussion:

- The analysis of the association between music-related information search patterns and users' socio-cognitive characteristics revealed that of all the socio-cognitive characteristics examined, only two questionnaire items emerged as worthy of consideration in predictive terms. Both of them pertain to users' overall engagement with music-related information (not assessing themselves as knowledgeable about their favorite music genre and not assessing themselves as engaged in music-related information search).
- A larger share of browsing steps taken on „Music Content" domains (*Deezer*, *Last.fm*, *Soundcloud*) within the total number of user's browsing steps indicates a larger propensity to agree with the statement that „I can never get enough information on music that I like to listen to". To add to this, a larger share of steps of the total steps, that was taken while addressing Task 1 (finding music content for one's own party) was associated with a larger inclination to deem oneself as knowledgeable in one's favorite music. These are two very promising results in light of further research on music-related information search behavior, as they establish the association between user's online behavior measured through objective quantitative criteria and his assessment of his engagement with music-related information search.
- "Listing" and „Ticketing" domains were correlated with responses that denote user's lower engagement with music-related information, in both aspects that emerged as worthy of consideration in predictive terms (not assessing himself or herself as knowledgeable on his or her favorite music genre and not assessing himself or herself as engaged in music-related information search). When it comes to the latter, a „misplaced" larger share of „Ticketing" domains within Task 1 (finding music content for one's own party) indicated a lower propensity to assess oneself as knowledgeable about one's favorite music. Together with the results from the previous bullet, this result opens the discussion and directions for further research to information seeking goals in relation to specific search patterns.
- Among the 284 indicators of music-related information search patterns, only the relative measures came out as significant predictors (shares of steps, shares of times, shares of domains), not a single absolute indicator (number). This highlights the importance of viewing the user's specific search behavior in context of his or her overall search

behavior. In other words, some „flags" to mark users of a particular profile or intentions (music-related information-seeking goals) that would be based on absolute thresholds are not likely to be sensible.

DISCUSSION

The aim of this research was to examine the impact of socio-cognitive characteristics of users (representing personal features) on the information behavior. The main focus was to determine the relationship between information search patterns on music content and music records and the socio-cognitive characteristics of the user seeking information. The goal was to try to find ways to identify user characteristics (or system features) through the logs collected while the user is seeking and searching for music related information. If that is possible, then we could describe patterns, as they represent behavior in the environment in quantitative terms.

If it is possible to identify the characteristics of the user and their information needs by means of machine observation of the information seeking and search activities represented in logs, then we can state that the information searching patterns could become input signal that the information system can use to adapt to the user.

Three hypotheses have been defined: a) different user information needs will result in different proprietary information search patterns, b) the user environment affects information search patterns, c) based on the records generated by machine observation of the information search process, characteristics of the user who searches the information can be predicted.

All three hypotheses have been confirmed, so we could say that different information needs will result in different information search patterns, the environment of the user will have impact on his information search patterns and that user characteristics could be predicted, based on the information search patterns.

By confirming hypothesis, based on the statistical analysis of quantitative data, this research opens new avenues in the information science research using log analysis method as research technique problems related to the limitation of qualitative research. In information science, user studies are relatively often used. They could be understood as a set of methods that are aimed at understanding user information motivations, needs and behavior through different observation techniques. If we have the logs collected and analyzed through the whole process of interaction

of the user with the information system, then we have a clear and quantitative description of the human information behavior together with the information system behavior. This is one of the main reasons why a model of socio technical information behavior was presented in this thesis. By understanding, recognizing and employing a user information need as feedback, better information systems could be designed. If log analysis is used for that purpose, this could be done almost in real time using computers to process the data[400], then in real time data could be restructured in the information system, triggering new functions of information system [401] and supporting users to help them meet their information needs faster,[402],[403] which is proved in the first hypothesis. Being able to do so, user could be faster at solving their "task at hand" and observers could be better at understanding the user information behavior and performance of the information system.[404] It is necessary to state that such an approach in research (applicative and scientific) asks for the multidisciplinary teams including designers, engineers and computer scientists along information scientists through the whole process.

By confirming the second hypothesis (the user environment affects information search patterns) this study contributes to the understanding of different information use cases. Somebody will search for the music, and somebody will search for the patient's records, but DJs will not share his information search patterns with the crowd on the dance floor, much like doctors will not share their information use of patient related documentation with the patients. But in the end, DJ will try to make the crowd dance and doctors will try to heal the patients. So, different environment result in different information behavior patterns. Proving that, it is possible through the logs analysis to understand human information behavior in different environments and at the

400 Dipta, D, Schiewe, M., Brighton, E., Fuller, M., Cerny, T., Bures, M., Frajtak, K., Shin, D. and Tisnovsky, P., 2020. Failure Prediction by Utilizing Log Analysis: A Systematic Mapping Study. In: Proceedings of the International Conference on Research in Adaptive and Convergent Systems, pp. 188–195.

401 Zirije, H., 2017. Robust anomaly detection algorithms for real-time big data: Comparison of algorithms. In: 2017 6th Mediterranean Conference on Embedded Computing (MECO), pp. 1–6. IEEE.

402 Yaming, F., Lomas, E., and Inskip C., 2021. Library log analysis and its implications for studying online information seeking behavior of cultural groups. The Journal of Academic Librarianship 47, no. 5, 102421.

403 Biplob, D., Solaimani, M., Ali Gulzar Gulzar, M. Arora, N., Lumezanu, C., Xu, J., Zong, B., Zhang, H., Jiang, G. and Khan, L., 2018. LogLens: A real-time log analysis system. In: 2018 IEEE 38th international conference on distributed computing systems (ICDCS), pp. 1052–1062. IEEE.

404 Liang-Yi, L. and Tsai, C., 2017. Accessing online learning material: Quantitative behavior patterns and their effects on motivation and learning performance. *Computers & Education* 114, 286–297.

same time design information systems that support different human information behavior in different environments. For example, mountain hikers and climbers will not use their mobile phones with installed GIS systems but professional devices with information systems designed explicitly for mountains environment. With the current development of the smart devices and home appliances, log analysis[405] could be one of the supportive methods used in designing better information systems and recognizing user information behavior in a way that they are more suitable for the environment where the human - computer interaction takes place in information behavior and the performance of information systems. Such claims could be found in various studies such as Malek, Abuhelaleh and Almaiah [406], Sharikov, Krasov and Volkogonov, [407], Jiamin and colleagues[408], Arias, Maquieira and Jara, [409] and Ollila. [410]

With the confirmation of the third hypothesis (on the basis of the records generated by machine observation of the information search process, characteristics of the user who searches the information can be predicted) we combine machine learning, data mining and artificial techniques into the one end-to-end process. After detecting information behavior patterns through the logs, it is possible to establish supervised and unsupervised machine learning functions in information systems[411],[412] which will be more adoptive to the user information needs.[413], [414].

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405 Gajewski, M., Mongay Batalla, J. Mastorakis, G. and X. Mavromoustakis, C., 2019. A distributed IDS architecture model for Smart Home systems. *Cluster Computing* 22, no. 1, 1739–1749.

406 Malek, A., Abuhelaleh, M. and Almaiah, M., 2019. Towards a model of quality features for mobile social networks apps in learning environments: An extended information system success model, 75–93.

407 Sharikov, P. I., Krasov, A. V. and Volkogonov, V. N., 2020. A study of the correctness of the execution of a class file with an embedded digital watermark in different environments. In: IOP Conference Series: Materials Science and Engineering, vol. 862, no. 5, p. 052052. IOP Publishing.

408 Jiamin, D., Liu, R., Qiu, Y. and Crossan, M., 2021. Should knowledge be distorted? Managers' knowledge distortion strategies and organizational learning in different environments. The Leadership Quarterly 32, no. 3, 101477.

409 Arias, J. Maquieira, C. and Jara, M., 2020. Do legal and institutional environments matter for banking system performance? Economic research-Ekonomska istraživanja 33, no. 1, 0–0.

410 Ollila, M., 2019. Creating architecture for a digital information system leveraging virtual environments.

411 Kersten, J., Bongard, J. H. and Klan, F., 2021. Combining Supervised and Unsupervised Learning to Detect and Semantically Aggregate Crisis-Related Twitter Content. In: International Conference on Information Systems for Crisis Response and Management (ISCRAM).

412 El Aissaoui, O., El Alami El Madani, Y., Oughdir, L. and EL ALLIOUI, Y., 2019. Combining supervised and unsupervised machine learning algorithms to predict the learners' learning styles. Procedia computer science 148, 87–96.

413 Palm, A., Metzger, A. and Pohl, K., 2020. Online reinforcement learning for self-adaptive information systems. In: International Conference on Advanced Information Systems Engineering, pp. 169–184. Springer, Cham.

Implications of this research was aimed toward the exploration of the design of the information systems that are adoptive to the information needs of the user, environment where users search and the prediction of the user characteristics. Confirmation of all three hypotheses give solid fundamentals for future research in this area. Limitation is relatively small number of participants in the research (after sifting through the data, 155 participants findings were left to be processed and analyzed). Also, there is not much of similar research conducted, so it was difficult to follow already existing research protocols and experiment design.

Limitations of this research could be divided into the two parts. One part is related to the survey development and design with the aim to characterize user features. The other part is the quasi experiment method carried out in the lab. Challenges with the development of the survey are related to the lack of the existing research that combines information need and information behavior of the Wilson 2nd model into the one profiling survey. Since this research is based on the socio-cognitive paradigm, it was a challenge to develop a survey that covers social and cognitive aspects of the user characteristic features description. On the other hand, the experiment was conducted with only 172 participants (ending with data from 155), which is still not a large number. To develop research further, it is necessary to work with multidisciplinary team of sociologist, psychologist, and computer scientist. However, the experiment could be repeated in the online environment. To do so, it is necessary to develop a browser plug that could collect logs while users are seeking, searching and using obtained information. If such a tool is developed, studies could be repeated all over the globe and results could be combined. Also, this research took quite a long time because it was necessary to develop the right algorithm and find appropriate statistical method.

The challenge was that by analyzing data manually by the researcher, the differences of the types of the users and their social environment were clearly seen (i.e., second task was to find a song for the one of the parent's birthday, and by looking into the logs, some experiment participants knew what their parents listened, while the others did not). But how to find the algorithm and

414 Ennouamani, S. and Mahani, Z., 2017. An overview of adaptive e-learning systems. In: 2017 eighth international conference on intelligent computing and information systems (ICICIS), pp. 342–347. IEEE.

statistical method that could be run by machine including six different approaches? In the end, Lasso method and developed algorithm based on the relative indicators showed encouraging results.

Along the process of finishing this research, some ideas emerged how this and similar information behavior research using the log analysis method could be improved. Improvements could be mainly in the area of development of special analytical tools that could be used in similar research. Improvement could be made in the way of storing data in the database and functions that process collected data.

To test those concepts related to new analytical tools in the laboratory of the author and his collaborators, two technical prototypes were developed. One was computing infrastructure that separates three computing environments, one that deals with applications that collect logs and collect survey data (such as browser plug in or information system usage logs), another that covers the database designed to store logs (network, time series data and columnar database), and the third one where R as a computing language and tool for statistical analysis operate. In that way multidisciplinary teams could work together and the changes in one environment should not influence another. For example, a new survey development or new logs collection app should not be interrelated to the design of the database. Also, when the data are collected, they could be accessed by the third type of expertise, specialist in R as a computer language and statistical tool (including data visualization). Another concept comes out as a new direction in the domain of research in information and computer science called ABC HCI, meaning affective behavioral and cognitive human computer interaction. HCI as a research domain is also multidisciplinary. Concept of ABC HCI systems could sense, estimate, stimulate, process, and respond to users' emotions, behavior and cognition patterns by using appropriate observational sensors, human-computer interfaces (HCI) and software tools. This complex field is related to other computer science fields such as artificial intelligence and computer vision, and it is based on computational affect recognition and processing, information behavior and cognitive computing.

As an outcome of this thesis at the theoretical level, two approaches of information sciences are developed: a system-oriented and user-oriented approach are combined, contributing to the integrative approach to the domains of information behavior, information retrieval, information

systems and machine learning. Also, another theoretical contribution could be seen in terms of selecting the socio-cognitive paradigm in the development of the survey that describes user socio-cognitive characteristics. The first chapter integrates two different sets of theories, one related to the human information behavior and to the information system design providing insights into the theories that could be used to design more adoptive information systems.

CONCLUSION

The thesis starts with providing evidence in the literature regarding two paradigms of information system design: design science and behavioral science when behavioral science paradigm deals with human or organizational phenomena while design science is rooted in engineering and being more problem solving paradigm. In behavioral approach, the goal is truth and in design science, the goal is utility.[415] This assertion is put it in the context of the music seeking and searching, both aspects should be covered. Human relation to music is very subjective, and music could have different functions in different context. For example, music is used as a background in some physical space and sometimes it is used for entrainment. In this way, focusing on music related information behavior provides the area of research in which these two approaches to the information system design are combined.

Only if we could combine these two systems: the user and information system that users apply to listen to music, it would be possible to give full potentials and benefits of recommendation algorithms, streamline and personalise the human computer interaction and design interfaces that are adaptive to the users. Users will listen to the music recommended based on their needs and the environment (i.e., different songs will be played in different social environments). Information systems used to support user music information behavior could be designed based on the understanding of patterns of music related information behavior. Thus, it is possible to develop functional utility that could support user in their music listening habits depending on the characteristics and environment. Whitworth[416] proposed four levels of information system as follows:

- social level (such as roles, norms and culture) which is rooted in sociology
- cognitive level (dealing with opinions, beliefs and attitudes) which is rooted in psychology
- information level (dealing with data and software programs) which is rooted in computing
- mechanical level (such as hardware, computers, networks) which is rooted in engineering.

[415] Hevner, A., March, S. T., Park, J. & Ram, S., 2004. Design science in information systems research. MIS Quarterly, 28(1), 75–105.

[416] Whitworth, B., 2006. Social-technical systems. In: Encyclopedia of human computer interaction, pp. 533–541. IGI Global.

Lee[417] gives a similar proposition stating that information systems consist of three artifacts: information, technology and social artifact. The first chapter gives an overview of the existing theories used in human information behavior research along the selected theoretical work related to the design of the information systems. It leads us to one of the premises of this research - that users and information system(s) they use to find information should be understood as one open system. In current time we evidence that music is mostly listened through connected electronic devices or are implemented in some kind of information system. Usually, those information systems are ultra large and there are not many of them (YouTube, Spotify, Deezer etc.). All those ultra large systems have complex music recommendation procedures implemented in their design based on the collection of data from the user interaction with those information systems used to find and listen to music. Furthermore, the music industry was one of the first industries that was transformed by the development of advanced digital technologies and information systems. Such state of the domain provides a solid starting point for the research as it is already in everyday use and gives us evidence that concepts presented in this thesis are not abstract but real and working. Another premise of this thesis is that we need to design information systems that are more adoptive to the user information needs. And by gaining insights into music related information behavior, we could open new avenues for applicative and scientific research to develop similar adoptive information systems in other domains. Next premise of this research is that by collecting, structuring and processing logs collected in the process of information, seeking and searching is one of the possibilities to have quantitative data which describe behavioral patterns and that those patterns, if recognized by information system, can be replicated and used as a mechanism in the design of more adoptive information systems of the next generation.

As music information behavior can be understood as a complex behavior including social and technical aspects, the second chapter proposes a socio technical model of the information behavior. It covers process in which some social situations are experienced, and the music related information need appears resulting in the music seeking processes followed by search for a particular song.. In the proposed socio-technical model of information behavior, the information behavior patterns are the main focus. It consists of socio-cognitive information experience,

[417] Allen S., L., 2010. Retrospect and prospect: information systems research in the last and next 25 years. *Journal of Information Technology* 25, no. 4, 336–348.

information seeking, information searching and retrieval, recommendation and content consumption and the use analysis. The model is divided into five „blocks" and the activities related to each „block" could be performed by humans or computers. In order to build an information system that will support better music listening experience, patterns of music information behavior must be observed and code it into the information system. The proposed model comes out as a result of a research of existing models of information behavior and all five „blocks" were rooted in the existing literature and research. The proposed model contributes to the existing corpus by adding a clear distinction between those „blocks" and how they are connected based on the feedback between them including the flow of the signal used as feedback into the social or technical channels of communications and not making the difference between them. It is important that those feedback loops between those „blocks" are defined by the time available, their signal processing capacity and the quantitative data collected, stored and processed to support those feedback loops. Those feedback loops can be understood as signals that trigger the changes in another „block" making them more open and adoptive depending on the situation and the context.

After proposing a socio-technical mode of information behavior, a systematic literature review is conducted in the next chapter. It presents an analysis of a large corpus of published papers in the leading information science publications . This systematic literature review is an extension of a previous research and the same information science journals are used as the source of the paper selection including the same model of classification. The primary aim was to find and analyze previous researches that used log analysis as a research method and therefore, all selected papers were analyzed in terms of methodologies and methods used. As an output of that chapter an extensive list of methods was enlisted as well as their frequency in terms of how many researches they were used in. In the second part of this systematic literature review, selected papers that used log analysis were analyzed qualitatively. Concurrently, those papers using log analysis as a research method were put in the context of the proposed socio technical model of information behavior and each of the selected paper was analyzed to find out how many and which of the proposed „blocks" of the model are included in research. One of the important findings, relevant to this thesis, is that a very small number of the actual researches used the log analysis methods. On one side, this insight was encouraging as it opens up a new space fthe future enquires while

on the other, such a deficit in previously published papers made research design for this thesis difficult.

In the chapter that follows, the research design is explained and the developed algorithm and statistical analysis of data are presented. Based on the systematic review of the literature including the log analysis method, it is possible to state that research design is aligned with the other researches in the domain. The main statistical tool was LASSO method (least absolute shrinkage and selection operator). Developed algorithm that is used could contribute to future research of the log analysis and support the design of better information system not only in the music related information system but in others, too. As researching the logs collected through the process of seeking and searching for the information provides the only true insight into the behavior, further development of logs analysis method may overcome the issue that up to 85 – 95% of thought takes place outside of awareness and qualitative methods cover only other 5 – 15% of information behavior.[418] But at the same time, finding that only relative indicators have predictive value calls for combining quantitative and qualitative methodologies to come to better understanding of the information behavior including music related information behavior. Based on statistical analysis of the information behavior related search logs, it is identified that user's overall engagement with music related information could be predicted. This is important, because if information systems built to support music related information behavior could predict the user music engagement (utility), then they could support such process (truth). The results from the statistical analysis that showed that a lot of search that the user performs in the music content services such as *Deezer*, *Last.fm*, *Soundcloud* (or other similar information system developed to support music consumption) indicate that participants were always looking for more information about music they like („I can never get enough information on music that I like to listen to"). Probably what was the most interesting finding from the statistical analysis of information search logs is that among a large number of indicators analyzed only the relative measures came out as significant predictors (shares of steps, shares of time, shares of domains); not a single absolute indicator had any predictive power. It should challenge the current state of the overall global trends where likes, shares and plays are the main focus. In fact, counting them does not tell us

[418] Albright, K. S., 2011. Psychodynamic perspectives in information behaviour. Information Research, 16(1), pp. 16–1.

anything important and this could not contribute to design better music listening supporting information systems.

At the methodological level, this research explored and listed different methods used in information behavior with a special focus on the log analysis method. A deep dive into the different researches that used log analysis enabled design experiment for this thesis that is aligned and anchored with previous work of other authors. In the experiment and later in the process of analyzing data it was shown that information behavior can be qualitatively described through logs collected in the process of the users interacting with different web pages with the aim to find information need. By collecting two sets of data, one that describes the user based on the survey and another that quantitatively describes information behavior through the logs exploring causalities between research opens up new possible approaches to use machine based observation of human information behavior. And as results showed, it is possible to predict, or better to say, recognize user socio-cognitive characteristics; it is also possible to apply those findings into design of more adoptive information systems. This research started with the logical premise that different users searching for the music related information and music itself have different information behavior. Trying different techniques to prove the hypothesis that computer could calculate what human eye could see becomes top priority. Along the time of doing this research, a huge development in the music recommendation algorithms took place. Also, the music industry changed radically. Music industry was the first one that was taken by the digitalization and shaken to its foundations. Another motivation of this research was that music industry was one of the first that was digitalized and the others followed. If we could understand what happened in the music industry and how information systems related to it have evolved over the time, then we have a solid basis to understand other domains such as cars, pharmaceuticals, energy, food, construction and education, just to name a few. This research is quite small in its analysis of population size but at the end, the hypothesis was confirmed, experiments could be repeated, and the body of knowledge could be improved. It is important as we are increasingly going beyond the understanding computers as we see them today – keyboard, black box with processor, hard disk and memory and screen. Even in the classical set up (screen, black box and keyboard) it is possible to use voice to text function instead of using keyboards. In the music domain, computer scientis and musicians started to write algorithms and develop information systems that could compose classical music. Another thing that was surprising in this research

was discrepancy of log analysis method used in the information science and computer science. In computer science business process log analysis was one of the flourishing fields of the research while in information science the focus is still on the user studies, small qualitative observation and quite of the lamentation at the scientific conferences about where information science is going and why. Information science is by itself multidisciplinary and should be praised as such. This research used quantitative methodology butas a supplement to qualitative methodologies.. This research has proved that there is a clear connection between human music information behavior and music itself, depending on the users socio-cognitive characteristics.

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APPENDIX 1 - SURVEY

Cilj istraživanja je ispitati stavove ispitanika o glazbi.

Anketa je anonimna i trajat će oko 10 minuta, a nakon ispunjavanja ankete dobit ćete još 4 kratka zadatka vezana uz traženje informacija o glazbi.

Mišljenja i informacije kojima ćete pridonijeti ovom znanstvenom istraživanju bit će povjerljive i neće biti dostupne trećim osobama. Vaši odgovori bit će prikazani samo kroz skupne statistike.

Molimo vas da zaokružite jedan od navedenih odgovora.
Zahvaljujemo na suradnji, Vaši iskreni odgovori su za nas izuzetno važni.

DEMOGRAFIJA

1. Spol:
1) Muško
2) Žensko

2. Koje ste godine rođeni? _____

3. Molimo zaokružite kojem području pripada vaš studijski smjer:
1) prirodne znanosti
2) tehničke znanosti
3) biomedicina i zdravstvo
4) društveno humanističke znanosti
5) umjetničko područje
6) poslovna škola

4. Grad u kojem sam odrastao veći je od 100,000 ljudi
1) da
2) ne

INFORMACIJSKE POTREBE

5. Koliko su vam bitne ključne riječi kada pretražujete novu glazbu putem interneta ?
1) Uopće nisu bitne
2) Nisu bitne
3) Niti su bitne, niti nebitne. Ne znam
4) Bitne su

5) Izrazito bitne

6. Molim da procijenite koliko često iz navedenih razloga tražite glazbu:

Razlozi	Nikada	Gotovo nikada	Ponekad	Gotovo uvijek	Uvijek
1. Za posebne prilike (kućne zabave, rođendani)	1	2	3	4	5
2. Kako bih bio u toku s glazbenim trendovima	1	2	3	4	5
3. Istražujem i širim spoznaje o pojedinom žanru ili glazbeniku koji me zanima	1	2	3	4	5
4. Istražujem i širim spoznaje o pojedinom žanru ili glazbeniku koji nije od mog primarnog interesa	1	2	3	4	5
5. Kako bih imao stimulaciju kada nešto radim (tjelovježba, intelektualni rad, kuhanje...)	1	2	3	4	5

7. Kada pretražujete glazbu, koliko često koristite pojedini format izvora informacija?

Glazbu pretražujem:	Nikada	Gotovo nikada	Ponekad	Gotovo uvijek	Uvijek
1. Slušajući glazbene zapise	1	2	3	4	5
2. Kroz povijesne činjenice o glazbeniku	1	2	3	4	5
3. Putem tekstova koji opisuju glazbenika	1	2	3	4	5
4. Putem statističke informacije kao što su slušanost, prodaja, broj linkova na youtube-u	1	2	3	4	5

5. Putem kritika i izvještaja s koncerata	1	2	3	4	5

8. Kako bi ocijenili kompleksnost (složenost, ozbiljnost) izvora informacija iz kojih se informirate o glazbi?

O glazbi se informiram putem: (medij može biti online i offline)	Nikada	Gotovo nikada	Ponekad	Gotovo uvijek	Uvijek
1. Dnevnih novina (online ili offline verzija)	1	2	3	4	5
2. Specijaliziranih časopisa (i web portala) o glazbi	1	2	3	4	5
3. Glazbenih TV emisija	1	2	3	4	5
4. Znanstvenih radova o glazbi	1	2	3	4	5
5. Nešto drugo: _____	1	2	3	4	5

9. Koliko vam je važna objektivnost izvora informacija kada tražite informacije o glazbi ?

1) Naprotiv, isključivo se informiram putem subjektivnih izvora (npr. subjektivna sugestija prijatelja)
2) Nije mi važna
3) Svejedno mi je, informiram se iz objektivnih i subjektivnih izvora
4) Važna mi je
5) Jako mi je važna, informiram se isključivo putem objektivnih izvora (npr. top lista najprodavanijih pjesama)

10. Koliko često "potrošite" više vremena na traženje i konzumiranje informacija o glazbi nego ste planirali?

1) nikada
2) rijetko
3) katkad da, katkad ne
4) ponekad
5) uvijek

11. Koliko su vam važni važan ugled i kvaliteta izvora kada tražite informacije o glazbi?

1) nisu mi uopće važni
2) nisu mi važni
3) niti su mi važni, niti nevažni
4) važni su mi
5) izrazito su mi važni

12. Koliko vam je važno da članci o glazbeniku o kojem istražujete budu "svježi", odnosno novijeg datuma
1) nije mi uopće važno
2) nije mi važno
3) niti mi je važno, niti nevažno
4) važno mi je
5) izrazito mi je važno

13. U kojoj mjeri se slažete s tvrdnjom: Kada istražujem o nekom glazbeniku, čitam sve članke bez obzira na datum kada su objavljeni?
1) uopće se ne slažem
2) ne slažem se
3) niti se slažem, niti ne slažem
4) uglavnom se slažem
5) potpuno se slažem

14. Koliko vam je važna pravovremenost informacija o glazbi? (pravovremenost znači npr. već za vrijeme trajanja koncerta, na koji niste uspjeli otići, pretraživati snimke posjetitelja na youtube-u)
1) uopće mi nije važna pravovremenost
2) nije mi važna pravovremenost
3) niti mi je važna, niti nevažna
4) važna mi je pravovremenost
5) jako mi je važna pravovremenost

15. Kada tražite informacije o glazbi, koliko vam je važno mjesto od kuda dolazi informacija (npr. ako je glazbenik iz SAD, čitat ćete samo članke iz SAD-a, a one iz Hrvatske ćete zanemariti?)
1) uopće mi nije važno
2) nije mi važno
3) niti mi je važno, niti nevažno
4) važno mi je
5) jako mi je važno

16. Koliko vam je važno kako je informacija koju tražite prezentirana, odnosno u kojem je obliku (tekst, video intervju...)

1) uopće mi nije važno
2) nije mi važno
3) niti mi je važno, niti nevažno
4) važno mi je
5) jako mi je važno

INFORMIRANJE

17. Molim vas ocijenite na ljestvici od 1-5 koliko često tražite informacije o glazbi da:

	Nikada	Gotovo nikada	Ponekad	Gotovo uvijek	Uvijek
1. podržite vaše glazbene stavove i uvjerenja	1	2	3	4	5
2. promijenite vaše glazbene stavove i uvjerenja	1	2	3	4	5

18. Koliko se često eksponirate prema izvorima glazbe ili informacijama o glazbi koja nije u skladu s vašim interesima (npr. čitate časopise o glazbi koju ne slušate ili idete na koncerte koji nisu u skladu s vašim ukusom)?

1) nikad
2) gotovo nikad
3) ponekad
4) gotovo uvijek
5) uvijek

19. U kojoj mjeri se slažete s navedenom tvrdnjom: Kada se informiram o glazbi tražim onu informaciju koja odgovora stereotipima glazbenih ukusa društva ili grupe s kojom se družim.

1) uopće se ne slažem
2) ne slažem se
3) niti se slažem, niti ne slažem
4) uglavnom se slažem

5) potpuno se slažem

20. Prema subjektivnoj procjeni, smatrate li se melodičnim (npr. zapamtite melodiju pjesme vrlo lako)?
1) nisam uopće melodičan
2) nisam melodičan
3) niti sam melodičan, niti nisam
4) melodičan sa
5) izrazito sam melodičan

21. Ocijenite koliko vam poteškoća stvara čitanje o glazbi na stranom jeziku
1) izrazito otežava
2) otežava
3) niti otežava, niti ne otežava
4) ne otežava
5) uopće mi ne otežava

22. Utječe li emocionalni dojam kojeg je neka glazba (pjesma ili izvođač) ostavila na vas, na pretraživanje informacija o toj glazbi (pjesmi ili izvođaču)
1) uopće ne utječe na pretraživanje informacija o toj glazbi (ili pjesmi i/ili izvođaču)
2) ne utječe na pretraživanje informacija o toj glazbi (ili pjesmi i/ili izvođaču)
3) niti utječe, niti ne utječe
4) utječe na pretraživanje informacija o toj glazbi (ili pjesmi i/ili izvođaču)
5) izrazito utječe na pretraživanje informacija o toj glazbi (ili pjesmi i/ili izvođaču)

23. Kako biste ocijenili kvalitetu informiranja o glazbi koju dobivate od društva s kojim se družite
1) izrazito su niske kvalitete
2) niske su kvalitete
3) niti su niske, niti visoke kvalitete
4) visoke su kvalitete
5) izrazito su visoke kvalitete

24. Koliko vam je važno informirati se o glazbi od društva s kojim se družite?
1) uopće mi nije važno
2) nije mi važno
3) niti mi je važno, niti nevažno
4) važno mi je
5) jako mi je važno

25. Kako biste ocijenili vašu kritičnost prema izvorima informacija o glazbi i glazbenim zapisima?

1) nisam uopće kritičan
2) nisam kritičan
3) niti sam kritičan, niti nisam
4) kritičan sam
5) izrazito sam kritičan

26. Ocijenite vaše znanje o glazbenom žanru kojeg volite i pratite

1) vrlo nisko
2) nisko
3) osrednje, niti visoko niti nisko
4) visoko
5) izrazito visoko

27. U kojoj mjeri se slažete s navedenim tvrdnjama?

	Uopće se ne slažem	Ne slažem se	Niti se slažem, niti ne slažem	Uglavnom se slažem	Potpuno se slažem
1. Čim saznam dovoljno informacija o žanru kojeg volim i pratim više me ne zanima i tražim novo područje interesa	1	2	3	4	5
2. Što više znam o žanru kojeg volim i pratim pada mi motivacija za informiranjem	1	2	3	4	5
3. Što više znam o žanru kojeg volim i pratim brže nađem nove informacije prilikom pretraživanja	1	2	3	4	5
4. Što više znam o žanru kojeg volim i pratim, to mi treba manje vremena da dođem do više informacija	1	2	3	4	5

prilikom pretraživanja					
5. Nikada mi nije dosta informacija o onome što volim slušati	1	2	3	4	5

28. O žanru glazbe kojeg slušam znam:
1) gotovo ništa
2) malo
3) niti malo, niti puno
4) dosta
5) gotovo sve

29. O glazbi općenito znam
1) gotovo ništa
2) malo
3) niti malo, niti puno
4) dosta
5) gotovo sve

30. Koliko često slušate glazbu sa niže navedenih izvora

	Nikada	Gotovo nikada	Ponekad	Gotovo uvijek	Uvijek
1. CD/Ploča	1	2	3	4	5
2. Radio	1	2	3	4	5
3. Online Radio	1	2	3	4	5
4. Streaming servis (Spotify, Deezer)	1	2	3	4	5
5. Youtube	1	2	3	4	5
6. Mobitel	1	2	3	4	5

7. Download-irani mp3	1	2	3	4	5
8. S linkova koje dijele prijatelji na društvenim mrežama	1	2	3	4	5

EKONOMSKE ZNAČAJKE

31. Koliko novca mjesečno u prosjeku potrošite na …..?

	0 - 200 kn	201 - 400 kn	401 - 600 kn	601 - 800 kn	801 i više kn	Ne znam
1. Originalna glazbena izdanja (CD, ploče)	1	2	3	4	5	9
2. Download glazbe	1	2	3	4	5	9
3. Glazbene događaje	1	2	3	4	5	9

32. Na koliko ste glazbenih digitalnih servisa poput Deezera ili Spotify-a pretplaćeni?
1) 0
2) 1
3) 2
4) 3
5) 4 i više

33. Koliko tjedno imate vremena na raspolaganju za pretraživanje nove glazbe?
1) ne pretražujem glazbu
2) do 1 sat
3) 1-2 sata
4) 2-3 sata
5) 3-4 sata
6) 4 i više sati

34. U kojoj mjeri se slažete s navedenim tvrdnjama?

Slobodno vrijeme koje posvetim glazbi najviše trošim na:	Uopće se ne slažem	Ne slažem se	Niti se slažem, niti ne slažem	Uglavnom se slažem	Potpuno se slažem
1. Odlazak u klubove i na koncerte	1	2	3	4	5
2. Informiranje o glazbi putem raznih izvora (časopisi, internet portal…)	1	2	3	4	5
3. Slušanje glazbe sam	1	2	3	4	5
4. Slušanje glazbe u društvu	1	2	3	4	5
5. Svoje slobodno vrijeme ne trošim na aktivno slušanje glazbe	1	2	3	4	5
6. Dijelim glazbene linkove putem društvenih mreža	1	2	3	4	5

35. Koliko je za vas točna tvrdnja "Spreman sam platiti više novca ako mogu brzo doći do pouzdanih i kvalitetno prezentiranih informacija o glazbi“?

1) potpuno netočna
2) netočna
3) niti točna, niti netočna
4) točna
5) potpuno točna

OBRASCI TRAŽENJA INFORMACIJA

36. Kada čujete dobru pjesmu u kafiću nije vam problem pitati konobara koja je to pjesma

1) točno
2) netočno

37. Društvo s kojim se družite utječe na vaše informiranje o glazbi

1) uopće ne utječe
2) ne utječe

3) niti utječe, niti ne utječe
4) utječe
5) izrazito utječe

38. Ocijenite koliko su različiti vaši izvori informiranja od izvora informiranja društva s kojim se družite i slušate glazbu
1) potpuno različiti
2) različiti
3) niti različiti, niti slični
4) slični
5) potpuno isti

39. Kako na vas utječe glazbeni elitizam odnosno zatvorenost pojedinih društvenih skupina koje se vežu oko nekog glazbenog pravca (npr. mi znamo sve o tom pravcu, a ti ne znaš pa se nećemo družiti) (ako smatrate da ga nema onda zaokružite uopće ne utječe).
1) uopće ne utječe
2) ne utječe
3) niti utječe niti ne utječe, ne znam
4) utječe
5) izrazito utječe

UTJECAJ OKRUŽENJA

40. U kojoj mjeri se slažete s navedenim tvrdnjama?

	Uopće se ne slažem	Ne slažem se	Niti se slažem, niti ne slažem	Uglavnom se slažem	Potpuno se slažem
1. Ako nemam vremena neću ni početi pretraživati	1	2	3	4	5
2. Ako nemam puno vremena potrošit ću na traženje informacija onoliko koliko ga imam	1	2	3	4	5

3. Ako su mi uvjeti informiranja loši (slaba veza interneta, nedostatak svjetla za čitanje), neću pretraživati	1	2	3	4	5
4. Informirat ću se o glazbi bez obzira na uvjete	1	2	3	4	5

STAVOVI

41. Što vam je važnije, individualizam (sve vrijednosti se sagledavaju kroz pojedinca) ili kolektivizam (ljudska međuovisnost i zajednica je značajna)?
1) Jako mi je važan individualizam
2) Individualizam mi je nešto važniji
3) Oboje podjednako
4) Kolektivizam mi je nešto važniji
5) Jako mi je važan kolektivizam

42. Je li vam u životu važnija dugoročna ili kratkoročna perspektiva?
1) Važnija mi je kratkoročna perspektiva
2) Kratkoročna perspektiva mi je nešto važnija
3) Vodim računa o kratkoročnim i dugoročnim ciljevima
4) Dugoročna perspektiva mi je nešto važnija
5) Važnija mi je dugoročna perspektiva

43. Izbjegavate li neizvjesnost (iznenađenja i neočekivane situacije)?
1) Nikada ne izbjegavam
2) Češće ne izbjegavam
3) Ne znam, ne mislim o tome
4) Češće izbjegavam
5) Uvijek izbjegavam

44. Ocijenite koliko vam je važno materijalno
1) Materijalno mi je isključivo nevažno
2) Materijalno mi je nevažno
3) Niti mi je važno, niti nevažno
4) Važne su mi materijalne stvari
5) Isključivo su mi važne materijalne stvari

45. Ocijenite koliko vam je važna briga za druge

1) Uopće mi nije važna
2) Nije mi važna
3) Niti mi je važna, niti nevažna
4) Važna mi je
5) Izrazito mi je važna

APENDIX 2 - MUSIC SEARCHING TASK

Zadatak 1
Kod kuće priređujete tulum. Molimo vas da napravite novu ili odaberite postojeću play listu koja će sadržavati glazbu koju ćete puštati na svom tulumu (kućnoj zabavi) koristeći vama omiljen izvor glazbe online. (npr Youtube, online radio, online dućani s mp3...) U slučaju da glazbu kupujete, idite do vašeg online dućana gdje glazbu inače kupujte, napravite selekciju glazbe koju želite kupiti, te ju stavite u košaricu za kupnju (kada ste napunili košaricu završili ste zadatak).

Kada završite sa zadatkom posjetite TVZ.HR

Zadatak 2
Jedan od vaših roditelja ima proslavu rođendana i zamolio vas je da mu pomognete s izborom glazbe koja će se puštati na proslavi. Molimo vas da se informirate o glazbi koju bi puštali i izaberete pjesmu večeri za taj tulum (kućna zabava).

Kada završite sa zadatkom posjetite TVZ.HR

Zadatak 3
Odlučili ste se za izlazak u klub ili koncert ovaj vikend kako biste slušali glazbu. Molimo vas da se informirate o događanjima, izaberete gdje ćete izaći te pronađite web stranicu gdje se nalaze detaljne informacije o tom događaju. Kada ste se odlučili za događaj, pokušajte kupiti ulaznice online (dođite do opcije “kupi” ili “buy”).

Kada završite sa zadatkom posjetite TVZ.HR

Zadatak 4
Na nagradnoj igri dobili ste karte za vikend putovanje u London za dva tjedna. Odlučili ste posjetiti koncert ili klub gdje nastupa vama drag glazbenik, band ili DJ. Molimo vas da se informirate o događanjima, izaberete gdje ćete izaći te pronađite web stranicu gdje se nalaze detaljne informacije o tom događaju. Kada ste se odlučili za događaj pokušajte kupiti ulaznice online (dođite to opcije “kupi” ili “buy”).

Kada završite sa zadatkom posjetite TVZ.HR

APENDIX 3 - AUTHOR CV

MSc, Sergej Lugović, MBA, (PhD Candidate), 19.01.1974
Radnička Cesta 34a, Zagreb, Croatia,
Contact: lugovic.sergej@gmail.com / 00385914658199

A business information system designer, researcher and practitioner with a solid research background, industry experience and a teaching portfolio. Interested in developing a career which combines teaching, research and practice in the domain of inovation, technology entrepreneurship and development of new technologies.

Sergej Lugovic is a senior lecturer teaching Information Economy, Technology Entrepreneurship and e-business at the various universities in Croatia. He's also a PhD candidate at the Information Science department of the Faculty of Humanities and Social Sciences, University of Zagreb. His research interests are information behavior and needs in intelligent socio-technical systems. He holds a Master of Science degree from Plekhanov Russian University of Economics and an MBA from The London College UCK. Along with his academic career, he had a business career in Moscow, London, and Zagreb, working for blue chip companies, for the government of the Republic of Croatia, in technology ventures, and in the fashion and the music industries. He holds and continuous education degrees from MIT (Big Data) and University of Amsterdam (Digital Methods) and professional SAP Hybris Marketing Functional Analyst.

Formal Education

2012 – Present – PHD candidate in Information Science, Humanities and Social Sciences, University of Zagreb, Zagreb, Croatia
1998 - 2000 - MBA Degree, The London College, London UK
1994 – 1997 MSc Degree in Banking and Finance, Plekhanov University, Moscow, Russia

Other qualifications

2015 - MIT Big Data Summer School
2016 - Digital Methods, University of Amsterdam
2017 - SAP Hybris Marketing Functional Analyst

Teaching/supervising experience

- Supervising undergraduate and graduate dissertations

- Assisting with programme development and student assessment
- Delivering teaching sessions on partners insitutions and practitioners events
- Assessment of internal communication system for the purpose of implementig ISO standards
- Guest lecturer; University of Applied Sciences Technikum Wien
- Summer school, Vodice - "Gaining Powerful insights into Social Media Listening", 2017,2018
- Big Data Summer School, Zagreb, 2016, 2017
- Founder of Big data lab at Zagreb University of Applied Sciences
- Development of customised education programs for different companies
- Mentor at SPOCK, University of Zagreb, faculty of electrical engineering and computing
- Mentor at ZICER - Zagreb Innovation Centre
- Mentor at Startup factory Zagreb
- Mentor at Zagreb Connect
- Two times finalist in SAP CEE innovation challange with the solutions developed at Big data lab

2021 - Present, Marko Marulić Polytechnic in Knin, Senior Lecturer, Zagreb, Croatia

- Sales and Distribution
- Market research

2019 - Present, The Polytechnic of Šibenik, Senior Lecturer, Zagreb, Croatia

- Digital marketing and analytics
- Business communication and social media

2005 – 2019, Zagreb University of Applied Sciences, Senior Lecturer, Zagreb, Croatia

- Digital economy
- E-business - economics, organization and management
- E-business and software
- Economics and management
- Business ethics and law
- Technological entrepreneurship
- Strategic Technology Entrepreneurship
- Socio-technological aspects of Information Systems
- Market communications
- Organization and economics
- Digital entrepreneurship
- Management
- Sociology
- Economics and organization of business systems

2000-2001 - VERN University

- Business organisaton

Publications

1. Ahmed, Wasim, and Sergej Lugovic. "Social media analytics: analysis and visualisation of news diffusion using NodeXL." Online Information Review (2018).
2. Lugović, S., Dunđer, I., & Horvat, M. (2017, January). Primary and Secondary Experience in Developing Adaptive Information Systems Supporting Knowledge Transfer. In 40th International Convention on Information and Communication Technology, Electronics and Microelectronics MIPRO 2017
3. Lugović, S., & Dunđer, I. (2017, May). Automatic information behaviour recognition. In Information and Communication Technology, Electronics and Microelectronics (MIPRO), 2017 40th International Convention on (pp. 1217-1220). IEEE.
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15. Using a Viable System Model in the Design of the Communication System at Zagreb University of Applied Science' by Sergej Lugović, Predrag Valožić, European Meetings on Cybernetics and Systems Research, 2016
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Work Experience

2019 – present, Vesela Motika, CEO, Founder,

Vesela Motika is a university spin-out developing digital eco transformation solutions. First clients among others are the City of Zagreb, Institute of Biodiversity, leading Croatian Agrifood Cooperative, Kroštula/Bread club (craft bakery), and other numerous technology advanced farms in Croatia. Vesela Motika portfolio consists of; Cleverville; software that covers short food

supply chain processes, SOFIA; IoT platform for indoor and outdoor farms automatization and sensors management, Farmica.shop; the online market place where independent food and drinks suppliers connect with consumers and the urban vertical farm in the center of Zagreb.

2005 – 2019, **Zagreb University of Applied Sciences**, Senior Lecturer, Zagreb, Croatia

- Technology Entrepreneurship, Market Communication, Socio-technical Information Systems, e-business
- Head of SAP HANA lab @ TVZ (supported by SAP)
- Partnering with City of Zagreb on Zagreb Connect - startup conference, Startup Factory, pre acceleration program
- Founder of the first university co-working space for students at Polytechnic of Zagreb
- Involved in sales process development of 'Lifelong Learning' initiatives

2011 – 2018, Compliant Risk Technology, Business partner, Zagreb, Croatia

- Solutions and technology for regulatory reporting in the financial sector (Solvency II regulations)

2007 – 2013 - Night Clubs: Sirup (Founder) & Porat (Managing Partner), Zagreb, Croatia

- Porat and Sirup were two most popular clubs in Croatia, according to Resident Advisor
- During summer of 2009, the two clubs employed over 70 people excluding performers, DJs and promoters.
- Porat was the first Croatian club featured in 'Top 100 clubs in the World' by DJ Mag
- Moderated and participated in various panels and conferences related to music and contemporary culture

2005 - 2008 - 4yTV, Founder and Director, Zagreb, Croatia

- First online video company in Croatia and the first Croatian video blog in 2005
- Developed technical infrastructure and video formats to stream video content for corporate and governmental clients such as the Croatian Parliament, Ministry of Foreign Affairs of Croatia, Glaxo, Reckitt Benckiser
- Set up numerous webcasts from leading Croatian business events and conferences

2001-2005 - SAP Croatia, Marketing Director, Zagreb, Croatia

- Responsible for all marketing and PR activities
- One of the first 4 employees, office grow to 26 employees
- Responsible for hiring over 20 employees
- Key account manager

2000 - 2001 – CGEY, E-Business Consultant, Zagreb, Croatia

2000 – 2000 - Croatian Government, **Office for Strategic Development**, Zagreb, Croatia

1999 - 2000 - PetsPark.com, Business development, London, UK

1999 – 1999 - Pfizer, Internet Strategist, Sandwich, UK

1997 - 1998 - LeForm Fashion Store , Manager, Moscow, Russia

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