Journal of Print and Media Technology Research

Special issue

Audience, design, technology and business factors
in new media innovation

Guest Editors
David M. Frohlich & John Mills

Scientific contents

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Introduction to special issue:
Audience, design, technology and business factors in new media innovation

The print and media industries have been going through significant and prolonged change in recent years due to the digitization of media content. As with many innovations, the earliest phase of change involved a kind of replication of existing services with new technological processes. Hence the replacement of analogue with digital printing machines simply allowed print media to be produced more flexibly and efficiently. This resembled the motorized carriage design of early cars, echoing the horse drawn carriages they were replacing. More recently, print itself is being threatened by screen-displayed content, which can not only reproduce the printed word and image, but go beyond this by packaging multiple pages in a highly portable and convenient e-book form, providing instant access to multiple sources of web-based content, and integrating other media such as sound, video and interactive games. Similar things could be said about the digital broadcasting of radio and TV content, which is now ready for more radical integration with paper and the web.

In this special issue, we examine some of the factors involved in new media innovation within this context of media digitization and convergence. In particular, we consider the future of print media in relation to screen-based media, and some possibilities for combining them in different ways. The papers were invited from presentations at the IARIGAI 2015 conference on Advances in Printing and Media Technology in Helsinki from the 6th–9th September last year. Furthermore, four out of the five papers were submissions from members of the EU COST network FP1104 on '*New possibilities for print and packaging: Combining print and digital*'. The non-FP1104 paper was a related keynote paper on digitization and service business model innovation by Viljakainen, Toivonen & Seisto. The COST network is comprised of 140 academic and company members from 29 countries across Europe, and has been meeting for four years to share and generate new research on augmented print and packaging: http://www.cost.eu/COST_Actions/fps/FP1104. It also held the *Paper Evolutions* exhibition of new product concepts in the area at the IARIGAI 2015 conference (Seisto et al., 2015). The selected papers are a small window on the discussions of the network regarding the future of paper, and the need to think about its innovation from an interdisciplinary point of view.

Those points of view broadly echo the disciplinary orientation of the work packages of the COST network. They consider audience, design, technology and business factors in new media innovation. These ingredients need to come together in any new business opportunity so as to provide media content and experiences people enjoy and are willing to pay for at a sustainable price, through an appropriate design of the right technology. Research however, often provides insights into these factors separately, through the methods and languages of each contributing discipline. This is largely true of the selected papers that approach their subjects from sociological, psychological, technological, economic, and management perspectives respectively. Nevertheless, together they begin to point to bigger themes which the reader may appreciate by reading them as a set, and hopefully to stimulate cross-disciplinary discussion out of which new ideas may come.

Hence the first paper relates to **audience factors** and is by Vincent, on *'Students' use of paper and pen versus digital media in university environments for writing and reading – a cross-cultural exploration'*. This summarises a new cross-cultural study of students' current attitudes to reading and writing on paper and screens. The study involved data collection from 12 countries, made possible by collaboration within the COST network, and involved the administration of questionnaires with multiple choice and free text questions about students' use of pen and paper, keyboard and screen for both learning and leisure purposes. Perhaps surprisingly, given the ubiquity of screen-based technologies in European universities and homes, students still reported use of pen and paper for reading and writing of certain kinds. This is the beginning of a general theme about the complexity of preferences for print and screen media, and their relationship to individual, group and cultural differences as well as the tasks and content to which they relate.

This theme is taken further in the second paper of the issue. This relates to **design factors** and is by Laine and Leppänen, on *'Experimental comparison of user experiences of different digital and printed newspaper versions'*. The paper reports an experimental comparison of reading experiences with five different versions of a Helsinki newspaper; the Helsingin Sanomat. One version was the printed newspaper while four versions were different e-book versions displayed on an Apple iPad 4 tablet. Participants browsed each version in randomized order whilst wearing glasses that tracked their eye movements, and later rated and discussed their experiences for each version of the newspaper. Different questionnaire statements were more closely associated with one version than another, but there was no overall winner in terms of preference. In fact preferences differed within and between participants, despite the fact that the content was identical across versions. This shows the role of content and interaction *design* as well as medium, in shaping reading experiences and preferences. The author also reports a consistent split in the group between those who preferred a conventional bounded collection of news, as in a traditional newspaper, and those who were more open to a continuous changing stream of news, as in an evolving webpage. This points to the importance of *audience* factors again, and the emergence of new audiences willing and able to deviate from conventional formats and expectations, irrespective of medium.

The role of **technology factors** in creating new formats and combinations of media is addressed in the third paper. This is by Fedorovskaya, Hickerson, Desai & Cheng, on *'The RocReadaR – A system for transmedia news publishing using augmented reality'*. The authors describe a novel system for what they call transmedia publishing of print-and-digital content. Essentially this is an app running on an Android Nexus 5 smart phone which can display associated content linked to a printed magazine on 'Research at RIT' (Rochester Institute of Technology). Holding the phone over the magazine brings up related content options which users can select from on-screen

icons replicating printed icons on the magazine. While many of the features of the app were rated positively, there was no clear preference over paper alone. In fact the experiment threw up new design issues relating to which type of content to associate with what type of article, and how to cue and control this while reading the paper. In parts, the associated information could add interest, information and fun to the reading experience, and make it easier to remember. But there were also concerns that it could distract from reading and understanding the printed article. Unlike the Laine paper, there was also no third condition of e-magazine alone to contrast with the paper and augmented paper versions. The AR technology and approach therefore appears to demonstrate promise in the context of paper documents, but requires time for further development and design experimentation.

Business factors are covered in the last two papers of the special issue. In the fourth paper, Viljakainen, Toivonen & Seisto discuss '*Digitalisation and service business model innovation in media*'. This begins with a review of literature on the trend from product to service design in the printing industry, where print products are seen as carriers for content-based services rather than ends in their own right. A related shift is said to involve a new relationship with customers as co-creators of content rather than mere 'consumers'. The second part of the paper reports on the findings of an interview survey of 50 staff from media firms across three Nordic countries, extending the literature review for this population. Service thinking is recommended as a route to business model innovation, which for some printing companies may mean diversification into content delivery over other channels.

The openness of the printing industry to print and digital innovation is examined in the fifth paper of this issue. This is by Tiekstra, Držková, Miranda, Isaías, Vehmas & Seisto, and is entitled '*Attitudes of the European print industry towards innovative combinations of print and digital*'. The study gathers perspectives on 'innovative printing' – a term which encompasses printed electronics, printed intelligence, augmented reality and QR codes, many of which seek to embed or connect with digital interactions and experiences. Taking a pan-European approach, the cross-cultural study surveyed 217 companies from 10 European countries via a common questionnaire. It asked about their size and characteristics, involvement with universities and gathered industry perspectives on these various new forms of printing and packaging. Although the survey data suggests the print industry has a complex series of views and varying degrees of engagement with 'innovative printing', a number of key findings begin to emerge. The authors discovered a consistently held desire within the sector to learn more about these innovations. The paper also suggests that cross-disciplinary collaboration and greater links between industry and academia could foster a more effective environment for innovative printing.

Taken together, the papers in this special issue illustrate the diversity of approaches to new media innovation in the print and publishing industry. It is often said in this industry that 'content is king', implying that if the media content is interesting enough to audiences, then they will pay for its delivery irrespective of the way it is packaged or sold. This does not appear to be true from the papers just described. Audiences are very sensitive to the form in which content is delivered, whether it be printed or screen-displayed according to Vincent, or laid out as a conventional newspaper or evolving webpage according to Laine & Leppänen. Furthermore, new technology such as the transmedia publishing system shown by Fedoravskaya and colleagues, can open up new possibilities for authoring content differently to be split between paper and screen. This has subsequent implications for the user experience of reading and watching content of different kinds concurrently. Whether content is sold as a product or service also affects the economics of its value, according to Viljakainen and colleagues.

This is not to say that media content itself is unimportant to new media initiatives. Bad content can never be attractive or commercially viable, however well it is designed and delivered. Rather, content is not the only factor to be considered within a media ecosystem, especially one in the current state of change and flux. As the Tiekstra et al. survey data suggests, a multi-stakeholder and cross-disciplinary approach is perceived by companies to be a key component in creating innovative responses to market conditions. We have adopted such an approach here, and suggest that the richness provided by multiple research disciplines and their varied approaches, is necessary to identifying coherent new business opportunities which have the right combination of audience, technology, design and business factors.

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Students' use of paper and pen versus digital media in university environments for writing and reading – a cross-cultural exploration

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Abstract

This paper offers a summative cross cultural analysis of qualitative survey data collected to investigate the impact of digital media on writing and reading within universities from different countries. It addresses the particular aspect of the student's experiences of paper and pen versus digital media. This study is based on the results of individual qualitative research conducted in 10 countries in two continents by members of the COST Action FP1104, Work Group 1 – Customers and Users. The methodological approach used is qualitative content analysis of the reported research and analysis of the individual country surveys. The survey was conducted in the national language of each country using the same research questions. Various survey methods were deployed – online questionnaire; questionnaire and interviews or hand written essays. The principal results show that there are many similarities between the countries studied but that some use pen and paper less whereas others are more prepared to use hand writing, this may link to the availability and use of digital technologies as well as to personal preferences. Reading and writing competencies are changing with the use of digital technologies but students still see benefits of reading and writing with paper which they continue to use, especially to convey private emotions and intimate feelings. This study provides new learning about the contrasting use of paper and digital media within an educational rather than business setting. These surveys provided the basis for the design and analysis of a follow up quantitative study (not examined in this paper) and for further exploration of this important research topic within the countries surveyed, particularly in social sciences and pedagogical studies.

Keywords: computer, education, keyboard, paper, reading, writing

1. Introduction and background

This paper reports a summative analysis of a cross cultural transdisciplinary qualitative study comparing and contrasting the use of pen and paper and the use of keyboard and screen in 11 university educational settings: Italy, UK, Slovakia, Bulgaria, Hungary, Russia, China, Hong Kong China, Portugal, Finland and Germany. The study was conducted by members of COST Action FP1104 Work Group 1 Customers and Users (WG1) who explored the effect of the changing media use habits on traditional media within the context of new possibilities for print and media (see acknowledgements for further details of countries and members of the survey team).

Personal and business relationships, communications, and management of everyday life are increasingly mediated via digital technologies and the use of paper books and writing on paper appears to be at risk of declining. Smartphones, tablets, laptops and personal computers are at the heart of contemporary society enabling people to work and communicate in almost any loca-

tion. We learned from the work of Sellen and Harper in 2002 that, contrary to expectations, the arrival of computers did not result in a paperless office. Their study, based on business users, was conducted over ten years ago (Sellen and Harper, 2002). Our present study not only provides more contemporary research but it asks students in 10 different countries in a university environment about their preferences for pen, paper or digital for reading and writing. Do they still have a use for pen and paper or has digital literacy superseded writing by hand and reading on paper? Studies that research the comparative and contrasting use of paper and pen with digital technology are scant and tend to focus on e-reading versus paper books and on electronic substitutes for paper and pen, rather than also considering handwritten notes and letters (Dillon, 1992; Chen, Guimbretière and Sellen, 2013; Baron, 2015). Publications by members of the Survey Team are cited elsewhere in this paper. However, a psychological study of students (Mueller and Oppenheimer, 2014) has recently reported findings that students retained

more knowledge when they wrote notes with pen and paper, results that are complementary to our own findings. It is notable that prior to our study university students in educational settings have not previously been researched about their use of paper, pen, screen and keyboard for both reading and writing and thus our research provides opportunities for developing new knowledge in this area of study. Our aim was to understand whether paper and pen, especially when used for writing and communicating, still figured in the daily lives of the students whom we knew to be avid users of digital technologies via keyboard and screen.

In this paper the outcome of our unique study of 633 university students in 10 countries from Europe and Asia is reported. The students were asked about their use of writing and reading with pen and paper and keyboard and screen. Lead by the sociological approach outlined in Fortunati and Vincent (2014) the study includes contributions from graduate and postgraduate students in media and communications, chemical and metallurgy, linguistics, psychology, human computer interaction, design, computer sciences and paper science disciplines.

The foundational work for this study involving 24 graduate students was carried out by Leopoldina Fortunati at the University of Udine in Italy (Fortunati

and Vincent, 2014) and explored the research questions: how do students perceive the affordances of electronic reading/writing when compared to writing and reading with paper? And, have electronic writing and reading become richer experiences than paper writing and reading? These questions draw on theories and concepts regarding electronic writing (Ong, 1986) and media richness theory (Daft and Lengel, 1984). Contrary to expectations that paper and pen may have fallen out of use this cohort of Italian graduate students did, indeed, use this medium. They valued handwritten messages and letters for intimate communications as well as finding it to be integral to their research and learning processes. They were also voracious users of digital media, intertwining digital and paper note taking and reading in their academic work in particular. The Survey Team thus aimed to replicate this Italian study to ascertain whether or not there may be indications that the uses of pen, paper, and digital technologies were similar among countries in the European Union and in Russia and China.

Following this introduction and overview of complementary literature that frames this study, the next section outlines the methodology for the survey and a summary of participating Universities. This is followed by discussion of the findings articulated in five themes and finally the conclusions drawn from this research.

2. Methods

The seminal paper by Fortunati and Vincent (2014) and their research questions and methodology formed the basis for an especially designed qualitative survey in 10 of the countries represented in the WG1 survey team. Note that a new group of undergraduate students was surveyed in Italy providing new data for this country. The members from Serbia and Ireland did not conduct the qualitative survey although they participated in the survey design and discussion of the findings. The same research questions were used in each of the 11 qualitative surveys (two surveys were carried out in China – in Beijing and Hong Kong) conducted in 2013 and 2014 but the data was gathered using some variations in method. The survey was not funded and thus the approach taken in each country reflected the method most suited to local circumstance. In Italy, for example hand written essays discussing the questions were submitted for course work; in most other countries (see Table 1) the survey was conducted on line and, in Russia and China, a structured questionnaire with some interviews were used. The responses were analysed by the survey team member and a report of the results was provided at the meeting of COST Action FP1104 in Ljubljana 4 November 2013. In some instances the country data was subsequently published in more detail in journal articles

(Taipale, 2014; 2015; Kaputa and Paluš, 2013; Lasheva, Blazheva and Lasheva, 2014; 2015; Vershinskaya, 2014; Farinosi, Lim and Roll, 2015; Isaias, Miranda and Pifano, 2015). Additional analysis was reported and discussed at the WG meetings in 2014 to 2015 and in skype calls between survey team members. These country reports, journal articles and reflexive team discussion form the data used for this present article.

In the surveys university students were asked to freely write about their reflections on four themes articulated in three questions (Vincent, 2014). They were not given instructions on how to write about each theme because we were interested in their spontaneous thoughts.

1) Describe the differences you find when using a pen and using the computer. Furthermore describe what you like and dislike about both these modalities.

2) Describe which differences you find in reading paper and reading on a screen. Furthermore, describe what you like and dislike of both these modalities.

3) Think now of the gestures and postures you assume in reading and writing using paper and on a screen. Reflect and describe them.

Table 1: Summary of Qualitative Survey Data Sources from Participating Countries
(Source: COST Action FP1104 WG1 Survey Team)

Country Lead Researcher	Number Surveyed Gender Breakdown Male/M, Female/F	Period of Survey	Undergraduate/UG Graduate/G	Range or average Age where known	Survey method
Bulgaria Veska Laysheva Chemical Technology & Metallurgy University Sofia	38 24 F 14 M	April–June 2014	25 UG 13 G	19–26	Online questionnaire
China Yao Nie Peking University	40 unknown	2013	21 UG 18 G 1Visiting Scholar	23	Questionnaire and interviews
Finland Sakari Taipale Jyvaskyla University	26 23 F 3 M	Jan–Feb 2013	13 UG 13 G	27	Online questionnaire
Germany Joachim Höflich University of Erfurt	54 41 F 13 M	June–July 2013	46 UG 8 G	21.9	Online questionnaire
Hong Kong China Chung Tai Cheng Hong Kong Polytechnic University	28 14 F 14 M	June–July 2013	28 UG	unknown	Questionnaire
Italy Manuela Farinosi University of Udine	129 52 F 77 M	April 2011 to October 2012	129 UG	21	Hand written essay
Portugal Pedro Isaias Lisbon	98 unknown	2013	98 UG/G	unknown	Online questionnaire
Russia Olga Vershinskaya Russian Academy of Sciences Moscow	25 unknown	Sept–November 2013	25 UG	19–21	Online questionnaire
Slovakia Vladislav Kaputa Technical University Zvolen	100 unknown	2013	100 UG/G	21.5	Online questionnaire
UK Chris Lim University of Dundee	23 unknown	May 2013 to October 2014	13 UG 10 G	26.9	Online questionnaire
Hungary Rozalia Szentgyorgyvolgyi Óbuda University Budapest	72 unknown	Feb–March 2014	68 UG 4 G	23.6	Online questionnaire

The surveys were conducted in the national language of the respective country and the findings reported to the survey team were translated into English by the country representative. Table 1 shows a breakdown of the respondents by University location and the survey method.

Conducting these surveys in multiple countries simultaneously highlighted some challenges for implementing this research. Although the three core questions are the same the survey was variously set as a hand written essay or questionnaire, typed online question and answer survey, or structured interview. The student demographic was consistent but the gender split and courses studied varied. The students were a mix of graduate and undergraduate, with fewer graduate students overall. Some graduate courses are 4 years (e.g. UK) which means there is some inconsistency in the average ages of graduates and undergraduates. It was reported by Slovakia and Finland that fewer male students were willing to contribute to open ended questionnaires online, whereas the gender balance in Italy reflected the student cohort completing the survey as part of their coursework. Additionally there are nuances not explored: for example, differences between reading printed and hand written text; between reading a paper

or e-book and the size of the screen. Another limitation was that as this study was not funded it had to be incorporated into the everyday work of Survey Team members. Nevertheless, a set of rich qualitative material was obtained from these country surveys. Analysis of the material was conducted initially by the respective country researcher and subsequently by discussion in the survey team meetings at the COST FP1104 Work Group sessions, and in some online meetings.

In order to explore the data from a comparative perspective the data obtained from a qualitative survey would usually be coded and analysed using NVivo or similar qualitative software, and indeed some teams used this method for their country data (e.g. Portugal). However, as not all the surveys were conducted with an identical approach, comparative coding was not possible and instead the research was analysed on a country by country basis. The results were not compared until after this initial analysis. In this paper the data published by each country has been examined according to content analysis of the reported data and the outcome of reflexive analysis of the material in work group discussion. The following sections build on these survey results and discussion by examining the data in five themes.

3. Results

Delivering a detailed breakdown of results of all the studies according to each research question, and separated according to preferences for pen or keyboard when writing and paper or screen when reading, would be cumbersome and is not the purpose of this present paper. Furthermore, detailed analysis by some countries is already available as reported in Section 2. Instead the results are explored in this section by first providing a short summary overview, followed by a discussion of the findings according to themes identified by the author of this paper. These themes are illustrated by quotes taken from the individual survey reports.

Overall there were many more similarities than differences between the results reported from each country. The consensus of the Survey Team was that the discipline and level of study might be a factor in the choice of media used for reading and writing. Additionally some courses are conducted using mostly online reading material giving students no paper option and assumes they are digitally competent. It is noted here that there is already considerable debate on digital literacy and digital natives (Helsper and Eynon, 2010) and regardless of their competences university students are required to study within a digital learning environment. Furthermore, their institution is expected to provide and respond to their changing digital needs. As

this Hungarian student commented 'Most of my school materials exist only in electronic form'. Nevertheless, students' uses of paper books, pen and paper, and handwritten note-taking prevails alongside their digital equivalents. In the discussion below the results from the surveys are used to illustrate the contrasts and correlations between the student's experiences of writing and reading with pen, paper, keyboard and screen; we use quotes from students to explicate the findings (Vincent, 2015). Names and ages of individual students are not shown but the quotes provided have been identified as exemplary of the findings from the relevant survey.

There was consensus of views and responses across all the countries covering a variety of topics relating to the functionality and status of digital technologies in society and old and new ways of doing things. The findings from the research are explored through discussion of 5 themes cross-cultural differences: aesthetics and emotions, ease of use, costs, and corporeal comfort.

3.1 Cross-Cultural Differences

Cross-Cultural differences were discussed by WG1 Survey Team members at their meetings. Drawing on the overall results from their surveys this reflexive team discussion highlighted that there were many more

similarities and fewer differences between countries than had been expected. Vershinskaya in her report of the Russian survey comments:

'The first rather astonishing result is that there are lots of coincidences in opinions of Russian, Italian and other countries' students which show how great the influence of globalization is. It needs further research.' (Vershinskaya, 2014, p. 1).

Overall, the conclusion from the Portugal study sums up the similarities in the findings across all studies: 'While the computer is seen as a fast and effective tool, the paper provides increased concentration levels and a more sensorial experience' (Isaias, Miranda and Pifano, 2015, p. 143). In contrast, the cross cultural differences were more nuanced. For example, Bulgaria and Finland showed a proclivity towards a more wholly digital experience than others. Possible reasons for this discussed in WG1 suggested it was do with the domestication of digital technologies in university, within society generally, or it may be influenced by the discipline or subject matter studied by the respondents. In his analysis of the Finnish results Taipale (2014) addresses this point by comparing findings from Finland and Italy (Fortunati and Vincent, 2014) in the context of the theory of technological frames in which 'people are inclined to approach the new in terms of their pre-existing technological frames' (Orlikowski and Gash, 1994, p. 191). In Finland the high penetration of use of digital technology is such that digital writing was the frame of reference for Finnish students whereas the Italian respondents, answering in hand written essays deferred to the older technique of hand writing when considering digital writing. Taipale also notes, however, that this difference does not extend to reading and the responses to digital reading are framed by experiences of reading paper books in both countries (Taipale, 2014, p. 16).

3.2 Aesthetics and Emotions

The aesthetic of the chosen medium is a deciding factor for many; the haptic qualities of the interaction; the touch, feel and smell, as well as the emotions elicited by the encounter were noted by numerous respondents in all countries. As one might expect there was strength of feeling for all modes of reading and writing but it was the use of a pen and paper for hand writing that generated the most keenly felt responses. Pen, paper and paper books are treated with affection and nostalgia as in these examples that express emotions regarding the use of paper and writing by hand:

> *Handwriting is slower and impractical, but at the same time more personal and enjoyable. Writing with a pen also relates to the joy of chirography. My chirography is unique and it often catches other people's attention. I feel that it says*

something about my persona and perhaps because of this I want to cherish handwriting. (Finland)

The taste of browsing something material is priceless! I like very much to enjoy the scent of the book through the fragrance of the paper. (Italy)

Writing by hand is much more personal, more subjective. This allows us to bring up all of our emotions: happiness, sadness, nervousness. Based on the features of the texts we can understand how the writers felt at the time of writing. (Italy)

I use paper to write on when I have to write important messages, with passion, because in my opinion, your own handwriting makes the message very personal. (Italy)

Sociological studies of the use of information and communication technologies by Vincent and Fortunati (2009) has highlighted the electronic emotions that are lived, re-lived and created when using machines. With regard to using pen and paper no machine is involved (although one can argue it is a form of ICT) but it is clear from the student's experiences that the smell of paper, for example, evokes strong emotional responses but particularly with regard to the olfactory properties of paper. The smell of a laptop or other devices was not mentioned as a reason for preferring it. Perhaps, following Taipale (2014), we have hitherto taken for granted the emotional ways we express ourselves in hand written notes and communications. Is it only now, with the interplay between digital and these more traditional ways of communicating, that the importance of the aesthetics and the emotions as well as the content and modalities of all communications media are worthy of note. Further findings from our qualitative research show that it is not simply a matter of being digitally literate, and 'doing things digitally' but there are sometimes special conditions that mean digital technologies do not work. The sentiment of the communication cannot be communicated unless expressed in hand written form. For example, Yao Nie in her analysis of the survey conducted in China reported: 'Chinese characters are not just an information carrier, but also a culture carrier. Aesthetically, calligraphy is more concerning handwriting itself than the concrete information the characters bear' (Yao Nie, WG1 2013). Emotional differences in the expression of national identity through the characters of chirographic script were also noted by some Hong Kong respondents who are more able to express themselves in the strokes of hand written characters than in coded form on the computer.

3.3 Ease of Use

The choice between digital or paper based reading and writing was greatly influenced by the amount of dexterity the affordances of each medium offered to the students. The practical qualities of easy search and cor-

rection is judged by many respondents to only be possible with computers and despite problems of posture and tired eyes, writing and reading online is usually more practical in the education setting.

Most students are not wholly paper or digital but combine paper and digital to suit their particular needs. For example when drafting notes and writing them up, printing out work and annotating it, and most often using hand written notes to quickly record ideas. The flexibility of working online (e.g. writing up course work), however, is favoured by many when there is no substitute to the particular features such as hypertext; multiple simultaneous texts and so on. This refers also to the ease of correction, neatness and legibility of their work.

I am so used to hypertexts that I miss this application when reading texts on paper. (Germany)

The text is easier to edit on a computer afterwards, so it is more likely that all ideas will come out, while when writing on paper you sort of have to manage with what comes to your mind at that particular moment, and thus the outcome is easily unclear and inconsistent. (Finland)

I used to write essays by hand at high school, it would annoy me how much paper and time we would waste having to re-write the same essay over and over again until there were no mistakes and it looked neat. (UK)

There is another reason to favour handwriting, however, and this is the role it plays in learning and retaining knowledge. Many of the students in our study found making hand written notes leads to greater retention of the data than if it is typed and there is a firm belief that retaining new knowledge is more likely to be successful when writing notes during the learning process than when reading or listening online.

If you get prepared for an exam, no information is left in your head if you use a keyboard. Writing with a pen allows you to remember what you write. (Russia)

In printed form the school-work is more transparent, and easier to remember. Digital display flickers and disorders. (Hungary)

Some respondents felt that writing using paper strengthens memorization because Chinese handwriting requires you to write by stroke so that you might be more concentrated. (Hong Kong China)

Our findings are borne out by Mueller and Oppenheimer's (2014) research in which they conducted psychological tests on 142 students to determine the effectiveness of long hand or computer note taking; the long hand note taking was the more successful for memory retention.

This usefulness of hand writing is further highlighted by challenges posed by representing mathematical symbols or graphic symbols online:

It is easy to write lectures on the computer but to write down formulas it is much easier to use a pen. (Russia)

Graphs or complex formulas are not easy to input while writing on screen. (China, Beijing)

Additionally, when writing by hand, students often make personalized use of spatial layout or annotation markers:

I use white space and the positioning and grouping of notes on a page to aid understanding. This is a rapid process which cannot be achieved on screen. (UK)

What I like most about a pen, is that it is quick to add notes, comments, and all kind of drawings in the text and on the side. For example, for me drawing arrows is easiest by hand. (Finland)

On the other hand, a great thing in pen writing is a possibility to write on different parts of a paper sheet, in different directions and with different coloured pens, use text of different size, and insert this and that here and there. Making a mind map with a computer is, in principle, much more difficult, and requires efforts to a different extent. (Finland)

There was recognition that computer mediation can be a distraction as it can fragment thinking and it was noted in Hong Kong most respondents emphasized that reading and writing using paper encourages them to treat these as a complementary behaviour, whereas using a screen makes them experience reading and writing as separate units. In Portugal students underlined the difference between the formality of the computer and the flexibility and informality of the paper and in Russia age matters. The hypothesis suggested by the Russian survey, (Vershinskaya, 2014) is that the younger the student is the less accustomed to handwriting and to reading books he/she is: *Using a pen becomes more and more obsolete. I learned to print quicker than to write.* (Russia). It is clear that students have experienced different learning practices and acquired different reading and writing skills from their early use of computers such as explained by this UK student.

When I was little I used to play text adventure games on my dad's computer. As the games used a command line interface I had to write out actions and there was no tolerance for misspelling commands. I'm pretty sure that both my reading and writing improved through playing these games while reading physical storybooks only really made me more confident with reading. (UK)

3.4 Corporeal Comfort

Corporeal comfort refers not only to the physical comfort regarding the effects on the body when using different media but also to an individual's perceptions of what are the better tools for them for reading and writing. These are expressed in terms of competences such as eye strain, weight of books and speed of reading which in turn affect body postures and the practicalities of holding open a book or reading in bed.

Until last year I was mostly a paper reader but I slightly evolved so that now I think I'm equally competent as a paper and online reader. I used to print articles if they were longer than 10 pages but nowadays I manage to do that online. I got used to it but I also got this application to write notes on a PDF file so that I can act on online documents as much as I would do on paper. (Finland)

I like digital more, because it is more [easy to] mobilize if I have the appropriate book/manual on my laptop, instead of many, many books to carry. (Hungary)

When I travel I do not want to carry extra weight (books) with me. (Hungary)

The strain of the weight of books is mentioned as well as the strain on the eyes of reading screens. This latter point was often mentioned and expressed with frustration and anxiety.

There is nothing like reading [hard copy]. Not only is reading more comfortable for the eyes but also reading is giving you the feeling that the content is more tangible. (Germany)

The posture usually adopted when reading was important when deciding whether to read hard copy or from a larger screen as indicated by the research from Portugal and Finland.

The computer requires a specific posture, while a book, for example, can be read in numerous positions and locations. (Portugal)

When reading from a screen, your hands are free. You can, for instance, lean on them or just mess about with something else. It is not very good, if you have, say, a scab or the like that you shouldn't scratch. On the other hand, if your hands are free you can also take down notes. But a [printed] book won't stay open by itself. (Finland)
(Taipale, 2015, p. 773)

Although eyestrain was an uncomfortable outcome of using a computer, hand cramps when writing was also reported by this student from Germany:

I suffer cramps after long periods of handwriting. (Germany)

In concluding his analysis of the Finnish qualitative survey Taipale highlights the different approaches students have with regard to their bodily practices depending on whether they are doing coursework or just using a digital device for social media:

'Students reflect their bodily practices predominately in relation to their coursework, which includes the reading and writing of longer factual texts. It is obvious that in their spare time they use portable digital tools for reading (e.g. news feeds and social media streams) and for writing shorter texts (such as emails, social media status updates, tweets, etc.), and in a much more flexible and innovative manner.' (Taipale, 2015, p. 774).

3.5 Costs, Appropriateness and Sustainability

The range of options for reading and writing are manifold and students actual behaviours may be at odds with their preferences when cost of use, or the appropriateness of particular media for the task at hand are considerations.

How much books weigh, how awkward books or computers are to use may influence the student's choice of media for reading and writing, but so does the cost of printing a long document.

Reading for me is easier when not staring at a screen for hours but when papers are 15 pages long and you have about 30 to read, it's not economical to print them all off. (UK)

Issues regarding the cost and volume of electricity consumption for sustaining digital technologies further highlight some new challenges and opportunities for future research. It would appear that students will continue to use, adapt and shape the technology most appropriate to their affordable needs be it paper, pen, keyboard, screen, e-book or paper book but they still have a demonstrable need for all to be available for their use in the University setting.

E-books are sometimes necessary in modern life, they became affordable. You can find a digital copy of a rare or very old book. So I use both forms. (Russia)

Paper and pencil are always available, and do not need electricity; such as when having a sudden inspiration in bed. (Germany)

Printing is expensive, I need to bring with me a lot of papers and paper stacks. (Hungary)

But there are other situations when only digital technologies will do. In Bulgaria all respondents reported that they extensively use computers in everyday life, learning and work, and cannot imagine life without them (Lasheva, Blazheva and Lasheva, 2014). In Slovakia the

value of the internet is highlighted for staying in touch when apart, writing letters would be so much slower with less certainty they would be delivered.

> *Internet simplifies the communication: my husband (professional soldier) took part in missions in Afghanistan a couple of times so I cannot imagine my existence without having contact with him for some months.*
> (Slovakia)

4. Discussion and conclusion

In considering the contribution of this summative study to the body of knowledge on students reading and writing practices one might ask why publish these qualitative results and not wait until the outcome of the follow up quantitative study is complete? To answer this I note first the unique breadth of countries explored in this paper. Five of the university studies reported in this paper did not participate in the quantitative survey (China, Hong Kong, Germany, Finland, Portugal) and the findings from their research would be under-reported in a future analysis. Secondly, it is clear from these initial surveys that new knowledge regarding student reading and writing practices is emerging and further research is certainly needed. The respondents in this study are extensive users of digital technologies but using pen and paper for writing and reading as well as, and combined with, digital technologies remains part of their normative practices. Motivations for using paper and pen are influenced by the haptic qualities of reading and writing – the feel and the smell of the paper and the grasp of the pen, the turn of the page, and extend also to the practical usefulness of note taking and writing in margins while reading. Conversely the use of hypertext and automatic error correction in online writing are making the use of keyboard and screen more compelling. Issues of multi-tasking, chirographic skills, intimacy of paper versus digital, interleaving of using digital and printed text as well as problems of eye strain and posture were identified.

There is no doubt that students have embraced the use of digital technologies in the educational setting of their university with enthusiasm but they have also found that the affordances of chirographic writing and the use of paper have special qualities that cannot be matched by digital media. In the Russian study, Vershinskaya, comments that 'Speed of [technological] change is very quick. Gadgets are becoming smaller and lighter, making the weight of the bag you carry to the university less

In this example we return again to the emotional aspects of communication when regardless of cost keeping in touch is the priority by whatever means is necessary to achieve this. This gives a clue to the conundrum faced by students and their choice of paper, pen or digital media as in many instances they must find the most cost efficient and convenient mode that suits their immediate need, and this might not be their preferred choice.

heavy. That makes students below 20 more attached to computers. The age matters.' (Vershinskaya, 2014, p. 4). This raises further new research questions regarding the impact of age on student's preferences and the impact of the pace of technological change. Maybe new gadgets will be developed that satisfy some of the sentimental and practical reasons given for retaining paper books and chirographic skills.

The new learning from this study, which is the first to examine the topics of both reading and writing in the educational setting of universities, has benefits for the academic and pedagogic communities some of whom place strong emphasis on digital literacy and less on the quality of handwriting skills and the continued use of paper books. The normative practices of students show that there is still a demand for pen and paper as well as keyboard and screen and that in some instances the use of paper is preferred.

There are many new questions raised by our study and further research is required to explore the topic in more detail and with greater statistical validity. However, it is clear that we live in an historical period of strong hybridization between print and digital technology and the technologies of writing and reading they convey; furthermore the political debate on print and eBooks in schools and universities lacks clarity and would benefit from more detailed analysis. In this paper the research conducted by the COST FP1104 Survey Team has delivered a body of new knowledge about the media practices of nearly 650 graduate and postgraduate students in Europe and Asia. It is anticipated that new funded research will now be developed on the basis of this foundational knowledge leading to a transfer of specific knowledge to policy makers about the lived experiences of reading and writing technologies on which the world of education, information and organisation in all aspects of life is based.

Acknowledgments

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Experimental comparison of the user experiences of different digital and printed newspaper versions

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Abstract

A laboratory experiment comparing the user experiences elicited by five different newspaper publication versions (four digital versions and the printed tabloid format newspaper) was carried out. The study had the parallel goals of testing and developing user experience measures for evaluating news reading experiences evoked by different publication designs and to learn of the different styles of news reading and reader preferences regarding the design and layout of the content. The results show considerable differences between the user experiences evoked by all five publications versions, and provide information on the usefulness of different measures in measuring relevant aspects of news reading experiences. The participants could be roughly divided into two main clusters based on their preferences of different publication versions. The most significant difference between the two groups seems to be the attitude towards reading news articles in the form of continuous streams as often found on different web sites. One group preferred the printed newspaper and digital versions that can be understood to stem from the tradition of the printed newspaper. The other group preferred the web style of news presentation and saw no need for digital versions mimicking the printed paper.

Keywords: user experience, news reading, questionnaire, experience mapping, eye tracking

1. Introduction and background

The ongoing digital transformation is strongly affecting the news reading habits of consumers. Media companies are increasingly offering different types of digital newspapers and digital news services. While the long tradition of printed newspaper making has resulted in a solid practical understanding of what kinds of designs work for printed newspapers, these design rules do not necessarily apply as such in the digital world. Thus there is a need for understanding the user experiences of digital newspapers, what kinds of experiences are preferred and how different design choices affect them. It is also useful to understand how the user experiences of various kinds of digital editions compare to the conventional printed newspaper.

Newspaper design or design of other kinds of publications or media services more generally, is an evolving craft with connections to and a potential to benefit from the advances in a number of different fields of research and scientific study. The Gestalt laws are a well-known traditional example of visual design rules having been derived from the findings in the field of perceptual psychology: based on the fundamental human visual perception, in their modern form they still offer a useful general basis for informing visual design in a wide range of application areas (Graham, 2008).

With the advent of digital news reading, starting with the first news web sites, news reading and the design of news publications have entered the realm of human-computer interaction (HCI). As a research field and professional discipline, HCI has evolved from its human factors roots in seeking to improve the performance of systems involving computers and human users, evaluated with measures such as time on task and number of errors, in various tasks and work contexts to encompass also aspects such as usefulness, ease of use, emotional impact and perceived value of interaction to the user. The concept of usability arose with the recognition that instead of seeing users only as potential sources of delays and errors, to be instructed and trained in the proper use of the given software, the overall system performance and also the acceptance of technological solutions could be better served by also taking various perceptual and cognitive human factors better into account in the interaction design, allowing users to carry out tasks relevant to reaching specific goals with relative ease. Most conceptual usability frameworks, as well as some questionnaires designed for measuring perceived usability in practice, include usefulness (in reaching relevant goals) and ease of use as dimensions of usability or aspects related to it, with overall user satisfaction with the sys-

tem also often incorporated as a dimension of usability (e.g. Lund, 2001). Other aspects of usability that are sometimes treated as separate sub-dimensions include learnability, controllability, efficiency, and effectiveness (e.g. Kirakowski and Corbett, 1993; International Organization for Standardization, 1998).

Usability research and testing allows one to identify and subsequently correct the possible problems that certain design choices might pose to the effortless use of the publication. Good usability can be considered as a prerequisite for good user experience (Hartson and Pyla, 2012). User experience, however, is understood to consist also of a number other psychological dimensions, such as those related to emotional impact and perceived value of use, in addition to strictly usability-related aspects (Hassenzahl, 2010). While the significance of user experience to the success of interactive systems has been widely recognized and has been studied from numerous perspectives, the concept of user experience remains somewhat vague, with a large number of different definitions reflecting different approaches and goals of user experience researchers and practitioners (Lallemand, Gronier and Koenig, 2015). Generally, and for the purposes of the current study, user experience can be understood as a holistic view, containing classical usability but also looking more widely at all thoughts, feelings, and perceptions arising from interaction with a product or service, before, during, and after the interaction. This kind of loose definition naturally leaves open the question of which aspects of user experience are relevant in a given case or field of application, and how to use them in practical design processes.

Hassenzahl's conceptual model of user experience (Hassenzahl, 2003; 2010) provides a theoretical basis that has relevance also in examining news reading experiences and the effect of design variables on those experiences. In Hassenzahl's model the attributes of a product or service, as perceived by the user, are divided into pragmatic and hedonic qualities. The pragmatic qualities relate to achievement of so-called do-goals (e.g. finding a specific item in an online store, or reading news of a specific event), while the hedonic qualities relate to the ability of the product or service to support the achievement of the user's so-called be-goals (such as being competent, being stimulated, or being related to others). Whereas the pragmatic qualities reflect the usability of an interactive system in carrying out particular tasks, the hedonic qualities have to do with motivational aspects, the reasons why the user is using the product to carry out certain tasks. AttrakDiff questionnaire was developed for measuring the pragmatic and hedonic aspects of user experience in practice (Hassenzahl, Burmester and Koller, 2003; Hassenzahl, Schöbel and Trautman, 2008). It uses semantic differential scale items anchored at opposite ends by pairs

of adjectives such as comprehensible/incomprehensible and controllable/incontrollable for evaluating pragmatic quality, and pairs such as exciting/dull and impressive/nondescript for evaluating hedonic quality. A third set of adjectives measures the overall appeal of the product or service to the users, with the assumption that both pragmatic and hedonic qualities affect the overall appeal. Variations of the AttrakDiff scheme, with the number and content of items adapted to fit different contexts, have been reported (Schrepp, Held and Laugwitz, 2006; Chorianopoulos and Spinellis, 2004).

It seems likely that also in regard to news publications, there are relevant perceived attributes of different levels, related to a number of different underlying goals, whether conscious or not, that the users might have for reading the publication. Presumably, the publications or services that best support the users in achieving the relevant goals are the ones that the users perceive as the most appealing and valuable to themselves, and that these are the publications that they prefer to use. The goals of use are likely to vary from one user and context to another, possibly ranging from things like keeping informed of the relevant events in a specific area of interest to relaxation, entertainment, and inspiration.

While Hassenzahl's model of user experience, as well as a number of other models and frameworks, contain components apparently relevant also to news reading experiences, until the recent years there has been a scarcity of studies examining the concepts of these frameworks from the perspective of news reading, or from the perspective of using and experiencing media products and services more generally, and how and if they can be applied in practice in order to measure news reading experiences and to inform the design of news publications. Shortly put, the grand challenge is to identify the user experience dimensions that are relevant to news reading experiences and to find appropriate methods to measure the perceptions and experiences evoked by news services of interest along those dimensions: in other words, to find out the relevant qualities of news reading experiences and the measures for quantifying them. Questionnaires developed in the field of HCI for a number of different purposes and application areas are good candidates for tools to be used in measuring news reading experiences. However, they may not be appropriate as such for the domain of news reading and may not be sufficient to cover all the relevant aspects of news reading experiences. Experimental studies are required to increase the understanding of relevant news reading experience dimensions and how to measure them.

Some recent studies have provided valuable knowledge needed to progress on the path to meeting the challenges discussed above. Particularly, Aranyi and

coworkers have carried out a series of experiments and analyses to create and test a model of user experiences evoked by news websites (Aranyi, 2012; Aranyi, van Schaik and Barker, 2012; Aranyi and van Schaik, 2015; 2015). They measured and modeled the relationships between user experience variables derived from an exploratory study based on concurrent think-aloud of participants while they used a news website (Aranyi, van Schaik and Barker, 2012), and from theoretical background of Hassenzahl's user experience model discussed above (Hassenzahl, 2003 and 2010), as well as from the technology acceptance model (TAM) (Davis Jr., 1986; Davis, 1989), and the components of user experience model (CUE) (Thüring and Mahlke, 2007). In their experimental study with a between-subjects design and two news websites browsed on a desktop computer in laboratory conditions, Aranyi and van Schaik (2016) found that the user experience components of their model, measured with questionnaires and including hedonic quality, perceived enjoyment, positive affect experienced during interaction, perceived usefulness of content, and pragmatic quality, were strong predictors of the overall user satisfaction with the news website. The user experience components in turn were significantly related to the perceived artifact characteristics of the model: perceived aesthetics, adequacy of information, and perceived disorientation. Further, perceived trustworthiness, identified by Howard Chen and Corkindale (2008) as one of the main drivers in the adoption of online news services, was found to have a significant positive relation with overall user satisfaction.

Lu, Wang and Ma (2013) studied the user experience and design implications of reading news from devices with different screen sizes in a laboratory experiment with a desktop computer, a tablet computer, and a smartphone. They found that advertisements were experienced as more distracting on the smaller screens of the mobile devices. For desktop users, efficient use of space was not a major concern, some of them preferring more abundant and variable content on the front page of the news website to make it more appealing. Mobile users further expected to be able to carry out tasks with fewer and simpler actions, and to have more control over the appearance of the page, i.e. being able to adjust the text size and to pinch zoom to read text.

In contrast to laboratory experiments, Pesonen and coworkers (Pesonen, 2014; Pesonen, Jumisko-Pyykkö and Väätäjä, 2015) conducted two one-week field studies of digital news reading experiences, using questionnaires and user diaries for data collection. Three different browser-optimized versions of the same newspaper content with different layout designs were used by participants on iPad tablets in the first study, while in the second study digital replicas of three different printed newspapers were used by the participants on their own laptop or desktop computers. A general trend of improving user experiences over time was found in both cases, possibly as a result of increasing familiarity with the design. According to their results, designs resembling printed newspapers were generally preferred and printed newspapers were still used parallel with the digital versions in the daily lives of the participants. Like printed newspapers, digital versions were typically read once a day, usually in the mornings. In contrast, Ihlström and Lundberg (2002), in their earlier study of real-life news reading habits in Sweden, found that users tend to read online newspapers more often, especially reading updated news during the day.

Friedrich et al. (2014) emphasize the practical importance of open user experience evaluation methods, instead of relying solely on pre-defined measures and experience dimensions, in understanding the user experience in specific areas like news reading in a wider context. In a case study where a digital edition of a newspaper was tested in rural areas of Finland over a period of six weeks, they used online collaborative discussions with users to derive user-defined attributes for describing real-life reading experiences. For example, some participants, living in remote areas where printed newspapers are delivered later in the day, considered it a privilege to be able to read the day's newspaper early in the morning, and even reported changing their daily rhythms as a result of having access to the digital edition, waking up earlier to have more time in the morning with the newspaper. Other perceived benefits of digital newspapers, not directly related to user interaction with the publication but still part of the experience in a wider perspective, included being perceived as environmentally friendly and helping to keep the user's home tidy (by not creating piles of old newspapers). These results highlight the context- and user-specific nature of user experiences, and the importance of contextual analysis in the user experience design and evaluation process.

Other longitudinal studies of digital news reading include those by Tewksbury and Althaus (2000), Vaughan and Dillon (2006), and d'Haenens, Jankowski and Heuvelman (2004), focusing more on task performance and news recall differences between digital and printed news rather than user experience, however. Vaughan and Dillon (2006), based on their results of improved user comprehension, usability, and navigation with repeated exposures to a given design, stress the importance of designs that provide consistent structures that allow users to build mental representations of the information space: with evolving conventions of presenting online news, attention is needed in incorporating emerging conventions into news website design, in order to draw repeat users. d'Haenens, Jankowski and Heuvelman (2004) found no consistent differ-

ences in the consumption and recall between the readers of online and print versions of two newspapers in Netherlands. In contrast, in an earlier study Tewksbury and Althaus (2000) found that online readers of New York Times read less news of certain topics than the readers of the print version, and were less likely to recognize and recall events that occurred during the exposure period. They suggest that by reducing and reorganizing story salience cues, online news formats can alter the knowledge that readers acquire about public affairs.

In-depth discussion of newspaper design is beyond the scope of this text. It is, however, useful to briefly consider some general design aspects and their possible relations with the user experience. While views have been presented that emphasized "separation of content and container", it is currently well recognized in the user experience field that the visual form in which media content is presented, referring to the layout and visual design in its widest sense, including the design and positioning of all elements visible to the reader, plays a significant role in how the content as well as the product or service, and ultimately the brand, is perceived and experienced. Perceived aesthetic properties have been found to affect the perceptions of usability and how well the product is liked, for example (Lidwell et al., 2010). As an interesting example of the immediate effects of visual aesthetics, the users have been found to form a consistent impression of the visual appeal of web sites in a time interval of only 50 milliseconds (Lindgaard et al., 2009). Further, Albert, Gribbons and Almadas (2009) found that users could form opinions about trustworthiness of financial and health-care web sites based on equally brief flashes of images of the web sites. Beyond classical aesthetics, the visual design plays a central role in the user experience of media products in many other ways. The visual design helps or hinders the user's process of making sense of what kind of content is available and of understanding how to navigate within the available content. As an example, visual hierarchy is a central concept in the design of media products such as newspapers, whether printed or online. It refers to visually emphasizing and organizing the content so as to allow the reader to effortlessly use the publication. A related design aspect is abundance, referring to how much information is shown, at the given instant, to the user. Design variables such as these, along with other aspects related to implementation of navigation in the publication, for instance, are assumed to be central in the process of designing enjoyable news reading experiences.

In the field of user experience research there has been general discussion of whether it is reasonable to aim to actually design user experiences. Strictly speaking this would mean understanding the relationships between design variables and the relevant dimensions of user experience so well that one could tune the experience of a user in a predictable manner by adjusting appropriate design variables. Since experiences are bound to vary from user to user, and from time and context to another, it is generally not seen as possible to design individual experiences. To emphasize this, some practitioners talk about "designing for experiences" rather than "designing experiences" in the context of experience design. What user experience research generally aims to achieve is to inform and guide the design process, providing information about the users and their experiences at different phases of the design process (Hartson and Pyla, 2012), seeking to iteratively improve the experiences provided by products or services.

Digitalization provides a wide range of new kinds of opportunities for the design of news publications. At the same time, as mentioned above, there is still very little information on what kinds of design choices work in the digital world. There is also an insufficient understanding of and scarcity of research approaches for efficiently identifying and reliably measuring the relevant dimensions of news reading experiences, and methods for communication the user experience evaluation results in a manner that would be useful from the design perspective.

The general goal of this study was to produce knowledge that would be helpful in informing the design of digital newspapers. We compared the user experiences of different digital and printed newspaper versions, in order to find out the effects of certain kinds of design choices on the user experience, with the further and more specific aims of better understanding how different design choices suited different reading styles among readers and to see if a single digital newspaper design, of those included in the study, could sufficiently well serve different reading styles and preferences. Testing and integrating different user experience measurement and analysis methods within a single experimental setup was also an important aspect of the study. As discussed above, despite the contributions from a number of studies in the recent years, there is currently no single generally applicable and widely validated set of methods available for measuring and analysing the user experience of media services. This study sought to increase the understanding of how well certain research approaches, individually and when used in combination with each other, are able to yield meaningful and useful information on the user experiences evoked by different publication designs. We combined top-down approaches of measures derived from theoretical models and literature with bottom-up approaches of analysing user experiences based on open comments from users, thus aiming to increase the understanding of the relevant dimensions of news reading experiences and appropriate measures of them.

In the current study we carried out a laboratory experiment that compared the user experiences of the current five Helsingin Sanomat newspaper publication versions: four digital versions and the printed tabloid format newspaper, as they were offered in the summer of 2013. While necessarily restricted to publication versions from a single publisher, the results of these experiments were expected to provide more generally useful understanding of user experiences and preferences concerning news reading. A specific question we sought to answer was whether any single digital version would reasonably well satisfy different reading styles, suggesting that it would be appropriate to cut down the number of considerably different digital layout versions currently offered in favour of aiming for a more consistent publication design and reading experience across digital platforms.

In section 2 we describe the experimental setup and devices and methods used in collecting analysing the data. In section 3 we present the results of analysing the data, discuss the results in section 4, and make conclusions in section 5.

2. Materials and Methods

2.1 Participants

Fourty persons participated in the laboratory experiments. The participants were recruited by various means: by contacting people who expressed their interest when answering a web survey aimed at the library patrons using a new e-book loaning system, and by e-mailing and directly contacting people working at the VTT premises in Espoo, Finland in various positions, as well as their family members and other acquaintances, and through contacts within the Next Media research program.

The sample of participants was convenient for this study, and, while not a random sample, was comprised of persons with relatively varying backgrounds. Nineteen of the participants were women and 21 were men. The ages of the participants ranged from 19 to 64 years old (Figure 1). The average age among the participants was 40 (with standard deviation of 9 years). Due to the requirements of the eye-tracking device used in the experiments, only participants who were able to read without wearing eyeglasses were recruited (contact lenses were allowed). The participants received two movie tickets as compensation for their time and effort.
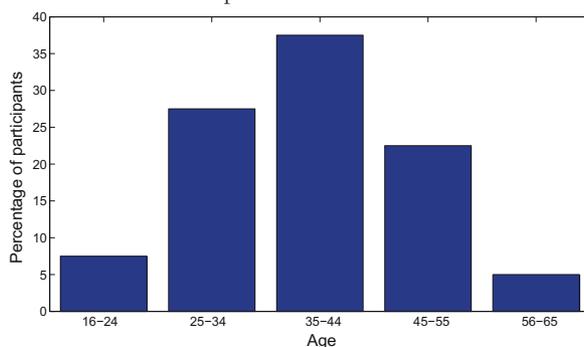
Figure 1: Age distribution of the participants

2.2 Newspaper versions

The five publication versions of Helsingin Sanomat newspaper shown in Figure 2, with current daily content, were used in the experiments. Helsingin Sanomat is the largest newspaper in Finland and well known to all participants. The different publication versions essentially share the same content, but there are considerable differences between the versions in the layout and the overall design. The four digital publication versions were all used with a black-framed Apple iPad 4 tablet.

2.3 Outline of the experimental sessions

After general introductions to the proceeding of the experimental session, the participant filled a digital survey form concerning the participant's background information (basic demographic information, and questions on news reading habits and the use of media technology, as well as questions measuring the personality traits of the respondent). The core part of the experiment consisted of the participant browsing and reading each of the five publication versions (presented in randomized order) for five minutes. The participant was instructed to imagine herself in a situation in which she had around five minutes to spare (e.g. waiting for an acquaintance to arrive in a cafeteria) and that she had decided to spend that time to take an overall look at the contents of today's newspaper (perhaps to read particularly interesting articles in more depth later), browsing and reading the publication in any way she wanted. The participants were instructed on how to use each version just before they were given that version for browsing. While reading the publication the participants wore SensoMotoric Instruments eye-tracking glasses, re-calibrated before reading each publication version and connected to a recording unit which recorded the eye movements of the participants while browsing the publication as well as a video of the scene they were seeing in front of them (i.e. the publication being browsed). The eye tracking device and analysis tools are further described in section 2.4.

Immediately after finishing reading the publication version, the participant answered a digital questionnaire containing statements related to the publication and its layout, as well as how it felt to use the publication. The questionnaire is described in section 2.5.

A: Printed newspaper
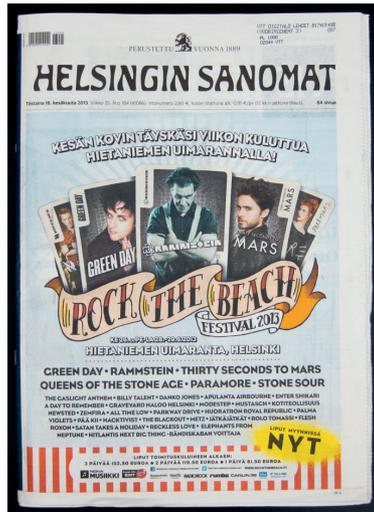
B: iPad app

C: Digital edition (print replica)
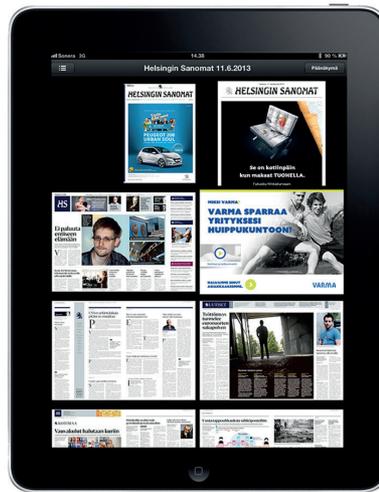
D: Browser newspaper
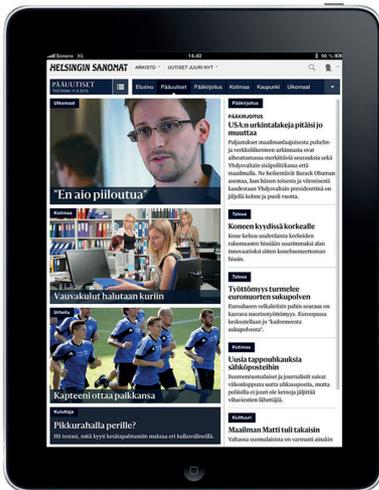
E: News web site
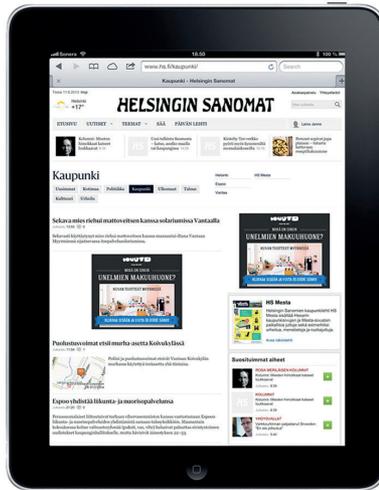
Figure 2: Publication versions used in the experiments; printed newspaper is not to scale

After finishing the questionnaire, the respondent was shown a video recording of their five minutes browsing the publication, with a cursor showing their gaze path augmented on the video. They were asked to retrospectively comment, while viewing the video recording, on their browsing session: How they used a publication? What they thought and felt about the publication and its design and layout – from their point of view, how well did the publication present its content to the reader? When needed, the instructor probed the participant with additional (unstructured) questions during the retrospective commenting, in order to extract more detailed information of the aspects of the reading experience that the participant brought up, taking care not to inadvertently guide or bias the participant's commentary by introducing aspects that did not naturally catch the participant's attention. Figure 3 shows a participant retrospectively commenting his experience with the publication version B. The review conducted by Hyrskykari et al. (2008) suggests that the gaze path stimulated retrospective think-aloud method produces more expressive comments and that the data are more informative and of better quality, as the drawbacks of concurrent think-aloud have been avoided.

After browsing all five publication versions, and providing the answers to the questionnaire as well as the retrospective comments for each version, the participant was asked to rank the publication versions in order of preference: Which publication version would they use if they could only choose one of them to use from now on in their daily lives? Once the most preferred version was chosen, that version was removed and the participant was asked to choose the preferred version to use from the remaining ones. This was repeated until all five versions had been chosen. The participant was asked to comment on his preferences while making the choices. What were the pros and cons of each version for him and what made it suitable, or not suitable, for his style of news reading?

2.4 Eye tracking

The SensoMotoric Instruments eye tracking glasses is a mobile binocular eye tracking system, which follows the movements of both eyes of the user and in real time calculates and stores the gaze position in the video of the scene that the user sees. The scene video is also captured by the eye tracking glasses. The benefit of such mobile eye tracking system is that it allows the participants to move relatively freely, as opposed to remote eye trackers which require the participant to sit relatively still in front of the screen. For natural use of the tablet and especially the printed newspaper in this study, the mobile eye tracking system was an obvious choice.

The drawback of the mobile system is that, unlike with a remote eye tracker connected to a display, in the analysis stage there is initially no information beyond the captured scene video of what was displayed on screen at any given moment. Calculation of descriptive fixation and gaze path statistics from this kind of data
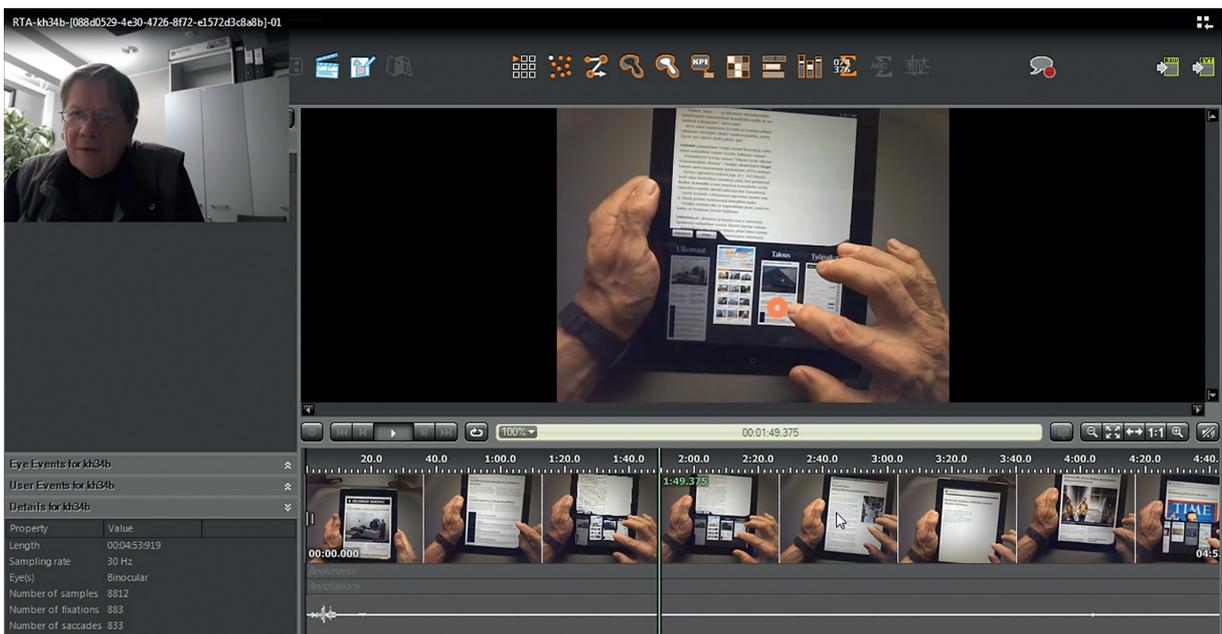
Figure 3: A frame from a video recording of the retrospective commenting session, using the SMI BeGaze analysis software, where the participant (top left corner) comments on the iPad app version, in this case, and his experience of using it, while viewing the freshly recorded video which shows his view during the session, and the orange gaze cursor indicates the point of his visual focus

would require a vast amount of manual work. In this case it was not considered worthwhile to carry out such manual encoding. Instead, the captured scene video, with the gaze path visualization and the recorded retrospective commentary of the eye tracking video by the participants was afterwards qualitatively summarized by the researchers, describing the actions and the flow of attention of the participants during the session, with further interpretations and other points added based on the retrospective commentary. The gaze paths were visualized, retrospectively commented, and analysed in the SMI BeGaze software.

2.5 User experience questionnaire

Immediately after finishing reading the publication version, the participant answered a digital questionnaire containing statements related to the publication and its layout, as well as how it felt to use the publication. The questionnaire contained, in random order, the relevant statements from the Next Media MX Questionnaire (Helle et al., 2011), as well as additional statements from The User Engagement Scale (O'Brien, 2010). In total, the questionnaire was comprised of 92 items. Included in the MX Questionnaire, and also adapted for the questionnaire used in this study was the scale for perceived visual aesthetics of web sites (Lavie and Tractinsky, 2004). All the items of the questionnaire used in this study are can be seen in Table 1. The Likert-type items were in the form of statements, and the participants responded to the items using a 9-step slider from 1 ("completely disagree") to 9 ("completely agree").

Apart from the scales mentioned above, the MX Questionnaire draws from a wide range of earlier research and questionnaires proposed for measuring different aspects of user experience. Major sources and influences for the usability related items included the After-Scenario Questionnaire (ASC) (Lewis, 1991); the System Usability Scale (SUS) (Brooke, 1996), reported extensive analyses of SUS (Bangor, Kortum and Miller, 2008 and 2009; Lewis and Sauro, 2009); the Computer System Usability Questionnaire (CSUQ) (Lewis, 1995); the Usefulness, Satisfaction, and Ease-of-Use Questionnaire (USE) (Lund, 2001); the Software Usability Measurement Inventory (SUMI) (Kirakowski and Corbett, 1993); and the Website Analysis and Measurement Inventory (WAMMI) (Kirakowski and Cierlik, 1998; WAMMI, 2016). These and other usability measures are described and discussed by Tullis and Albert (2013).

The concept of spatial presence has been much studied in the field of digital media such as games, but is potentially relevant also in the wider context of media use, including news reading. The related concepts of presence, immersion, and engagement have to do with focused attention

of the user: media that successfully capture the attention of their users and evoke the feelings of engagement, presence, or immersion are likely to become more popular. The ITC Sense of Presence Inventory (Lessiter et al., 2001) and the MEC Spatial Presence Questionnaire (MEC-SPQ) (Vorderer et al., 2004) were used as sources in designing the spatial presence (attention allocation) items of the MX Questionnaire.

The concept of flow experience, related also to the concept of focused attention, was introduced by Csikszentmihalyi (1990). The sources for designing the flow-related items in the MX Questionnaire include Novak and Hoffman (1997), Novak, Hoffman and Duhachek (2003), and Poels, de Kort and Ijsselsteijn (2006).

Self-assessment manikin (SAM) (Bradley and Lang, 1994) is a commonly used graphical instrument for measuring emotional responses. The valence scale consists of nine graphic depictions of human faces ranging from sad to happy expression and the arousal scale contains nine graphical characters varying from a calm state to a state of high visceral. Alternatively, emotions can be measured using conventional textual Likert scales, as was done in the current study. Adjectives like frustrated or enthusiastic, in the vein of the Positive Affect Negative Affect Scale (PANAS) (Watson, Clark and Tellegen, 1988), are also included in the MX Questionnaire items for measuring emotions.

The existing playfulness self-evaluation scales (Barnett, 2007) were used as a basis to MX Questionnaire items for measuring the playfulness experienced during media use, a presumably significant dimension of media experience in some cases. Other sources include those concerning brand experience (Brakus, Schmitt and Zarantonello, 2009) and trustworthiness (Gefen, 2002), both of which are considered particularly significant for news reading.

It should be noted that rather than a fully validated tool for measuring media experience, the MX questionnaire is better understood as a framework from which relevant parts may be adapted for the purposes of specific research. While based on wide range of literature and the work of a multidisciplinary team of scientists and media professionals, the questionnaire has not been fully validated. Indeed, one of the goals of the present study was to apply and test the MX Questionnaire in measuring the user experiences of news publications.

2.6 Multivariate data analysis methods

Factor analysis (e.g., Nunnally and Bernstein, 1994) was used to analyse the correlation structures of different items and dimensions of the questionnaire data. The

factors were rotated using the so-called Varimax criterion in order to make the factors as orthogonal as possible in an attempt to separate different user experience dimensions to different factors.

The experience mapping approach was used to further describe and compare the user experiences elicited by the different publication versions. Experience mapping, described for example by Mensonen et al. (2012), is based on principal component analysis (e.g., Jackson, 2003) of multivariate observations (here: questionnaire items related to different aspects of user experience) of multiple samples (here: different publication versions), and is intended for visualizing and describing the most significant experiential differences within a given set of products, services, or concepts, as well as depicting the correlations between different perceived attributes and experience dimensions for the given set of samples.

Dendrogram visualization of preference judgments was used for analysing the differences and similarities between the publication version preferences among the participants. Dendrograms are used in hierarchical cluster analysis in fields such as biology and market research for categorization and segmentation purposes (Aldenderfer and Blashfield, 1984; Mérigot, Durbec and Gaertner, 2010). Support for creating dendrograms can be found in software packages like Matlab and SPSS, and on the open source statistics platform R. In this case the preference judgments were mapped to the space of first two principal components, calculated with principal component analysis, in order to extract only the most significant differences between the participants. The dendrogam diagram was plotted, based on the Euclidean distances in the space of first two principal components, to depict the similarities and differences between the participants. The height of the connecting line in the tree-like diagram, the "branch" of the dendrogram, indicates how similar to or different from one another two participants, or groups of participants, were in their preference judgments: the greater the height, the greater the difference.

3. Results

3.1 Comparison of the experiences evoked by the publication versions based on questionnaire responses

The Experience Map in Figure 4 was calculated based on the responses to all 92 questionnaire items, averaged over all participants. Only attribute vectors corresponding to selected questionnaire items are labelled in the Figure 4 for clarity and in order to give a preliminary visualization of some of the most significant differences in the user experiences evoked by the different publications. The vectors pointing in the general direction of the given publication version indicate attributes that were most strongly associated with the given publication version.
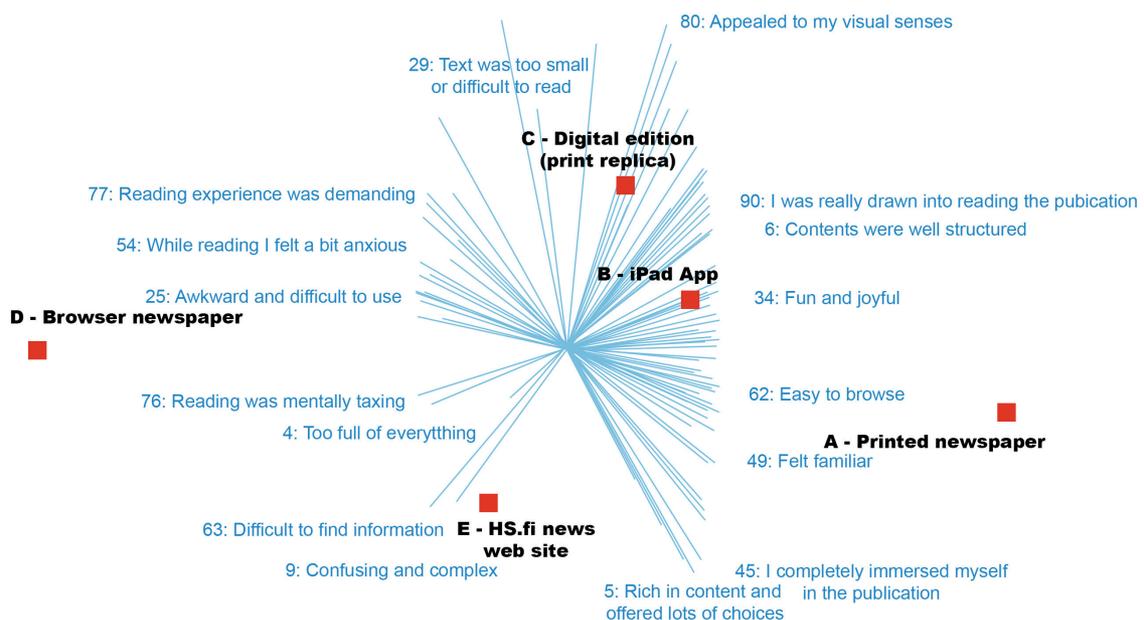

Figure 4: An Experience Map based on 92 questionnaire items visualizing the experienced differences between the publications, for results averaged over all participants

Table 1: Questionnaire items 1–92 and their factor loadings, with Abbreviations used in the "Preliminary dimensions" column of the tables (assumed main dimensions to which the items are related, followed by possible other related dimensions): AE: Aesthetics and presentational factors; A: Spatial presence (Attention allocation); USE: Usefulness; B: Brand; ENT: Entertainingness; F: Familiarity; USA: Usability; PV: Perceived value; Un: Unexpectedness; Ia: Interactivity; P: Playfulness; T: Trustworthiness; E: Emotions; INT: Interestingness; SP: Sensory perception

Item nr.	Statement	Preliminary dimensions	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Specific variance
AESTHETIC AND PRESENTATIONAL FACTORS										
Beauty (visual appearance perceived very quickly)										
1	The layout was good.	AE	0.45	0.56	0.34	0.16	−0.23	0.31	−0.08	0.19
2	The publication was colorful.	AE, SP	0.06	0.47	0.36	0.14	−0.08	0.18	0.05	0.58
3	Colors of the publication looked natural.	AE, SP	0.12	0.40	0.13	0.16	−0.21	−0.00	0.19	0.71
Abundance (The richness and variation of the options offered on a page)										
4	The publication was too full of everything.	AE	−0.42	−0.26	−0.03	−0.07	0.55	−0.06	0.12	0.43
5	The publication was rich in content and offered a lot of choices.	AE, Ia	0.14	0.27	0.24	0.16	−0.04	0.29	0.54	0.44
Hierarchy (Journalistic and visual order of the content by different levels of importance)										
6	Contents of the publication were well structured.	AE, Ia	0.53	0.59	0.16	0.12	−0.13	−0.01	−0.01	0.32
7	The main articles were well presented, they stood out.	AE	0.39	0.40	0.21	0.07	−0.10	0.13	0.15	0.60
Navigation (Visual aids for user orientation in the content)										
8	Sometimes I had the feeling that I was lost.	AE, USA, Ia	−0.75	−0.09	0.00	−0.11	0.30	−0.12	0.03	0.31
9	Design of the publication was confusing and complex.	AE	−0.61	−0.35	−0.11	−0.04	0.43	−0.18	0.09	0.27
Adapted from an aesthetic scale for websites (Lavie and Tractinsky, 2004)										
10	The layout was clean.	AE: classical	0.25	0.68	0.14	0.19	−0.12	0.26	−0.11	0.32
11	The layout was clear.	AE: classical	0.63	0.50	0.16	0.22	−0.14	0.12	−0.02	0.25
12	The layput was pleasant.	AE: classical	0.44	0.55	0.34	0.15	−0.22	0.39	−0.18	0.14
13	The layout was aesthetic.	AE: classical	0.01	0.55	0.55	0.10	−0.12	0.13	−0.04	0.36
14	The layout was balanced.	AE: classical	0.39	0.58	0.27	0.11	−0.24	0.16	−0.01	0.34
15	The layout was original.	AE: expressive	−0.02	0.24	0.64	0.09	−0.15	−0.04	0.08	0.49
16	The layout was stylish.	AE: expressive	0.18	0.73	0.35	0.14	−0.17	0.07	0.03	0.26
17	The layout was fascinating.	AE: expressive	0.24	0.35	0.59	0.28	−0.09	0.23	−0.00	0.32
18	The layout was creative.	AE: expressive	0.16	0.28	0.72	0.03	−0.10	0.08	0.12	0.35
ENTERTAININGNESS										
19	Reading the publication was entertaining.	ENT, P, E, USE	0.23	0.27	0.39	0.28	−0.20	0.57	0.05	0.27
20	The publication was quite dull.	ENT, P, E, USE	−0.25	−0.30	−0.33	−0.17	0.34	−0.38	0.03	0.45
21	Reading the publication was good pastime.	ENT, P, E, USE	0.34	0.31	0.26	0.21	−0.20	0.60	0.12	0.27
USABILITY										
22	In this publication it was easy to find what I was looking for.	USA, Ia	0.76	0.29	0.20	0.11	−0.11	0.12	−0.03	0.25
23	The articles in the publication were easy to read.	USA	0.46	0.19	0.24	0.12	−0.43	0.40	−0.02	0.33
24	The publication was easy to handle while reading.	USA	0.69	0.16	0.24	0.04	−0.16	0.03	0.08	0.41
25	The publication was awkward and difficult to use.	USA	−0.77	−0.13	−0.14	−0.07	0.25	−0.18	0.06	0.27
26	Glare or gloss of the publication distubed the reading.	SP, USA	−0.13	−0.15	0.08	0.00	0.43	−0.03	−0.06	0.77
27	The newspaper / device felt too heavy in my hands.	SP, USA	−0.15	−0.20	−0.00	0.06	0.30	−0.03	−0.03	0.84
28	I was able to use the publication the way I wanted.	USA	0.84	0.13	0.21	0.06	−0.15	0.13	0.13	0.17
29	Text was too small or difficult to read.	USA	−0.24	0.08	−0.06	0.06	0.42	−0.07	0.11	0.73
30	The length of row in the text was suitable.	USA	0.27	0.25	0.17	0.14	−0.27	0.08	0.25	0.68

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Item nr.	Statement	Preliminary dimensions	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Specific variance
UNEXPECTEDNESS										
31	The publication offered surprises.	Un	−0.11	0.03	0.63	0.24	0.13	0.04	0.01	0.52
32	The publication was exactly as I expected.	Un	0.62	0.09	−0.05	−0.02	−0.01	0.07	−0.02	0.59
33	The publication repeated the one and the same thing.	Un	−0.20	−0.31	0.01	−0.09	0.38	−0.27	−0.28	0.55
PLAYFULNESS										
34	The publication was fun and joyful.	P	0.19	0.13	0.54	0.32	−0.02	0.28	−0.08	0.47
35	The publication also had a playful attitude.	P	0.12	0.06	0.61	0.29	0.03	−0.05	−0.02	0.53
36	There was imaginativity in the publication.	P	0.17	0.13	0.75	0.10	−0.03	0.06	0.07	0.37
TRUSTWORTHINESS										
37	The content of this publication appeared reliable.	T	0.28	0.55	−0.18	0.22	−0.22	0.34	0.22	0.32
38	This publication was made by professionals.	T	0.38	0.57	0.13	0.13	−0.15	0.22	0.39	0.28
INTERESTINGNESS										
39	The publication attracted and invited to read.	INT	0.37	0.31	0.49	0.25	−0.23	0.35	−0.03	0.28
40	This issue of the publication was as interesting as the previous issues.	INT	0.39	0.35	−0.02	0.07	−0.00	0.35	0.02	0.60
SPATIAL PRESENCE (ATTENTION ALLOCATION)										
41	The reading experience was captivating.	A, INT	0.37	0.28	0.51	0.38	−0.14	0.31	0.07	0.26
42	I devoted my whole attention to the publication.	A, INT	0.10	0.12	0.11	0.82	−0.07	0.07	0.00	0.28
43	I concentrated on the publication.	A, INT	0.33	0.18	0.02	0.58	−0.29	0.27	−0.05	0.36
44	The publication captured my senses.	A, INT	−0.00	0.09	0.42	0.66	0.04	0.02	−0.02	0.38
45	I completely immersed myself in the publication.	A, INT	0.06	0.12	0.26	0.84	0.06	0.10	0.10	0.18
BRAND										
46	The publication was of high quality.	B, V	0.30	0.60	0.14	0.24	−0.15	0.30	0.26	0.29
47	I valued the publication.	B, V	0.46	0.48	0.12	0.30	−0.13	0.35	0.19	0.28
48	This publication had its own strong personality.	B	0.25	0.32	0.52	0.11	0.02	0.07	0.23	0.49
FAMILIARITY										
49	This publication felt familiar.	F	0.46	0.32	0.21	0.00	−0.04	0.23	0.01	0.58
50	I found the publication close to me.	F	0.37	0.31	0.38	0.27	−0.10	0.26	0.06	0.46
EMOTIONS										
51	While reading the publication I felt pleasant.	E: valence	0.56	0.32	0.26	0.28	−0.23	0.23	0.16	0.31
52	While reading the publication I felt aroused.	E: arousal	−0.37	−0.11	0.04	0.12	0.49	−0.09	0.04	0.58
53	While reading the publication I felt frustrated.	E: -v, +a	−0.71	−0.14	−0.13	−0.03	0.43	−0.21	−0.10	0.22
54	While reading the publication I felt a bit anxious.	E: -v, +a	−0.54	−0.12	−0.11	−0.05	0.57	0.06	−0.10	0.34
55	While reading the publication I felt tense.	E: -v, +a	−0.50	−0.13	−0.07	0.01	0.58	0.02	−0.13	0.38
56	While reading the publication I felt a bit bored.	E: -v, -a	−0.25	−0.25	−0.10	−0.04	0.45	−0.43	−0.16	0.45
57	While reading the publication I felt depressed.	E: -v, -a	−0.22	−0.13	−0.05	0.04	0.44	−0.25	−0.10	0.67
58	While reading the publication I felt enthusiastic.	E: +v, +a	0.21	0.16	0.62	0.43	0.07	0.23	0.12	0.29
59	While reading the publication I joyful or happy.	E: +v, +a	0.22	0.05	0.65	0.31	0.05	0.09	−0.03	0.42
60	While reading the publication I felt completely relaxed.	E: +v, -a	0.51	0.18	0.23	0.23	−0.36	0.11	0.25	0.40
61	While reading the publication I felt satisfied.	E: +v, -a	0.48	0.30	0.36	0.28	−0.19	0.36	0.12	0.29

Item nr.	Statement	Preliminary dimensions	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Specific variance
INTERACTIVITY										
62	The publication was easy to browse.	Ia	0.77	0.16	0.24	0.10	−0.10	0.05	0.17	0.28
63	It was difficult to find useful information because there was too much information.	Ia	−0.52	−0.20	−0.07	−0.08	0.45	−0.14	0.19	0.41
64	I was in control of the situation while reading and using the publication.	Ia	0.77	0.18	0.13	0.04	−0.25	0.17	0.09	0.26
65	While reading the publication, I could quickly jump from one page to another.	Ia	0.68	0.17	0.23	0.04	−0.08	0.05	0.14	0.42
OVERALL MEDIA EXPERIENCE										
66	The overall reading experience was good.		0.59	0.35	0.35	0.21	−0.22	0.40	−0.08	0.15
USER ENGAGEMENT SCALE ITEMS – Adapted from O'Brien (2010)										
Focused attention										
67	I was so involved in the publication that I lost track of time.	A	−0.10	0.15	0.38	0.72	0.14	0.04	0.12	0.28
68	I blocked out things around me when I was reading the publication.	A	0.01	0.07	0.12	0.86	−0.03	0.08	0.04	0.24
69	While reading the publication, I lost track of the world around me.	A	−0.06	0.18	0.16	0.87	0.15	0.07	0.04	0.15
70	I was absorbed in reading the publication.	A	0.09	0.08	0.24	0.84	0.01	−0.00	0.07	0.22
71	While reading the publication, I let myself go.	A	0.27	0.14	0.47	0.41	−0.24	0.24	0.05	0.40
Perceived usability										
72	I felt frustrated while using the publication.	USA, E	−0.71	−0.20	−0.08	−0.05	0.46	−0.15	−0.10	0.21
73	I found this publication confusing to use.	USA, E	−0.67	−0.19	−0.06	0.00	0.41	−0.18	0.05	0.31
74	I felt annoyed while using the publication.	USA, E	−0.63	−0.19	−0.09	−0.09	0.47	−0.09	−0.14	0.31
75	I felt discouraged while using the publication.	USA, E	−0.66	−0.12	−0.11	−0.06	0.46	−0.20	−0.00	0.29
76	Reading this publication was mentally taxing.	USA, E	−0.61	−0.21	−0.20	−0.07	0.58	−0.11	−0.10	0.18
77	This reading experience was demanding.	USA, E	−0.77	−0.10	−0.04	−0.11	0.43	−0.07	0.00	0.18
Aesthetics										
78	The publication was aesthetically appealing.	AE	0.27	0.71	0.33	0.09	−0.19	0.09	0.05	0.25
79	I liked the pictures and graphics of this publication.	AE	0.11	0.52	0.43	0.11	−0.12	0.23	0.24	0.39
80	The publication appealed to my visual senses.	AE	0.29	0.60	0.50	0.12	−0.17	0.04	0.02	0.26
81	The layout of this publication was visually appealing.	AE	0.30	0.64	0.41	0.09	−0.28	0.11	0.01	0.23
Endurability										
82	Reading this publication was worthwhile.	USE, PV	0.44	0.38	0.14	0.22	−0.14	0.57	0.18	0.22
83	I consider my reading experience a success.	USE	0.71	0.24	0.31	0.23	−0.17	0.31	0.02	0.16
84	The reading experience did not work out as I had planned.	USA, USE	−0.51	−0.18	0.02	0.02	0.24	−0.20	−0.03	0.61
85	The reading experience was rewarding.	USE, PV	0.48	0.27	0.43	0.26	−0.11	0.37	0.18	0.25
86	I would recommend this publication to my friends and family.	PV, USE	0.60	0.36	0.33	0.18	−0.15	0.21	0.18	0.27
Novelty										
87	The publication sustained my curiosity.	INT	0.40	0.36	0.27	0.23	−0.22	0.52	0.17	0.24
88	The publication incited my curiosity.	INT	0.35	0.39	0.32	0.21	−0.19	0.55	0.12	0.22
89	I felt interested in the publication.	INT	0.38	0.45	0.30	0.18	−0.20	0.37	0.31	0.25
Felt involvement										
90	I was really drawn into reading the publication.	INT, A	0.37	0.34	0.37	0.38	−0.27	0.27	0.05	0.32
91	I felt involved in reading the publication.	INT, A	0.30	0.13	0.33	0.59	−0.11	0.29	−0.08	0.33
92	The reading experience was fun.	ENT, P, E	0.36	0.17	0.50	0.36	−0.11	0.25	−0.12	0.38

In order to better examine the possible underlying user experience dimensions and to tentatively test the validity of the preliminary assumptions concerning the relevant dimensions and questionnaire items suitable for measuring them, factor analysis was carried out for the responses to the questionnaire items. The responses to all 92 questionnaire items concerning a single publication version by a single observer were treated as one multivariate observation. These observations were placed in the rows of a data matrix, resulting in a 200-by-92 data matrix, with the 200 rows (5 publication versions × 40 participants) corresponding to observations and the 92 columns to variables (questionnaire items). Factor analysis and rotation of the factors using the so-called Varimax criterion was carried out for the data matrix. While none of the tested factor structures could fully describe the variance inherent in the variables of this rather complex data set, the factorization into 7 factors yielded a factor structure that best separated the different item responses into different factors and provided the most intuitive interpretation of the data.

The factor loadings of this 7-factor model of the data are shown in Table 1 for all 92 questionnaire items. Loadings with an absolute value greater than 0.5 are emphasized by bold font and grey shading of the table cell. The factorization shown in Table 1 is further discussed in section 4. Here we note that the factorization model maps the different items relatively well to individual factors, as indicated by the fact that for the most of items only a single factor loading is higher than 0.5 or lower than −0.5. However, the fact that for many items the item-specific variance not mapped to the factors is relatively high indicates that there remains considerable variation in the responses that is not described by this factor structure, hinting at dimensions or specific aspects of user experience not mapped to these factors. Still, this factorization allowed us to better interpret the data, and together with investigating correlations between individual items lead us to a set of 21 relevant user experience dimensions. The dimensions and the questionnaire used to measure the dimension are listed in Table 2.

Figure 5 shows an experience map calculated with the experience dimensions of Table 2. The following sections build on these results by looking at the reading experiences from the perspective of other data obtained from the experiments. The results are further discussed in section 4.

Table 2: User experience dimension and the corresponding items used to measure them, derived based on the factor structure and item correlations of the full questionnaire data, where the items marked with asterisks (*) are reverse-worded and these item scales were inverted when calculating the value for the corresponding experience dimension as the average of the given item responses.

Dimension	Items					
Information overload	4					
Rich in content	5					
Visual hierarchy	7					
Navigation	8*	9*				
Classical aesthetics	10	12	14			
Expressive aesthetics	15	17	18			
Entertainingness	19	21				
Usability	22	24	25*	28	62	64
Playfulness	34	35	36			
Trustworthiness	37	38				
Attention allocation	41	42	43	44	45	
Pleasant feeling	51					
Frustrated and anxious feeling	53	54	55			
Enthusiastic and joyful feeling	58	59				
Relaxed feeling	60					
Focused attention	67	68	69	70	71	
Perceived usabillity	72*	73*	74*	75*	76*	77*
Aesthetics	78	79	80	81		
Endurability	82	83	85	86		
Novelty	87	88	89			
Felt involvement	90	91	92			

Table 3 lists the user experience dimensions for which the mean value of ratings, averaged over all participants, were significantly different in the case of each pair of two different publication versions. On each row, the dimensions on which the publication version indicated on the left hand side column had a significantly higher mean rating than the publication version corresponding to the column, indicated by the top row of the table, are listed. For example, publication version B had a significantly higher "Playfulness" rating than version C, while version C had a higher "Information overload" rating than B. The table provides information on the relevance of different dimensions in differentiating the experiences evoked by different publication versions.

3.2 Distribution of preference judgments

Considerable variation in preferences was evident among the respondents. The histograms in Figure 6 sum up the overall variability in the preference rankings of the five different publication versions. The first group of bars on the left side of the graph indicates

the percentage of respondents that ranked the given publication version in the first place in their order of preference. The highest bar corresponds to version A, indicating that 42.5 % of respondents ranked the printed newspaper first in their order of preference. While this was by far the favourite choice compared to the four other publication versions individually, it should be noted that the majority of participants would still prefer to use some digital publication version, rather than the printed newspaper, if they had to choose only one version for their daily news reading.

Looking further at the graph of Figure 6, the second group of bars indicates the percentage of participants that ranked each publication version second in their order of preference – i.e. the percentage of participants that would choose a given publication version if their most preferred version (the one they ranked first in their order of preference) was not available to use in their daily news reading. Similarly, the following three groups of bars indicate the percentage of respondents that ranked specific publication versions on the 3rd, 4th, or 5th, respectively, in their order of preference.
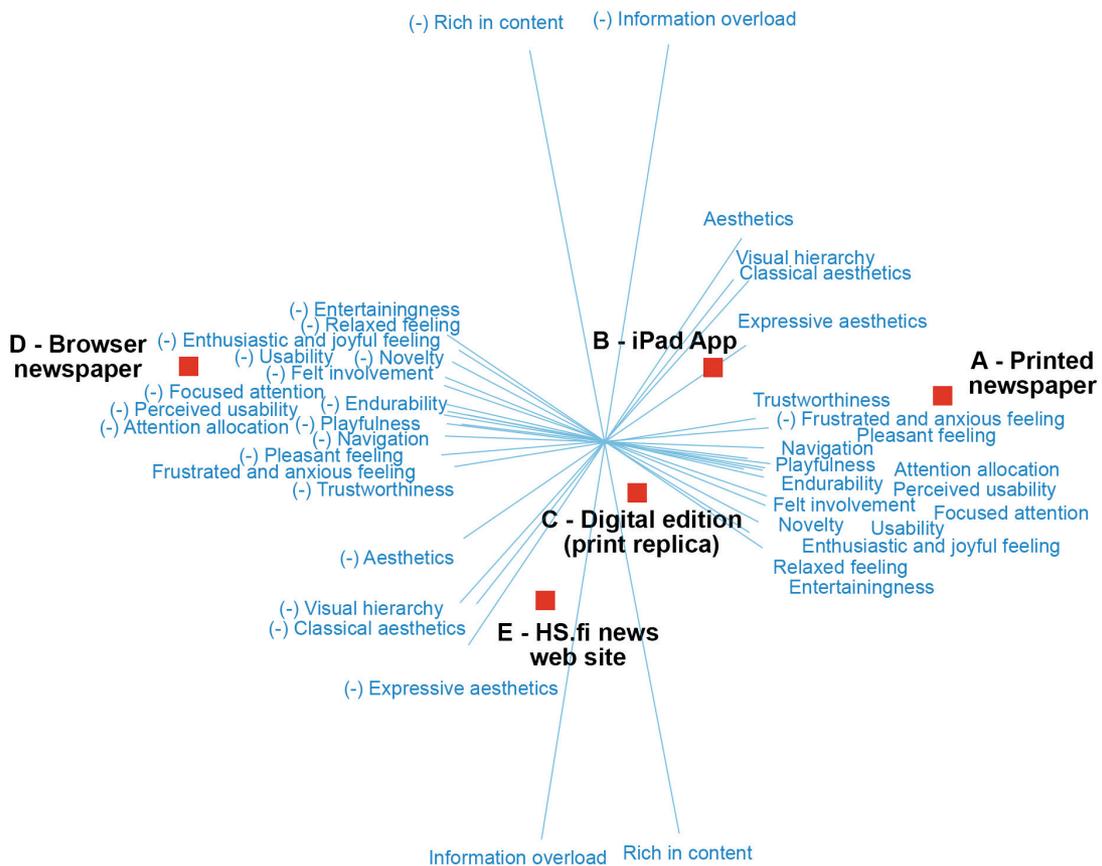
Figure 5: An Experience Map based on 21 derived relevant user experience dimensions, visualizing the experienced differences between the publications, for results averaged over all participants, where the dimension labels with the (−) prefix indicate the negative direction of the given dimension: for example, publication version D, located in the direction of (−) focused attention, evoked a low level of focused attention compared to the other publication versions

Table 3: Statistically significant difference, at 95 % confidence level, between the publication versions in mean values of different user experience dimensions, averaged over all participants. *** : p < 0.001, ** : p <0.01, * : p < 0.05

|	A – Printed newspaper	B – iPad App	C – Digital edition (print replica)	D – Browser newspaper	E – HS.fi news web site
A – Printed newspaper		Navigation***, Usability**, Perceived usability**, Endurability*, Relaxed feeling*	Perceived usability***, Relaxed feeling**, Usability**, Endurability*	Usability***, Perceived usability***, Endurability***, Navigation***, Relaxed feeling***, Pleasant feeling***, Entertainingness***, Novelty***, Trustworthiness***, Felt involvement***, Playfulness***, Classical aesthetics**, Aesthetics**, Enthusiastic and joyful feeling**, Attention allocation**	Navigation***, Classical aesthetics**, Trustworthiness**, Usability**, Aesthetics**, Perceived usability**, Endurability**, Novelty*, Pleasant feeling*, Visual hierarchy*
B – iPad App	Frustrated and anxious feeling*		Playfulness*	Playfulness***, Felt involvement**, Usability**, Endurability**, Perceived usability**, Pleasant feeling**, Enthusiastic and joyful feeling**, Aesthetics**, Entertainingness*, Expressive aesthetics*, Novelty*, Classical aesthetics*, Relaxed feeling*	Aesthetics**, Classical aesthetics*
C – Digital edition (print replica)	Information overload**, Frustrated and anxious feeling**	Information overload*		Usability**, Trustworthiness**, Endurability**, Novelty**, Felt involvement**, Entertainingness*, Navigation*, Enthusiastic and joyful feeling*, Rich in content*, Perceived usability*, Pleasant feeling*, Classical aesthetics*, Playfulness*	Trustworthiness*, Classical aesthetics*
D – Browser newspaper	Frustrated and anxious feeling*	Frustrated and anxious feeling*	–		–
E – HS.fi news web site	Information overload**, Frustrated and anxious feeling*	Information overload**, Rich in content*	–	Usability**, Relaxed feeling**, Rich in content**, Playfulness*, Perceived usability*, Entertainingness*, Endurability*	
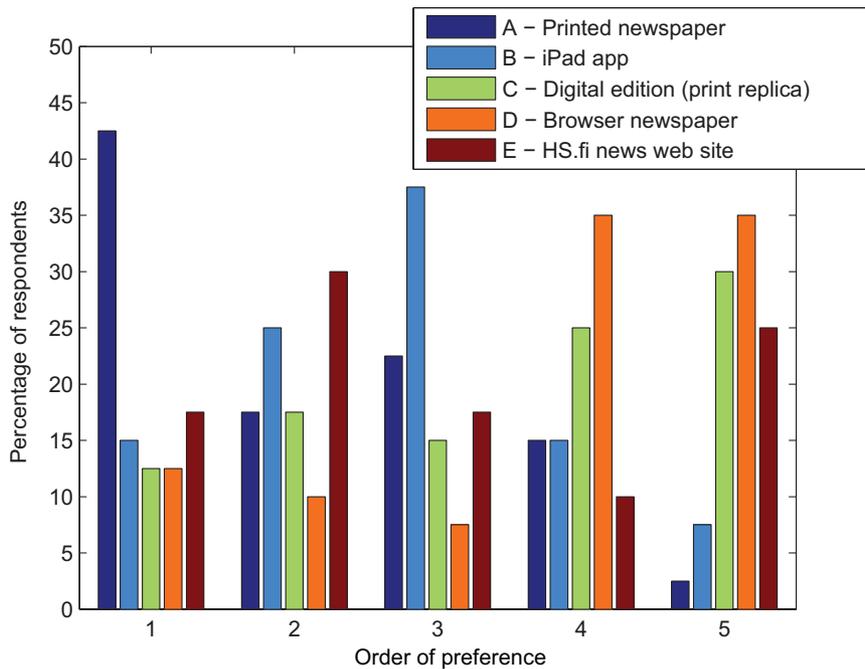
Figure 6: Histograms showing the overall distribution of preference rankings of the publication versions among the participants of the experiment

3.3 Clustering of participants based on preferences

Looking further at the differences in the preferences among the participants, multivariate data analysis revealed two distinct clusters of participants. The clusters are depicted in Figure 7. The diagram known as a dendrogram, described in section 2.6, connects two observers by a line whose height indicates the distance of their preference judgments in the space of first two principal components of preference judgments. The preferences among the participants were similar within each cluster but differed considerably from the preferences of the other cluster. Nineteen of the 40 participants were classified as belonging to the first cluster (the one on the left side of the dendrogram), and 12 participants formed the second cluster (the one to the right from the center of the dendrogram). The remaining 9 participants were left outside these two clusters due to their different preferences, and did not form a third cluster of like-minded persons either.

The mean preference rankings for each publication version in the two participant clusters are shown in Figure 8. The main difference between the two clusters appears to be the preference for web style of news reading in cluster 1 (news web site, version E, highly preferred) and the preference for more conventional style of newspaper-like news reading in cluster 2 (version E least preferred, printed newspaper, version A, most preferred). While the printed newspaper was rather highly ranked in both clusters (higher in cluster 2), in

cluster 1 the participants apparently saw no need for a digital version replicating the printed newspaper (version C less preferred). In contrast, in cluster 2 this rather straightforward transformation of the conventional newspaper into a digital format was appreciated (version C more preferred).

3.4 User-defined attributes

The video recordings of the eye tracking videos with retrospective comments and the audio recordings of the comments from participants during the preference judgments were reviewed by the main researcher in the study. Notes of the main events and comments in the eye tracking videos were made, and the comments made during the preference judgments were fully transcribed.

Attributes associated by the participants with different publication versions when they justified why they preferred one version over another were extracted from the transcripts. The 47 attribute categories seen in Table 4 were derived by reviewing all the extracted attributes. The frequencies of each attribute being associated with each of the publication versions were then noted by the researcher. The researcher and the administrator of the experiments reviewed, discussed, and agreed on this coding in collaboration. Table 4 lists the percentage of participants that associated a given attribute with a given publication version. Due to the degree of subjectivity involved in the cod-

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123
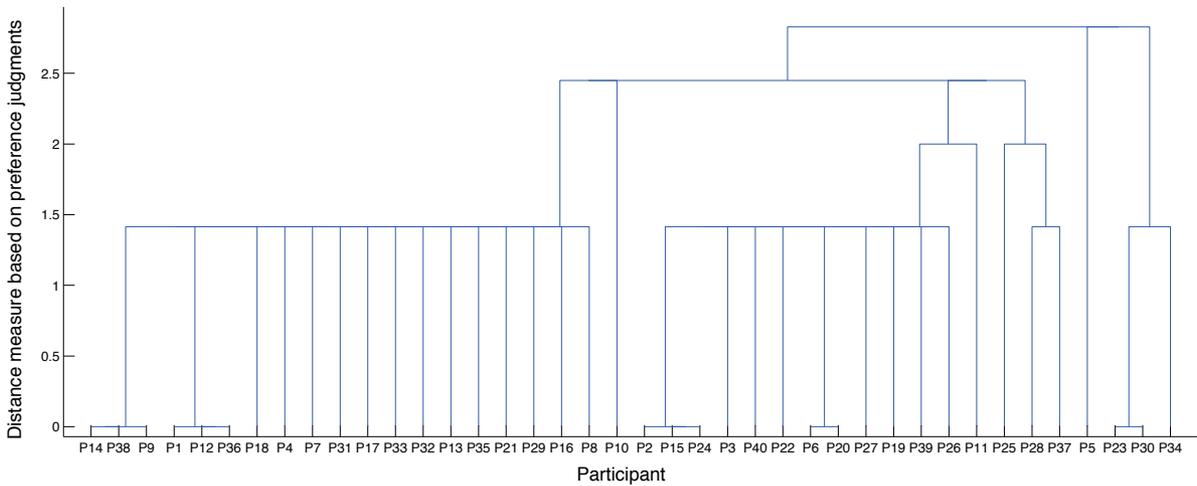
Figure 7: Dendrogram depicting the distances and clusters of participants based on their publication version preference judgments
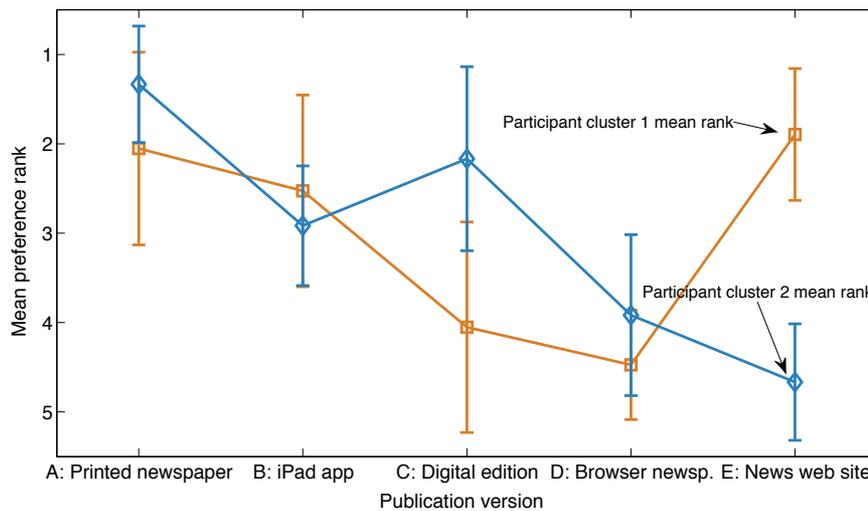

Figure 8: Mean preference rankings of the five publications versions for the participant clusters 1 (orange squares) and 2 (blue diamonds), where the error bars indicate the standard deviation of the rankings around the mean for each publication version in each cluster; notice that the ranking value decreases (preference increases) towards the top of the graph: for example, in participant cluster 1 version E (news web site) was the most preferred choice while in cluster 2 it was the least preferred publication version

ing process, the percentages should be taken only as roughly approximate indicators of the relative frequencies different attributes. The main point of Table 4 is to qualitatively identify the attributes that the participants themselves used in describing different publication versions, their experiences in using them, and why they considered each version more or less suitable for their daily used.

3.5 News reading styles

When the participants justified their preferences, they typically also described their daily news reading habits and told what made given publication versions more or less attractive for them. Based on reviewing these

comments the researcher derived the following three main categories of reading styles. Based on reviewing the transcripts of the comments each participant was then categorized into one or more of the reading style categories, collaboratively by the researcher and the administrator of the experiments.

Twelve participants were placed in two categories, as they commented on different styles of news reading in different contexts. None of the participants was classified into all three categories. Six of the participants could not be placed in any of the three reading style categories based on their comments, but neither did their comments suggest an additional reading style category.

Table 4: Percentage of participants that associated the given attribute with the given publication version when they explained their preferences

Attribute	Publication version					All versions
	A	**B**	**C**	**D**	**E**	
Familiar	35	5	5	5	22	73
Traditional feel	3	0	14	0	0	16
Intuitive, easy to use	32	22	14	8	14	89
Difficult, unintuitive to use	0	3	11	35	3	51
Abundance, richness of content	0	0	0	0	8	8
Scarcity of content	0	5	0	8	0	14
Too much information at once	0	0	0	0	14	14
Comfortable amount of information visible at once	3	3	0	0	0	5
Unecological	8	0	0	0	0	8
Ecological	0	0	3	0	0	3
Creates trash at home	8	0	0	0	0	8
Does not create trash at home	0	3	3	0	0	5
No disturbing glare	8	0	0	0	0	8
Disturbing glare	0	3	0	0	0	3
Not tiresome for my eyes	5	0	0	0	0	5
No need for device, electricity, or network connection	8	0	0	0	0	8
Newspaper sections can be divided between family members at home	5	0	0	0	0	5
Navigation is easy, intuitive	0	11	5	22	5	43
Navigation is difficult, unintuitive	0	5	5	11	3	24
Moving around in the publication is effortless	5	11	22	5	0	43
Moving around in the publication is cumbersome	8	0	11	5	5	30
Attractive layout and visual appearance, beautiful	3	5	5	0	0	14
Unattractive layout and visual appearance, boring, ugly	0	3	0	11	3	16
Easy to perceive all the content that the publication has to offer	11	14	16	5	5	51
Difficult to perceive all the content that the publication has to offer	3	5	3	3	3	16
Feeling lost, not knowing how to get back to frontpage or previously visited locations	0	5	0	11	8	24
Easy to know my location in the publication	11	8	0	5	0	24
Difficult to find what I am looking for	3	8	0	5	5	22
Easy to find what I am looking for	8	14	8	3	5	38
Easy to find interesting articles	3	14	0	5	16	38
Easy to find important news	3	3	0	0	3	8
Intuitive, easy-to-grasp structure	3	38	5	14	8	68
Complex, unintuitive structure	0	3	3	0	14	19
For enjoyable, sensuos, relaxing reading experiences	8	0	0	0	0	8
Feels good in my hands	11	0	0	0	0	11
Comments, discussions, sharing, searching, and other extra functionalities	0	0	0	0	14	14
No comments, discussions, or sharing options	0	0	3	0	0	3
Possibility to zoom in	0	0	3	0	0	3
Comfortable to read articles	5	3	0	8	0	16
Unpleasant to read articles	0	3	8	5	3	19
Latest, updated news	0	0	0	0	27	27
Not perceived as a daily publication	0	0	0	0	24	24
Easy to carry with me	5	3	0	0	3	11
Advertisements or other elements are distracting, difficult to concentrate	0	0	11	3	5	19
Advertisements are a pleasant part of the publication, not distracting	3	0	8	0	3	14
Pleasant size	11	0	0	0	0	11
Easy to access anywhere on any device	0	0	0	0	3	3
Chance to come across interesting articles and topics unexpectedly, serendipitiously	3	0	0	0	3	5

Participants categories: (1) Keeping up with what is going on in the world generally (38 %). Readers with this motivation typically want to browse through the whole publication, seeing all that it has to offer and stopping to focus more on articles that they consider to be important. (2) Keeping informed of what is going on in areas that are personally interesting (48 %). Readers with this motivation value quick access to sections that are of interest to them, without having to pay attention to anything else. (3) Finding latest, interesting, or entertaining news to read, quickly and easily (28 %). The motivation is not to read news of any specific category or to find specific information, but rather to catch up with the latest news or to read news content as an enjoyable pastime, typically on a short break between other activities.

3.6 Interpretation of experiences evoked by different publication based on questionnaire results and qualitative summaries of the reading sessions

Using the summaries written upon reviewing of the eye tracking videos with retrospective comments, and building on the previously presented results the following overall interpretations were made of the user experiences of the five publication versions.

3.6.1 Version A: Printed newspaper

The printed tabloid format newspaper, which many participants considered easier to handle in many reading situations than the previous broadsheet version, was generally well regarded. The larger size of a newspaper spread, and the well-used possibilities it offered for laying out the content, was appreciated by many participants. Enjoyable reading experience overall, as well as familiarity, supported the choice of this version for many participants. However, a considerable number of participants, while acknowledging the enjoyable reading experience of a printed newspaper, preferred to read their daily news articles from a digital medium – reading daily news from a printed newspaper had no place in their current daily routines. Considering the gaze paths, and the allocation of attention to different elements of the publication, many participants found the way the advertisements were incorporated in the layout of the printed newspaper to be natural and pleasant for them: they could easily pay closer attention to advertisements if they spotted something interesting (or decide not to do so) but they did not feel that this took away from the flow of reading the publication, as opposed to advertising in digital publications, which many participants commented to be distracting to their reading experience.

3.6.2 Version B: iPad app

The iPad app was generally considered to be visually rather impressive, and the navigation between sections via the bar available from the bottom corner to be intuitive to use. This native app also felt more responsive to most participants than the versions D and E, which were used in a web browser. Due to the relatively intuitive navigation, freedom from severe usability problems, and the pleasing visual appearance, the iPad app was generally rather well liked (77.5 % of the participants ranked it in their top 3 when choosing the preferred version).

3.6.3 Version C: Digital edition (print replica)

Some participants thought that pleasant layout of the print version transferred rather nicely to the digital device in this digital edition that replicated the pages of the printed newspaper. Other advantages mentioned included the immediate familiarity to those used to reading the printed newspaper. Also, the navigation through the multi-page view of the miniaturized pages was considered intuitive in its simplicity by some participants, and provided a clear overall view of all content available within the publication (something that was often perceived to be lacking from the other digital versions). Some participants used this miniaturized view extensively to browse the publication, only tapping to go to individual pages if they spotted something that appeared interesting. On the other hand, some participants did not see the point of reading a replica of the printed pages on a digital device (especially on a relatively small screen of a tablet). Reading the text was particularly problematic on this version for those participants that were not able to comfortably read the text at the default size at which the pages were presented: they had to constantly combine two-fingered zooming (in order to read paragraphs) and dragging (to scroll the page), which was cumbersome.

3.6.4 Version D: Browser newspaper

Preferred by some for the ability to use it across different digital platforms, the browser newspaper (used on the Safari browser in the iPad) did not generally provide a very good user experience. The navigation was considered to be confusing. While some positive comments were given for the ability scroll the article headers separately on the right side of the front page, most participants found the fact that the dragging on the front page only affected a part of the page to be confusing. The fact that links to all sections were not initially visible in the navigation bar was considered a disadvantage by many participants. Many participants reported feeling lost when moving from article to another within the publication; for example, it was not intuitively obvious how to get back to an article or a part of the publication where they had previously been in. The user experience also suffered from occasional delays in responses to user actions (problems in network connections may have caused some of the delays).

3.6.5 Version E: News web page (HS.fi)

Unlike the other versions, which were daily publications, version E was a continuously updated news web site, and in this aspect essentially different from the other versions. It also divided the opinions the most among the participants. It is likely that the different styles of news reading were most strongly reflected in the opinions regarding this version. Many participants felt that the layout was too full of everything (with many screens worth of material to scroll through on the home page, and additional links on the right side) and preferred what they considered to be a cleaner structure of conventional news publications. However, for the participants used to reading their daily news on the web, this version offered what they wanted in a familiar format, a serving of news for quick reading, with possibilities to quickly jump to the latest or most popular articles. Other flavours of the web, like seeing comments from other readers, also contributed to making this the preferred version for some readers.

4. Discussion

Factor analysis and experience map visualizations based on multivariate analysis of the user experience questionnaire responses provided information on relevant experience dimensions and appropriate items for measuring them, and allowed us to describe the perceived and experienced differences between the publication versions. Particularly, dimensions such as perceived usability, classical aesthetics, expressive aesthetics, and focused attention were consistently separated to different factors, and meaningful differences were found between the publication versions in these dimensions.

Based on the results it also appears to be possible to meaningfully measure and compare aspects such perceived trustworthiness, playfulness, and entertainingness or interestingness of different publication designs, as well as the emotional impact of different designs and the relationships between the experienced emotions and other dimensions. For example, in this data set low usability correlated with feelings of frustrated and anxious feelings, and expressive aesthetics correlated with perceived playfulness of the publication. Further, the data suggested that it could be possible to meaningfully measure the design concepts of visual hierarchy and abundance of information shown, as perceived by the reader. However, in the case of these and previously mentioned dimensions, it should be noted that the experiment and analysis carried out in this study does not constitute a full validation of the questionnaire dimensions and items. Rather, these results should be understood as a preliminary exploration into feasibility of meaningfully measuring these rather complex dimensions, with more work needed to build validated questionnaires for reliably measuring them. Still, it is interesting to note that it appears to be possible to meaningfully measure and also relate to one another various aspects of user experience, from aesthetics and usability to emotional responses and perceptions such as trustworthiness or entertainingness of the publication, all of which were found to vary with the layout of the content, despite the content intent itself remaining essentially the same. The attributes associated by the participants with different publication versions can be compared with the items and experience dimensions used in the questionnaire, and used to inform the further development and application of measures of news reading experiences.

The reliability and validity of different parts of the questionnaire can be judged to a degree based on factor structure of Table 1. The fact that items supposed to measure a single construct are loaded strongly on the same factor suggest their reliability as a measure of that construct, as is the case for items 72–77, constituting a measure of perceived usefulness, for example. Divergent validity of this measure is suggested by the fact that it is loaded onto different factor than the items meant to measure distinct constructs such as Focused Attention (items loaded mostly on factor 4) and Aesthetics (items loaded mostly on factor 2). It should be noted that not all dimensions are assumed to be consistent psychological constructs. Items 22–30, for example, are related to different aspects of usability, which is used as an aggregate indicator of these different aspects, rather than a single psychological construct. The fact that different constructs or indicators are loaded onto same factor should not be taken to mean that they fundamentally measure the same aspect of user experience; rather, it shows that they are correlated within this data set. For example, expressive aesthetics were associated with playfulness and joyful and enthusiastic emotional responses, all of them mostly loaded onto factor 4, while being presented with too much information at one glance (item 4, loaded onto factor 5) seems to be a possible cause of anxious and tense feelings (items 54 and 55, also loaded significantly on factor 5). Table 3 further shows the user experience dimensions on which significant differences were found between the examined publication versions, suggesting the relevance of these measures in differentiating between the experiences evoked by different designs.

The three general news reading style categories derived from the comments of participants cover the principal motivations among all the participants of the experi-

ment, with many additional personal idiosyncrasies in the reading styles, as was to be expected. The printed newspaper lends itself well to most of these different styles of reading, assuming it is at hand in the given context. The accumulated learnings from the design of printed newspapers are not directly applicable to the world of digital publications, and digital newspapers are still finding their form. It is not clear what kind of design choices are most suitable in digital news publications, or if any single type of layout would satisfy different reading styles generally. A given digital version may be suitable for a certain style of reading but not for another one, depending on its layout and how its navigation is implemented. The results from the experiment indicated that this was indeed the case here. The vast majority of participants liked the reading experience of a printed newspaper, even if they reported that printed newspapers did not anymore have a place in their daily routines. However, there was considerable variation among the participants in which of the digital versions was preferred for the reading experience it provided, not explained by the person's attitude to printed newspaper.

The results indicated that none of the digital versions included in the experiment, while satisfying some readers, would do very well in catering to all styles of reading. Specific aspects in which all digital versions struggled to various degrees in comparison to the printed newspaper was in giving the reader an intuitive feel for all the content that is available in the publication and allowing the reader to perceive her current position in the publication. Printed newspaper naturally enjoys all the benefits of a tangible physical object in this regard, while in the case of digital versions the layout choices, including the implementation of the navigation system, had a strong influence on how this is perceived. For some readers it was very important to have a good understanding of where a newspaper starts and where it ends, and to have a good idea of how to go back to a specific place in the publication that they had previously visited. Others were fine with and preferred a web style continuous stream of news over an easier-to-perceive set of news that they could digest; navigationally, for them it was sufficient if they could quickly return to the front page of the publication. Indeed, these were the two main preference-based clusters among the participants. In both groups the reading experience that the printed newspaper provided was valued rather highly, the difference being in their attitudes and preferences regarding the digital newspaper versions. One group preferred to have their digital news presented in a publication that followed the tradition of printed newspapers, while the other group saw no need to carry this kind of layout over into the digital domain, preferring a news web site style of dynamic and continuous news stream.

Further findings were related to the flow of attention in different versions. A pleasant flow of attention is known to be a central aspect of a good reading experience. Again the printed newspaper excelled in this regard, with more variability among the digital versions. A common example that came up in the experiments was the placement of advertisements and how it affected the flow of reading. Many participants commented on how a newspaper spread allowed one to smoothly direct one's attention to interesting parts, quickly noticing different elements such as advertisements but not paying much attention unless they appeared interesting. In some digital versions participants were in many cases clearly distracted and irritated by advertisements when they suddenly interrupted their flow of attention: the publications did not include pop-up advertisements as such, but the effect was as distracting if the person suddenly found himself looking at an advertisement, partly forced on him by the layout, and had to make an effort to continue past the advertisement. Again, while the results did not provide clear-cut general design rules for directing attention in digital news publications, it did show how different designs had considerable effects on the flow of attention and consequently on the overall experience provided by the publication.

Beyond the observations on the reading experiences and styles, the experiments served as a test of combining and integrating different approaches to evaluating the user experience of media products and services. We found user testing with eye-tracking, followed by a retrospective commenting session to be a very useful approach for extracting valuable information for interpreting the other results. During the retrospective commenting we showed the participant a video recording of their reading session, augmented by the gaze path from the eye tracking glasses, and asked them to explain their own experience: what they were doing, what they thought and felt. Seeing the video recording with the visualization of their own gaze path appeared to be a good motivator for most persons to retrospectively and introspectively consider and discuss their own reading experience, and also to relate it to their reading style more generally.

The gaze path data revealed the focal points and transition paths of attention, the retrospective commenting provided qualitative data, the both of which served to explain results of the multivariate analysis of the media experience questionnaire data. The final preference judgements between different publication versions and the comments to justify those judgments indicated what aspects of the experience the participants found valuable, and together with other data, helped to paint a more complete picture of the user experiences of the tested publication versions.

5. Conclusions

A multipart laboratory experiment was carried out in order to compare and investigate different aspects of the user experiences evoked by five different versions of a newspaper. These versions, a printed tabloid size newspaper and four digital versions with different types of layouts and design choices, essentially provided five different ways of presenting the same content to the reader. As the news reading habits and preferences are changing with the ongoing digital transformation, it is essential to understand how different kinds of design choices relate to different dimensions of user experience and what kinds of designs best serve different styles of reading.

While the properties of the publication versions included in the experiment necessarily bounded the user experiences that could be expected to arise in this study, the experimental setup was designed with the goal of increasing the understanding of news reading experiences, habits, and preferences also more generally, beyond the usability details related to idiosyncrasies of these specific publication versions. Multiple research methods were combined in the experiment for twofold purposes: to support the interpretation of results through integration and comparison of results obtained by different methods, and to test and develop the user experience measurement and analysis methods themselves. A central aspect of useful user experience measurement is finding out what to measure. Thus, through this experiment, we also set out to increase the understanding of the relevant and measurable dimensions of news reading experiences.

A mobile eye tracker was used to record a scene video and to capture the eye movements of each participant as she or he browsed the newspaper. After reading the given newspaper version, the participant was shown the video recording of his or her reading sessions, captured with the eye tracker and augmented with a cursor showing the participant's gaze path. The participant was asked to retrospectively comment on his or her reading experience while watching the eye tracking video, to comment on their own actions, goals, thoughts, and feelings throughout the reading sessions. Based on the videos and commentaries, summaries of each reading session were later written, describing the actions and the flow of attention of the participants during the session, with further interpretations and other points added based on the retrospective commentary. After each reading session each participant also filled a 92-item questionnaire, with items from a media experience framework that were postulated to be appropriate for measuring certain relevant dimensions of news reading experiences, as well as items adapted from two validated questionnaires for user engagement and perceived visual aesthetics of web sites. Finally,

having spent approximately five minutes reading each of the publications versions, each participant was asked to rank order the versions according to his or her own preference, first choosing the version that he or she would choose if she had to use only one of the versions in his or her daily life. The participant was also asked to justify her choice, to explain why she liked the particular version and why she thought it best suited her news reading style.

The analysis of the questionnaire responses showed that the questionnaire did in fact indicate meaningful differences between the tested publication versions on the different dimensions of media experience that it was designed to measure, and that the measures were consistent with the data acquired from other approaches. The questionnaire has so far not been extensively tested, and the work done in this study does not yet constitute a proper validation of the questionnaire, but these results do suggest that the questionnaire can be a useful tool in measuring media experience. The results, along with other similar studies published in the recent years, provide useful information for future considerations and validation efforts for media experience measures, as well as for practical application of such measures in different phases of iterative design processes.

The qualitative data from the retrospectively commented eye tracking videos was in line with the results obtained with the questionnaire, and further supported the interpretation of results, helping to see what kinds of design and experience aspects lead to the differences seen in the multivariate analysis and visualizations of the questionnaire data and to further explain the preferences among the participants. 42.5 % of participants ranked the printed newspaper first in their order of preference. While the printed newspaper was by far the most frequent preferred choice of individual publication versions and the reading experience that it provided was well liked across all participants, it should be noted that the majority of participants (57.5 %) still preferred one of the digital versions if they had to choose only one publication version for their daily news reading. Many of them commented that while they still enjoyed the experience of reading a printed newspaper, they did not anymore have room for it in their daily routines, thus preferring one of the digital versions.

However, the results suggest that, unlike the printed newspaper, none of the digital versions succeeded particularly well to catering to reading styles and preferences of different readers. This result was strongly emphasize by two distinct clusters of participants found based on the preference judgments. While the

printed newspaper was highly ranked in both groups, the most significant difference between the two groups seems to be the attitude towards reading news articles in the form of continuous streams as often found on different web sites. One group preferred the printed newspaper and digital versions that can be understood to stem from the tradition of the printed newspaper. The other group preferred the web style of news presentation and saw no need for digital versions mimicking the printed paper.

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The RocReadaR – a system for transmedia news publishing using augmented reality

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Abstract

We designed and tested a prototype of a system for collaborative publishing across different media platforms in the form of an application for smart personal Android-based devices. This system includes and uses a printed document (e.g. a magazine publication) as an entry point. The printed document is seamlessly linked to digital web-based material and collaboratively augmented by the users in an interactive fashion using personal computing devices. While the printed document stays the same, the associated virtual digital multimedia part is updated by the community of authors and readers and discovered by using image-based tags embedded in the printed document via augmented reality technology. We call this method of publishing transmedia publishing, since it has similar characteristics to transmedia storytelling. To demonstrate the feasibility and utility of the system we conducted a laboratory study where we asked student participants to use the system while reading a printed magazine and provide their evaluation of the quality of experience. The results of the experiments demonstrate that users on average preferred transmedia publishing over the regular printed magazine for its ability to provide compelling user experience and rich media content. They also emphasized an integration with social media and an option for uploading additional content as important advantages compared to print. The findings can be used to formulate design recommendations for implementing transmedia publishing system in practical real-life applications and to improve our prototype.

Keywords: transmedia, news publishing, print media, augmented reality technology

1. Introduction

It is widely acknowledged that the printing and publishing industries are undergoing tremendous changes complicated by rapid digital technology developments, the rising accumulation of knowledge and data on the web, and the ubiquitous use of personal electronic devices. During the last several years the place and role of web and digital media in publishing and communication grew exponentially, spurred on, in part, by instant access to vast web-based data sources, peer networks, social media, the availability of video and multimedia material, interactivity, and real-time modifications of digital media. At face value, this growth might seem to hasten the end of relevance for print media. Yet, many scholars and industry leaders continue to acknowledge specific advantages of the print medium, including physicality/tangibility, portability, and unique sensory qualities. The distinctive affordances of paper are not only related to its physical properties and, consequently,

actions of grasping, carrying, folding, manipulating, and writing, as noted by Sellen and Harper (2003). The paper has been shown to support collaborative work as a tool for managing and coordinating actions in a shared environment, as a medium for information gathering and as an artifact in support of discussion. Case and laboratory studies demonstrated that people use pen and paper to think, plan and organize the work (Sellen and Harper, 2003). Additionally, print media is associated with more effective reading comprehension and knowledge gain (Davidson et al., 2010; Mangen, Walgermo and Bronnick, 2013; Jabr, 2013).

Increasingly scholars and practitioners are exploring ways to incorporate print media and its benefits with digital products. Together, the unique affordances of the different media and their distribution channels are being successfully exploited in cross-media marketing

campaigns and transmedia "entertainment supersystems" (Kinder, 1991). However, despite proposals by Veglis (2012), there are few studies that test how transmedia can be used to engage traditional print news audiences. We hypothesize that traditional printed publications using transmedia storytelling approach could, potentially, find ways to engage audiences outside their traditional publication cycle and receive additional audience metrics that may be useful to share with their advertisers. Looking to advance our ideas beyond speculation, the goal of this project was to build and test a transmedia system for publishing that would provide baseline data for why or why not users may favor such a system for news stories.

2. Transmedia storytelling

Transmedia storytelling, defined by Jenkins (2006) as "stories that unfold across multiple media platforms, with each medium making distinctive contributions to our understanding of the world" (p. 334), has largely been studied in the context of individual creative projects with emphasis on collaborative content and production (e.g. Freeman, 2014; Gambarato, 2014). However, as noted by Jansson (2013), the potential effects of transmedia stories are much broader. Until recently, the term cross-media was used to mean the same thing as transmedia (see, for example, Davidson, 2010). Now, however, there is a growing consensus that cross media refers to releasing the same or similar content across multiple media platforms (Phillips, 2012). Other terms, including mixed media or interactive print, are often used to point toward combining variety of media together to produce a single physical or interactive experience, rather than in reference to the process and content of communication, and as such can be used for many purposes, including transmedia storytelling. Specifically, the flexibility of transmedia stories challenges and redefines the traditional social spaces we interact with stories, providing new spaces for media engagement that may have a profound influence on not only our use of media, but also our information processing and behaviors after engaging with a story. Jansson goes so far as to suggest transmedia storytelling necessitates reformulating Lasswell's (1948) famous communication model, "Who says what, in which channel, to whom, and with what effect?," as "What social practices amalgamate with what media, under what textural conditions, and with what social consequences?" (p. 292). One way to try and answer such questions is to build and test the feasibility and effectiveness of transmedia news publishing by employing technology that can provide easy access and seamlessly integrate different media and media channels, such as augmented reality.

3. Transmedia publishing system design

The potential benefits of linking digital media while interacting with paper-based material to produce enhanced storytelling experience have been recognized since early 2000s. In particular, Vogelsang and Signer (2005) described "The Lost Cosmonaut" installation, a prototype of an interactive narrative environment based on digitally enhanced paper. It consists of a desk on which a user can interact with objects made of paper with a faint pattern of infrared-absorbing dots by using a special electronic pen developed on the basis of Anoto AB (2016) technology. This pen has a camera placed alongside the writing stylus. By pointing the pen at text or picture, the user can view video and animations, displayed on a separate screen, and listen to the audio. The audience is encouraged to write and draw with the pen, and the created content is captured and stored in the database for the later access, making the installation an open entertainment system that can grow through a collaborative effort. Norrie and co-authors (Norrie and Signer, 2005; Norrie et al., 2007) developed the EdFest system – a knowledge sharing environment for The Edinburgh Fringe Festival, the world's largest international arts festival, and the underlying context-aware platform for mobile data management. The system provides access to information about venues and events and allows tourists to enter and share reviews of events, as well as their views on local restaurants. The access is accomplished through the interaction with the digitally enhanced paper brochure and an electronic pen, similar to the Lost Cosmonaut. The Java-based platform utilizes a cross-media link server and an object-oriented framework for advanced content publishing.

Recently, augmented reality (AR) technology received a significant attention as a tool to integrate digital and tangible media forms. Unlike in the early stages of AR development, when head-mounted displays were used to overlay virtual information over real world environment, the new versions of AR software for smartphone and tablets allow to easily link various digital media items with physical objects, including prints. Several companies (e.g. Metaio, Aurasma, Wikitude, Vuforia) released their implementations of AR software, and made software development kits, SDKs, available for custom application development. In a previous study we used Aurasma software for the experiment, where we asked participants to read short fictional stories pro-

duced and presented in several ways, including in electronic form, print, and paper with AR. We found that the latter method of reading that integrates paper and electronic mediums, significantly enhances user experience and interest level as opposed to just plain reading from print (Fedorovskaya and Yu, 2014), potentially leading to better comprehension and retention of information. This method of reading was on par and even slightly better, in comparison with interactive reading from the screen.

To explore further we decided to design an AR-based prototype of a collaborative transmedia communication system, the RocReadaR, and test its feasibility and usefulness, specifically, for news and information media, by creating and evaluating a limited implementation of the method as an application for the personal smart device. The designed system links three different media channels: printed publication, digital web-based information and social media with its collaborative capability of sharing and adding content. It can be characterized by several key features:

a. it is print-centric – printed information is an entry point to the process of communication;
b. it integrates print and additional digital content by linking digital data through image-based trigger;
c. the digital content can be located anywhere on the internet or a secure server in the form of files, video, audio, web pages, images, 3D interactive models, etc. and can be easily updated, added or replaced;
d. it is interactive – users can navigate to digital information associated with the print via personal devices (a smartphone, tablet or a wearable augmented reality device, where Google Glass could be an example);
e. it is collaborative – users can contribute to the document creation by adding material, leaving their comments, photos, etc.;
f. it enables a fluent and seamless switching between print and digital; between reading and contributing;
g. it potentially transforms the printed document into one of the channels of social media.

Our system shares several key elements with what has been proposed earlier: they all aim to harness the strengths of paper where it is used as a starting point for the interaction; through the paper and an electronic device, users can access various digital media, providing therefore a basis for integrated media experience; and finally, the users can add to the content in some form that can potentially lead to the collaborative expansion of the story. For example, in our prototype, as in the EdFest mentioned earlier, the printed material is a starting point for the interaction, through which the user can access web-based digital media. Similarly,

there is a possibility for adding content by the users themselves, such as comments and reviews. The main differences between the EdFest and the RocReadaR are in the underlying technology and the interaction method employed: we use AR-based mobile app to integrate different media and to provide an interface for exploring and creating digital content on the server. Furthermore, social media such as Facebook, Twitter, Google+, etc. become accessible in the integrated communication, as well as the expansion of modalities for content delivery – 3D models and visualizations in addition to web pages, video, audio, text files and photos; and content authoring – video, photos, textual files. As the physical vehicle to carry the interaction with printed publications, we chose smartphones and wearables, as the next step, with the hope to make the system flexible and readily available for every user. This choice also allows the inclusion of objects in the physical and virtual environments in the process of storytelling in the future developments. Finally, the intended application space is different – we are interested in developing a platform for transmedia publishing and news communication and in the process, figuring out the necessary requirements to make it useful and appealing.

The concept with all these components in combination has not been implemented for news media communication, and we believe its characteristics, the unique interaction design and the ubiquity of smartphones and, potentially, wearable devices, can make this an attractive publishing platform for transmedia journalism and news publishing.

To build the prototype with the functionality that we deemed important, we used the Wikitude SDK, a software development kit for the mobile Android AR applications. We chose Wikitude SDK because the existing ready-to-use AR software systems that we evaluated (Aurasma, Metaio, Layar) did not provide multiple channel media integration and user interaction experience suitable for news publishing, at least at the time of the study conception and creation of the prototype.

We applied the user-centered design process with several iterations to develop a working prototype in the form of a smartphone application. The application aims to modify the reading experience of a news story published in a printed magazine by providing access to digital media content via the AR technology. Readers can view pictures, videos, and listen to audio and music when they scan the magazine, upload their own material, including photos, videos and text; provide feedback; and share information with friends on social media. The multiple media platforms employed in our system – print, web and social – contribute to the enhancement of the readers' experience by offering additional relevant content, the initial story extensions, and opportunity to interact and participate within the story. The above characteris-

tics are used to define transmedia storytelling. Hence, we call the method of publishing enabled by our system – transmedia publishing. To evaluate the viability of the proposed method, we address the following research questions: Does this method of publishing provide a desirable utility and an enhanced quality of reading experience? How does it compare with the traditional reading of the news magazine?

4. Method

4.1 Participants

The study was conducted in the Discover Lab at the School of Media Sciences at Rochester Institute of Technology in Rochester, New York, during the 2014–2015 academic year. Student participants were recruited via flyers and an on-campus email. Twelve male and twelve female RIT students in the same age group (18–26 years old) participated in the experiment. The participants were screened prior to the experiment to ensure the same level of familiarity with the augmented reality concept. They had normal or corrected to normal visual acuity.

4.2 System prototype and materials

The system prototype tested in this study was implemented as a mobile application for an Android Nexus 5 smartphone. The application was developed using the Wikitude free trial Android SDK (Wikitude.com), available at the time of the experiment, which allowed to link digital content with the printed material.

In our RocReadaR system, the publisher provides page images which are annotated with additional content using a web application that we created using php, html and MySQL. The page image is characterized by a signature or 'tracker file' created by the Wikitude studio stored on the web server.

The Android application uses the Wikitude SDK to analyze images coming from the phone's camera and compares them against the tracker files on the web server. If a match is found, a control button is enabled which provides access to the page annotations stored on the web server. These steps are illustrated in Figure 1 and 2.

To inform about the availability and to access various digital content we implemented touch icons (control buttons) on the user interface for video, audio, web information, and 3D animation. The subsets of these icons appear on the interface only when the corresponding media content is linked to the page and mapped in the server database (see Figure 2, step 4). In addition, a comment icon and a share icon, as well as home

During the experiment participants were asked to use the prototype of the system while reading articles in the magazine and provide the evaluation of their quality of experience. We also compare reading experience with and without the system usage. At the end of the experiment we interviewed participants to solicit their overall comments and suggestions for potential improvements.

icon were always provided. The comment icon, when touched, allowed the user to upload their own multimedia content (photos or video) or type in their comments as text. It also provided access to the comments submitted by other readers. The share icon allowed the user to post and share their comments on social media sites: Google+, Facebook or Twitter. The home icon would show all media available for the entire magazine.

We used a recent issue (Spring/Summer 2014) of the Research at RIT magazine as a printed publication and redesigned it for the experiment by choosing three four-page articles. We assembled relevant digital content for each page of the articles. This digital content varied across pages and included different combinations of video, audio, a 3D animation, and a supplemental web material for different pages. The digital content was placed on the School of Media Sciences server.

Two versions of the redesigned magazine were printed. In the first version of the magazine we provided icons that designated available digital content on the margins of the pages. We used two colors for the icons: orange color signified media items that could be accessed from a particular page, while gray color was used for the media items that were not available for that page, but could be found on other pages of the magazine. This was done to inform the user about all digital media associated with the entire issue. The version of the magazine with the printed icons was intended for the use with the smartphone. When the user scanned the page, only those touch icons would appear on the screen (video, audio, etc.), if there were corresponding media items available for viewing. The user needed to scan the page to see the controls, but could move the smartphone away from the page afterwards to explore and view media without the necessity to hold the phone over the page. The second printed version of the magazine did not contain any such icons and was used for the traditional reading. The printed icons had the same appearance as the user interface touch icons on the smartphone application. Figure 3 illustrates the pages of the redesigned magazine with the printed icons (Figure 3a) and a screen of the smartphone application depicting touch icons, or control buttons, on the interface (Figure 3b).
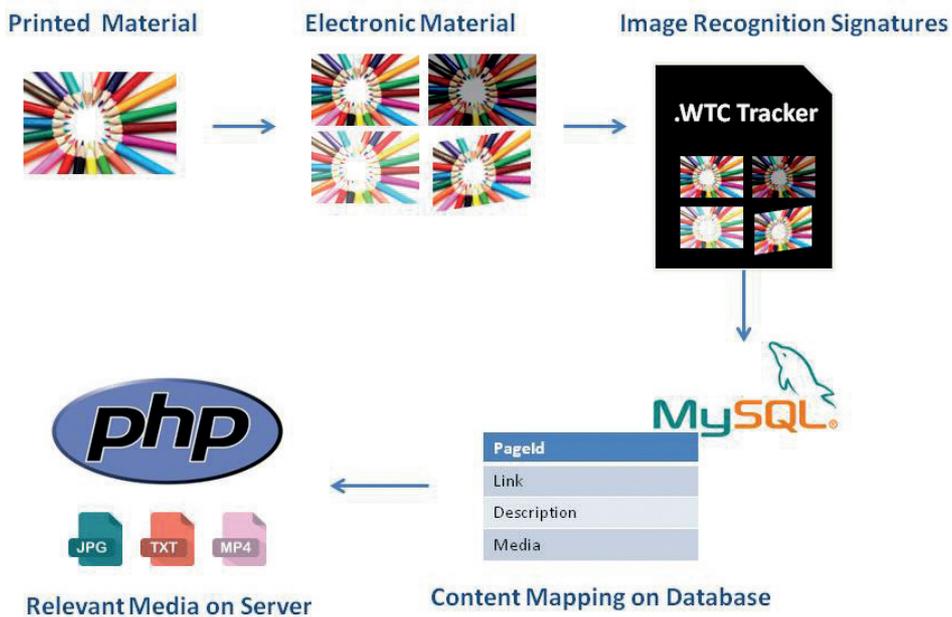
Figure 1: Operation of the RocReadaR system, where: 1) The publisher provides printed magazine or magazine pages alongside with digital media files or web links; 2) The necessary print material is converted to electronic format, such as PDF, PNG or JPG, and Multiple copies of the same print material with varying image characteristics such as brightness, contrast and skew angle are stored for better recognition to account for unknown environmental lighting conditions during recognition; 3) The Wikitude studio is used to create a tracker file of these images; this tracker file is stored on the web server and contains images' signatures of all our pre-defined content which is later used for recognition; 4) Each instance of print material is associated with multiple instances of relevant web media, these one-to-many mappings are stored in a MySQL database along with some metadata associated with the web media; 5) Upon image-recognition from print media, we can use the database mappings to fetch linked media stored on our server using PHP scripts
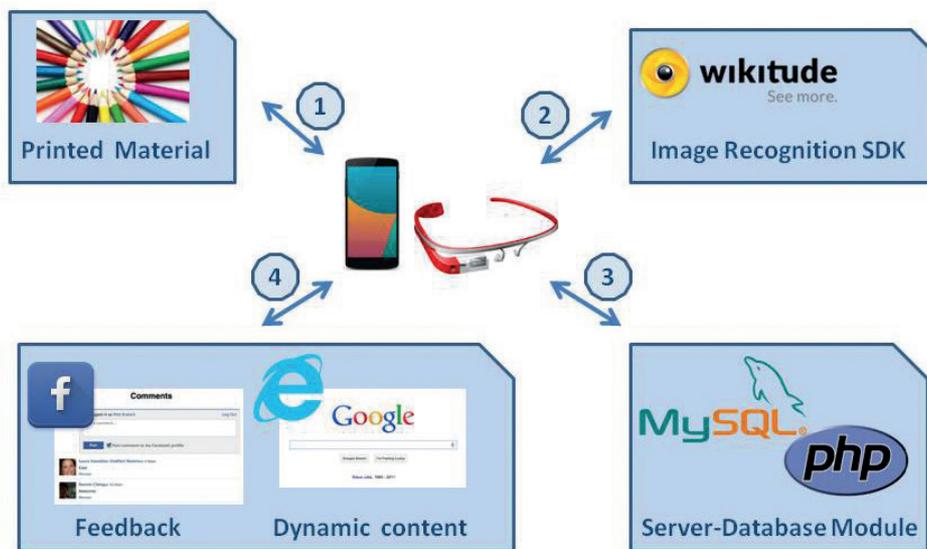
Figure 2: User interaction and image recognition with the RocReadaR app.: 1) The user runs our application on an Android smart device and points it at a printed document with the relevant media already linked with it, this media is stored on our server and is defined on our database; 2) The Wikitude SDK then helps to recognize if the print content is pre-defined or not, by using .WTC 'tracker' file that was generated when we stored the data, and by comparing the image signatures in the tracker, the SDK returns a match/miss result; 3) If a match occurs, we search for the mapping of print document to relevant media on the Server-Database Module and return this information to the Android device; 4) Using the response from the server database module and metadata of relevant media we present Web and Social media in an augmented environment on the Android device

Figure 3: The pages of the redesigned magazine: (a) An open page of the redesigned Research at RIT magazine with the printed icons on the margins designating digital content, where the icons for the available content are printed in orange color; (b) The Nexus 5 smartphone with the open smartphone application, where the touch buttons designate the available digital content matching the orange icons on the printed page, and clicking on the buttons provides easy access to the digital content

4.3 Experimental procedure

Participants were seated behind a desk with a magazine placed on the desk. After introducing the study with the orientation script, which contained information about the purpose of the study and the usage of smart devices, each participant was asked to fill out a consent form and a background information questionnaire. Afterwards, the participant was asked to read two different articles, each selected from a different version of the magazine, page by page, and after finishing reading each article in the magazine, answer a questionnaire. The combination of the two articles for each participant was randomized to minimize potential influence of the content. Participants were randomly assigned into two groups with different experimental reading conditions described below, ensuring an equal number of both genders in each group.

The first reading condition group read a selected article in the magazine without any device, in a standard way. Then they were asked to read a second article, this time using a smartphone (Google Nexus 5 smartphone) with our transmedia application, which was placed on the desk near the magazine. Participants were explained how to use the device prior to reading via a printed instruction sheet and then asked to explore the system. The availability of additional digital content affiliated with the article was designated by printed icons on the margins of the article.

In the second group, the sequence of reading conditions was switched. The participants were asked to use the transmedia application on the smartphone while reading the first article. Subsequently, they read a second article without any device. During the experiment

the selection of the articles and their order for every participant were randomized to minimize the influence of the content of the articles on the participants' responses. Both groups filled out a questionnaire after each reading, so that two questionnaires were filled by every participant.

The questionnaires consisted of 7-point Likert scales and were designed to evaluate the quality of experience and reading performance using self-reported measures. The questions focused on the reading performance contained scales to evaluate narrative understanding, attentional focus, narrative presence, interest and retention of information. We used Nurmi, Laine and Kuula (2014) approach when designing these questions. The questions directed to evaluate the quality of experience contained scales to rate both instrumental qualities, including usability, usefulness, and satisfaction, and non-instrumental qualities, such as aesthetic qualities, and motivational qualities (Geerts et al., 2010; Mahlke, Lemke and Thüring, 2007; Albert and Tullis, 2013). The reading performance questions were included in every questionnaire given after reading an article. The quality of experience questions were given in the questionnaire every time the participant read an article using the prototype. After reading the second article we also asked the user to explicitly compare quality of reading experience between the two reading conditions. All questions were presented along with the linear scale of 1–7, with the end points designated as "Not at all" for 1, and "Extremely" for 7. There were 39 rating scales in total.

When using the system, the experimenter suggested participants to try out different functions of the transmedia application, including sharing comments and

media content via social media, to gauge the participant opinion about the usefulness and desirability of these options. At the end of the experiment, after the

5. Results

To analyze the data, the questionnaire responses were aggregated in groups pertaining to the following evaluation categories: 1) reading performance including comprehension, attention level, information interestingness, and presence; 2) usability (ease of reading); 3) usefulness or utility (effectiveness of reading); 4) satisfaction (level of enjoyment when reading); 5) motivational quality (interest level for reading); and 6) aesthetics of the design. We treated responses as interval scale data based on previous research (Traylor, 1983).

To present the results, firstly, we will describe evaluations of the reading performance in two conditions: paper-only and augmented paper conditions. Secondly, we will compare reading experience in these conditions with respect to usability, usefulness, satisfaction, motivational quality, and aesthetics. And, finally, we will summarize participants' comments and responses during the interviews.

5.1 Reading performance

Here are the examples of questions we used for the reading performance assessment: "I had a hard time following the thread of the story"; "My attention was focused on the article"; "I recalled or pictured myself in the events or space in the story". The rating scores for reading performance with and without the smartphone prototype are shown in Table 1.

Table 1: The mean values and standard deviations
(in parentheses) for reading questions with and without the system usage

Question category	Mean values Reading with the system	Mean values Reading without the system
Reading: comprehension	4.2 (0.9)	4.1 (1.2)
Reading: attention	4.3 (0.9)	4.5 (0.8)
Reading: interest	5.2 (1.4)	4.9 (1.5)
Reading: presence	4.5 (1.4)	4.7 (1.2)

There were no significant differences between the articles in the two conditions for reading performance in terms of comprehension, the effort of focusing attention; and presence, when the ratings were compared using a paired t-test. The participants could remember and describe the content of the articles in both cases. However, in a number of instances in the prototype usage condition, when asked to recall a specific detail,

reading tasks and questionnaires were completed, participants were interviewed about their opinions, suggestions and insights.

the participants recalled the content they learned from digital media that was not contained in the printed material. When answering the questions on comparing quality of reading experience (Table 1), the participants found the articles read with the additional digital content provided by the system prototype easier to remember and more interesting to read. Similarly, during interviews they mentioned the availability of digital content as a factor to learn and remember more material.

5.2 Usability

Table 2 summarizes the results for different user experience dimensions in two reading conditions: digitally augmented reading condition, when the smartphone app was used; and paper-only reading condition, without the app. In addition to the ratings, the users were also given an option to explain their answers by providing written comments. The mean values for the usability and other user experience dimensions for both conditions are shown in Table 2, along with the paired t-test results.

Table 2: The mean values and standard deviations (in parentheses) for
user experience ratings when comparing two reading conditions

Question category	Mean value Reading with the system	Mean values Reading without the system	Paired t-test (two-tailed)
Usability	5.7 (1.6)	5.2 (1.8)	no difference
Usefulness	6.0 (1.4)	4.6 (1.8)	$t = 2.13$, $p < 0.05$
Satisfaction	5.7 (1.6)	4.3 (2.0)	$t = 2.12$, $p < 0.05$
Motivational quality	5.8 (1.1)	4.9 (1.5)	$t = 2.07$, $p < 0.05$
Aesthetics	6.4 (0.65)	4.6 (2.0)	$t = 3.66$, $p < 0.01$

Specifically, for the usability assessment we asked the participants to rate the ease of reading and the reading effectiveness for the two reading conditions (e.g., How easy was it to read the article in each instance?). The effectiveness was explained as to be adequate to accomplish a purpose, and/or produce the intended or expected result, according to the Dictionary.com. As it can be seen from Table 2, there was no statistically

significant difference in the usability measure based on the ease of reading and reading effectiveness. The users were divided in terms of their assessments: several participants gave higher values for the augmented reading condition ("it is more effective to read with digital inputs"; "helps the user to look for more information"), while others rated that reading from paper was more effective, were confused about how to properly scan the page, and reported that accessing digital media takes a long time. As one participant mentioned: "It is troublesome to scan every page. And it is a lot information to understand".

5.3 Usefulness

The usefulness was evaluated via the ratings on remembering the content of the articles. The difference in responses was above the significance level in favor of the article read using the smartphone app ($p < 0.05$). When commenting on their ratings, several participants explicitly mentioned that they remembered more about the article because of the additional content they observed on video clips. As one participant has written as a comment: "Again, pictures, audio and video will make the article easy to remember and understand. Therefore, I vote for the article presented to me with interactive media!" On the other hand, a few participants found a print article easier to remember because of their personal interests and specific content. One participant singled out the app as being a negative factor: "Content from the second article (print only) I can recall well because of interest and, probably, less distraction as there was no smartphone interaction".

5.4 Satisfaction

To evaluate the users' overall satisfaction, we asked them to rate how enjoyable their reading experience was in both conditions. Similar to usefulness, motivational quality and aesthetics, satisfaction was also higher for the augmented reading ($p < 0.05$). As with the other scales, not all participants agreed on the higher satisfaction assessment, which is reflected in the values of standard deviations. Five users preferred the paper-only conditions. One of them stated that print magazine is sufficient by itself to provide news information. The other four were not satisfied with the way the current prototype worked. As an example, below is the quote from the note written by one of the users for the satisfaction question: "I preferred reading the magazine without the use of the app. With the app, because it needs to scan the entire page, I needed to stand up, which was annoying after the second time. If it could scan a smaller area of the article in order to gain access to the media, that would be more comfortable for the user, as it would allow them to stay in a comfortable position (laying down, sitting, etc.) and would not

break their train of thought. Also, the media provided either too much information or was redundant; that, in itself, was annoying, too."

5.5 Motivational quality

Motivational quality in the context of the user experience evaluation can be understood as a characteristic of a system (or a function) that compels and motivates the user to utilize this system (Mahlke, Lemke and Thüring, 2007) or perform the function, and is associated with the level of engagement. To assess motivational quality, the participants were asked to compare reading the articles in two conditions in terms of the interest level (e.g., "Comparing two instances of reading, how interesting it was to read the article?"). As it can be seen from Table 2, the users rated reading the article in the "smartphone" condition, slightly but significantly more interesting, compared to the paper-only condition ($p < 0.05$). One of the participants commented: "With an augmented reality app as an extra reading tool, it's more interesting, for sure". When reading the paper-only article was deemed as more engaging and interesting, the content and its relevance to the user played a major role: "The second one (print-only) was much more interesting, since I recently participated in a table booth, I felt more related to the second one".

5.6 Aesthetics

The answers to the aesthetics related question ("Comparing the two articles, how appealing do you find the visual design of the content"?) showed a clear statistically significant preference for the article in augmented reading condition ($p < 0.01$). As stated by one participant: "The article … had more appealing design because of interactive visual content".

5.7 Interviews

The interview questions were designed to solicit users' input on observed shortcomings and attractive features, how to improve the system in terms of its usability and usefulness, what functions they would like to see, their expectations for the quality of content, and the likelihood of using the app for reading news media in the future.

Overall the users expressed many positive comments and favorable opinions about the system, and were particularly impressed by the availability of interactive digital and social media at their fingerprints while reading magazine articles: "In its current prototype, I really like the interactive media provided by RocReadaR!"; "The idea as it is, is great! The system could refer the reader not just to predefined sources on the server but also to links or other content depending

on keywords in the article. In that way it could be used for any magazine."; "It is really cool how there is the social aspect to it, and also the content aspect!"

For a few participants, if their response was less enthusiastic or neutral, it was often in relationship to the particular choice of the magazine, the selection of particular digital media, or an Android platform. They commented: "If it's an app for an Apple device, and if I read more RIT magazines, yes. I would use it. I think it's very cool, but personally I read novels over magazines, while this app is for magazines". However, there were more skeptical views, as well: "I think the news article is self-contained, and enough for a general reader. The digital media part is kind of unnecessary". And even: "I don't like it. You can use digital magazines instead".

The main concerns and suggestions for improving the usability of the system were associated with the speed of the application, its performance stability, configuration and the display quality of additional media items, particularly the video quality. The users wanted to have more feedback to know what the system is doing, e.g., if the page scanning is completed or the video clip is going to last more than a minute. They also suggested to use short, 1–2 minutes' video clips, and to provide an option for redirecting the user to a website if longer videos were available. If the access to the media items was not instantaneous, the users commented about losing track of reading.

The necessity to scan the entire page by holding the phone at a considerable distance was recognized as annoying. To correct for that, scanning only parts of the pages was proposed. Moreover, actions required to operate the current system could turn some people off. As the user put it: "The current state of the app is not very useful. As an individual, I would not like to select a page, put it in focus and then see the additional information." Although the users liked the printed icons on the magazine margins and their automatic appearance on the smartphone as control buttons, they repeatedly pointed out that a closer link with the media is desirable. For example, if there were a video complement-

ing a specific sentence or a paragraph in the text, then underscoring a relevant word, or marking a sentence with a symbol would aid in explaining or illustrating the text.

Among additional features the participants wanted to have was a search capability for finding more information about the topic. "More content using Google API and integrating search result using data mining techniques to get relevant information around the topic would be good." "What is being described in the article should be searchable through the app." On the other hand, some users felt that the augmentation with sufficient digital content eliminates the need to do a search: "It would be great if links are provided to the information on the people presented in the article, so that one does not have to do a Google or Wiki search". There was a recommendation to implement a "save" option for the later use: "I think the app could improve the user experiences, if everyone were able to log in and access their previous research and accessed content".

Commenting on creating and sharing content, the users wanted to be able to capture images, videos, or other media, provide textual comments and annotations and to share media and web links with friends via the app, social media, blogs and also, email.

There were suggestions to look at the accessibility issues. "I did not get quite the idea how it would be helpful for people with hearing impairments. Or maybe I had a wrong expectation." "The speed of showing the related information should be controlled for people having different abilities of taking in information." – are some of the comments we recorded.

Finally, there were numerous comments on the necessity to communicate relevant, compelling and high quality content that is not redundant. For many participants providing new information, not already explained in the article, especially video clips and interactive 3D content, is a critical factor for possible future use. As it was phrased succinctly: "I already know the content [of the article] and got tired of it. So it doesn't attract me".

6. Discussion

The RocReadaR system of transmedia news publishing system builds upon previously published concepts that integrate different media and devices including digital information, data on a web server, physical objects, and paper and printed publications for storytelling and communication (Norrie and Signer, 2005; Vogelsang and Signer, 2005; Norrie et al., 2007; Fedorovskaya and Yu, 2014). The aim is similar – to utilize the many unique affordances of paper as a traditional publishing medium (Sellen and Harper, 2003)

and combine it with digital data to enable embodied interaction and enriched user experience and, at the same time, incorporate evolving digital media channels with an easy access to the digital realm. Unlike several previously developed systems, however, which were created on the basis of special paper and an electronic pen as an enabling technology and focused on active writing to produce additional content, the RocReadaR uses Augmented Reality and is a smartphone application. This approach, we hope, can prove successful for

engaging a broader public with news media and collaborative transmedia storytelling, and inform future developments in publishing communication.

The results of the present study seem to indicate that. As evidenced in the participants' ratings and their comments, our transmedia publishing system, even in its current limited implementation, provided a compelling user experience. The users gave superior evaluations for many user experience dimensions we tested when reading the research news magazine using our system compared to the paper-only condition. Many users rated highly the perceived usefulness of the application and mentioned that they were able to learn more information in supplement to the printed content. Here is an example of the comments we have recorded: "Fun! Adds a whole other dimension to reading. Helps reader to remember and connect text to digital world in an innovative and helpful way … would love to see with text books."

The significant result that we obtained concerns motivational quality of this method of publishing, which can be particularly important for engaging young people with news media.

The way the printed magazine and the prototype conveyed the availability of digital content played a large role in this regard. Many participants acknowledged that providing easy to recognize, familiar icons on the articles' margins of the printed magazine motivated them to use the system and explore content further.

They commended the system's interaction design – that the icons signifying available digital media items on each printed page were appearing on the screen as control touch buttons after scanning the page to view the media.

The sharing feature was deemed very desirable for sharing interesting reads, and to engage friends by sending links, photos, notes or captured pages.

Among recommendations for future improvements and releases, the participants suggested to implement an instant "read" feature, so users can share views and content, if they happen to read the same material in synchronicity. They also asked for the "save" feature to bookmark digital material for later viewing, and repeatedly mentioned search function as necessary for the successful application.

Still, several users were rather neutral about the usefulness of the application for reading, particularly in its current form. When asked a question about which method of reading is more useful and preferred, 15 out of 24 participants chose interactive reading method because of more information and more enjoyment it provides, 4 participants reported no difference, while 5 participants chose traditional reading with no app, noting that the application distracts from focusing on the article. One user felt that the digital media part was unnecessary for news reading. She thought, however, that the application could be useful for other types of reading material such as text books.

7. Conclusions

The study results led us to conclude that the transmedia reading system is perceived to be a useful tool for providing more engaging reading experience, additional in-depth information to support learning, social sharing, and a cool factor that can help motivate news reading and reading, in general. The majority of our participants felt that they would use the system and recommend it to their friends if it is improved. They also acknowledged that this method of reading can change their perception of printed publications as obsolete and limited by providing interactivity and an access to distributed media.

The results of the experiments will be used to formulate design recommendations for implementing transmedia publishing system in practical real-life applications and to improve our prototype.

In the future we plan to improve the system based on the users' responses and run a large RIT campus-wide trial to obtain real-life usage data to investigate whether the benefits of the system can translate beyond the lab into the real world. The second goal is to fully implement and test the transmedia reading method using wearable devices.

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Digitalisation and service business model innovation in media

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Abstract

The traditional business of newspaper and magazine media is stagnating largely because of digitalisation, increasingly challenging business environment, and the resulting commoditization of mass media products. Creating new value to customers and partners with services is an increasing phenomenon in the media sector to enable growth and differentiation. Adapting to service-thinking however necessitates some fundamental changes in managerial mind-sets, strategies, and practices. It also requires for business model innovation. This study offers the service-logic business model framework to explore and explain the transformations taking place when media business is geared towards service(s).

Keywords: business model; business transformation; media management; servitization; service management

1. Introduction

Technological development and digitalisation challenge the business environment of media, gradually making the old business models that monetize media products and audiences obsolete (Küng, 2007). In the western world, traditional mass media products are experiencing commoditization; they are increasingly standardized, lack differentiation, and are being sold on the basis of price and discounts to sustain the reach of target marketable consumers. As many other industries, traditional media have two possibilities in this kind of environment: either disrupt, or be disrupted. In this study, we refer to traditional mass media as having a business model based on *selling and distributing media products (e.g. newspaper and magazine copies) and advertisement space* and as being designed to attract *mass audiences.*

Mediamorphosis would suggest media are able to adapt and change, mediacide the death of media as we know it (Lehman-Wilzig and Cohen-Avigdor, 2004). To endorse the former approach, technological advances and digitalisation are to be seen as enablers for creating new value to customers – a gateway to business model innovation.

Digitalisation enables the delivery of new value-added services. Accordingly, growth strategies in media firms are increasingly aligned towards services (Picard, 2005; Rolland, 2003). Services not only enable the creation of new value, but also enable media firms to seek for higher profit margins and stability of income (Gebauer and Friedli, 2005; Malleret, 2006); differentiation from competitors (Baines et al., 2007; Kowalkowski, Witell

and Gustafsson, 2013); increased revenues from selling more products (Suarez and Cusumano, 2009); and sustainability (Baines et al., 2007; Neely, 2008).

Adapting to service-thinking however demands for some fundamental changes in managerial mind-sets. Entering service business necessitates that the focus is shifted from the producer and manufactured output, to the user and the use-value of products and services (Kim and Mauborgne, 1999; Matthyssens and Vandenbempt, 2008). It means that media firms can no longer consider their customers as passive recipients of goods (i.e., audiences for professionally produced mass media content with focus on media exposure), but rather as active participants in the value creation process that takes place between individuals and institutions (i.e., co-creators of value in communities build around media brands with focus on media experiences). This means a firm does not create value *for* the customer, but *with* the customer (Prahalad and Ramaswamy, 2004). Traditionally media companies have been referred to as producers of media products and services that are purchased by others (Albarran, 2002; Picard, 2002). This study suggests otherwise. Media companies use their specialized competencies so that they benefit others: media *is* service (see also Vargo and Lusch, 2004, 2008; Viljakainen and Toivonen, 2014).

To explore and explain the transformations taking place in the strategies, practices, organizational cultures, and mind-sets in the media sector, this study uses servitization (Vandermerwe and Rada, 1988) and

service-dominant (S-D) logic (Vargo and Lusch, 2004) as theoretical frameworks. Servitization is seen as a business model innovation (Neely, 2008), and refers to the adoption of a new competitive strategy where services are added to the total offering in the expectations of greater financial returns and improved competitiveness (Baines et al., 2007; Gebauer and Friedli, 2005). S-D logic is a managerial mind-set, a worldview, which considers service (i.e. the act of using competencies and skills for the benefit of others) as the main focus in economic activity. It sees manufactured output (i.e. goods and services) only as vehicles to deliver service. (Vargo and Lusch, 2004, 2008) To take an analogy, individuals do not buy media products (goods and services) for the actual medium or technology itself (i.e. the actual printed copy or online media platform), but for the service it renders – it satisfies specific needs and provides experiences (cf. Arrese Reca, 2006; Gummesson, 1995).

While technology and digitalisation play a key role in presenting new business opportunities for media, the key source of competitiveness is in the phenomenological experiences and benefits that the new product-service offering provides for the users, taking account their specific contexts in which the use takes place (Vargo, 2008). As customer needs become more demanding due to ever increasing amount of choices, no company is able to deliver a service alone; the delivery of complex services necessitates the use of resources from business networks (Frow et al., 2014; Cusumano and Gawer, 2001). It means media management gradually departs from the gathering, creation, delivering, packaging, and storing of information products in value chains (Picard, 2002), into managing the integration of resources, offering, platforms, partners, and payment mechanisms to offer and maintain a 'flow of service' in value networks (Lusch and Vargo, 2008). The role of *platform leaders*, who enable the industry to innovate in better ways, influence future designs and take responsibility of managing the needed networks becomes increasingly important (Cusumano and Gawer, 2001). It also means the ability to see services

increasingly as value-adding to media products, rather than add-ons (Gebauer, Fleisch and Friedli, 2005; Oliva and Kallenberg, 2003). The movement is from the creation and delivery of product-focused services (e.g., special advertising solutions that monetize reach/exposure) towards the orchestration of use-oriented services (e.g., premium content archives that monetize the access for a specified time period), and result-oriented services (e.g., outsourcing services that monetize the achievement of pre-defined service outcomes) (cf. Gaiardelli et al., 2014).

To consider these transformations taking place in the media sector, the business model becomes a useful concept. Technology is an enabler for digitalisation, which is an enabler for business model innovation. Not only can a business model be used as a blueprint to describe how organizations function (i.e. as a static model), it can also be used as a tool to address change that concern entire industries (i.e. as a transformational model) (cf. Demil and Lecocq, 2010). The latter approach is the starting point in this study. We propose two groups of research questions to guide our work:

(1) *What kinds of changes are going on in the business models of the traditional media sector?*
(2) *How do these changes contribute to the understanding of business model innovation from a traditional manufacturing logic to a service-logic both in the business model framework itself and in a specific industrial context?*

From now on, we have structured the paper as follows. In the second section, we briefly summarise the literature on issues related to managing the transformation towards service business. In the third section we analyse service business models, and present the main differences between the traditional manufacturing-based business model and service-based business model. The context and methodology of our empirical study will be presented in the fourth section and the results in the fifth section. We end up our paper with the concluding discussion.

2. Literature of managing the transformation towards service business

Technological change and digitalisation have led to increased global competition and to the commoditization of product markets. Firms with decreasing product margins and lesser ability to differentiate themselves from competitors increasingly turn to services (Matthyssens and Vandenbempt, 2008; Oliva and Kallenberg, 2003; Reinartz and Ulaga, 2008). In the Western markets the share of the service sector from overall production and employment today is over 60 %; in the U.S. over 80 %, the U.K. 75 %, and Finland 70 % (Toivonen, 2015). Managing the shift to services

however necessitates a new strategic direction and the development of service-based business models, because the transformation is a challenging process and extremely bound to the firm's specific context (Kindström, 2010). Resources and capabilities that underpin service innovation differ to a great extent from those related to traditional manufacturing (Spring and Araujo, 2013; Ulaga and Reinartz, 2011). Hence, servitization is less common for smaller firms (Neely, 2008) largely because SMEs have limited resources to internalize knowledge and keep up with the rapid pace

of technological change, both of which are essential for service business model innovation. Service business model innovation involves the leveraging of resources from business networks. (Kowalkowski, Witell and Gustaffson, 2013)

The success in servitization usually mandates the establishment of a clear service strategy, because not only does it enable firms to grasp new service innovation opportunities, but also to execute appropriate organizational arrangements (Gebauer, Fleisch and Friedli, 2005) and recognize the financial potential and benefits in service business (Mathieu, 2001; Oliva and Kallenberg, 2003). The selection of a service strategy – particularly when it comes to SMEs – is fundamentally influenced by the external factor in which the firm operates: (1) the extent to which the product-service offering delivers competitive advantage to sustain profitability and margins; (2) the number of customers and the specificity of customer needs; (3) the internal organizational elements (such as prevailing corporate culture, human resources practices and reward systems, and organizational structures); and (4) the power and position of the firm in the ecosystem (Gebauer, Paiola and Edvardsson, 2010).

Establishing a long term goal and view on how to succeed in service business (i.e. a business strategy) and a map of how to reach that goal (i.e. a business model) (see also Osterwalder and Pigneur, 2005), should follow the question of why is the shift being made. Literature proposes four general motives for organizations to enter service business – financial, changing customer needs, competitiveness, and issues related sustainability (Baines et al., 2009; Neely, 2008; Oliva and Kallenberg, 2003; Raddats and Easingwood, 2010). These motives or drivers with appropriate references are presented in more detail in Table 1.

Regardless of the various drivers and perceived benefits from servitization, literature also suggests that successfully entering into service business is a great challenge. This is particularly the case in the early stages of servitization when firms still find it difficult to redesign the principles that underpin traditional manufacturing (Baines et al., 2009; Gebauer and Fleisch, 2007; Grönroos, 2007). Servitization is a fundamental change, because it requires the alteration of the strategy, business models, the offering, capabilities, business processes, mind-sets, and corporate cultures (see e.g., Gaiardelli et al., 2014; Neely, 2007, 2008; Oliva and Kallenberg, 2003). Taking an example, sales people may resist services because they come with lower price-tags compared to products, and customers may find it hard to buy results rather than product ownership (Neely, 2008). This is particularly a challenge to the media sector, where the dominant logic has been on the production and monetization of 'stars'; i.e., mass

media products that are able to draw large marketable audiences (Arrese Reca, 2006; Küng, 2007). Hence, a shift to service business requires changes both at the seller and the buyer sides (Kowalkowski, 2011). Take the sales of advertising space and airtime as an example: both media and marketers have locked-in to the common audience information systems – the official currencies that measure the reach and impact of each media product.

A common motive for businesses to enter service business is the expectations of higher returns (Gebauer and Friedli, 2005) – this is also a key motive for traditional media that have reached maturity and in many cases decline (Picard, 2002). Services are added to the media portfolios to increase the contact with the customer in the hopes of increased customer loyalty (Picard, 2005). There is however a downside for these widespread drivers, also known as the service paradox. Service paradox refers to a phenomenon where firms with high hopes for increased returns invest a great deal of resources in service business, but may actually find it difficult especially in the early years to make sufficient profits or higher returns due to increased costs (Gebauer, Fleisch and Friedli, 2005; Reinartz and Ulaga, 2008). Neely (2008) was able to demonstrate in his study that more servitized firms may in fact be more inclined to declare bankruptcy and be less profitable than pure manufacturing firms. He offers two explanations for this: (1) moving from products to services increases diversification, risks and investment needs; and (2) firms with financial difficulties enter into service business in the hopes of a better future, which makes their effort more likely to fail.

Because of the abovementioned motives and challenges, the issue of how to redesign the business model so that it functions as a tool for the focal company to depict managerial opportunities (Nenonen and Storbacka, 2010; Zott and Amit, 2010) and make the necessary changes (Demil and Lecocq, 2010) becomes topical. The following chapter discusses these issues.

2.1 Summary of the literature on service-based business models

Innovating the business model towards services increases complexity. This is particularly the case when the value proposition and the offering are extended into more comprehensive service solutions where the opportunities for business model innovation are greater. (Visnjic and Neely, 2013) Generally, this means moving from product-oriented services (i.e. services that support the functioning of the product that are priced individually), towards use-oriented services (i.e. services that support customers' processes that are priced based on product use), and result-oriented services (i.e. services that support customers' business that

Table 1: Literature review on the key drivers behind servitization

Business model	Baines et al. (2007)	Brown, Gustafsson and Witell (2009)	Cohen, Agrawal and Agrawal (2006)	Gebauer, 2008	Gebauer and Fleisch (2007)	Gebauer and Friedli (2005)	Kowalkowski, Witell and Gustafsson (2013)	Levitt (1976)	Malleret (2006)	Neely (2008)	Oliva and Kallenberg (2003)	Palmatier, Gopalakrishna and Houston (2006)	Reinartz and Ulaga (2008)	Sawhney, Balasubramanian and Krishnan (2004)	Suarez and Cusumano (2009)	Wise and Baumgartner (1999)
Economic motives																
Stagnating product sales				×												
New source of growth as business matures				×							×			×		×
Pursuit of higher product/profit margins		×		×		×										×
New business model and revenue source											×					×
More resilience against economic cycles			×		×				×		×					
Steadier flows of revenue		×	×			×										×
New revenue over lifetime of use																×
Sizeable opportunities in service markets				×												
Customer needs																
Customers' increased demands for services							×									
Customization and higher quality offerings							×				×					
Customers outsourcing non-core activities			×							×	×		×			
Customers reducing supplier base							×									
Competitive motives																
Differentiation from competitors	×				×	×					×					
Facilitation of product sales															×	
Reduced need to compete based on cost										×						
Stronger relationships with customers	×				×							×				
Increased customer loyalty	×							×	×							
Competitor lock-out								×								
Improved company image									×							
Sustainability																
Reduced consumption and environmental impact of products	×									×						
Job creation	×															

are priced based on achieved service outcomes) (see e.g., Gaiardelli et al., 2014; Toivonen, 2015). For example, consider *Kone Corporation* whose revenue already in the 1970s was divided somewhat equally between product sales (i.e. elevators and escalators) and product-oriented service sales (i.e. maintenance and modernization of the machines). Today, Kone's value proposition is concerned with 'people flow' and the strategy increasingly tapping on opportunities provided by digitalisation. Kone pursues more comprehensive service solutions in cooperation with a greater number of ecosystem partners to optimize the use of elevators and enhance the service experience relying heavily on IoT (Internet of Things) technologies; smart components, cloud platforms, data and data analytics, to name a few.

When the scope of the service provision is broadened, the relationship with the customer builds tighter enabling growing revenues but also increases complexity and risks (Visnjic and Neely, 2013). Hence, effectively implementing a new strategic direction necessitates strong managerial motivation and organizational arrangements that support the shift (Gebauer, Fleisch and Friedli, 2005). The shift to customer-centric solutions is first and foremost an internal organizational challenge, and as such demands for the development of new service-based business models (Kindström, 2010). The business model concept is a useful tool because not only does it present an understanding of how the business works and what is the firm's position in the market (Osterwalder and Pigneur, 2005), but also the way in which business is transformed (Demil and Lecocq, 2010). Transforming a business towards services is an evolutionary rather than radical change (Oliva and Kallenberg, 2003; Vladimirova, 2012).

Following Teece (2010, p. 173), 'a business model articulates the logic and provides data and other evidence that demonstrates how a business creates and delivers value to customers. It also outlines the architecture of revenues, costs, and profits associated with the business enterprise delivering that value.' The value perspective is typical in studies on the business model concept (e.g. Afuah and Tucci, 2003; Chesbrough and Rosenbloom, 2002; Johnson, Christensen and Kagermann, 2008). It is increasingly recognized that customer value cannot be separated from business value; the former is a necessary precondition for the emergence of the latter. Taking Kone Corporation again as an example, better understanding of the customer journey has become the core element of their service business model innovation.

This study uses the service-logic business model framework (Viljakainen, Toivonen and Aikala, 2013; Viljakainen, 2015), to explore and explain the transformation taking place in the media sector. This framework uses Osterwalder and Pigneur's (Osterwalder, 2004; Osterwalder and Pigneur, 2005, 2009) business model canvas that is grounded to the traditional manufacturing perspective as the starting point, and integrates it with the perspective of S-D logic. S-D logic is a managerial worldview that highlights the role of customers in value creation. It suggests that institutions do not gain sustainable competitiveness when focusing on the delivery of output (goods and services), but when engaging themselves in value co-creation with customers and other stakeholders in ecosystems. Hence, whereas the business model canvas considers how firms create value (embedded in products) and deliver it though value chains, the service-logic business model discusses the process of co-creating value in ecosystems (Viljakainen, Toivonen and Aikala, 2013). In other words, the former focuses on how to create and deliver products and services to maximize profits, the latter on the process of how to use products and services as vehicles to create phenomenal experiences that lead to customer loyalty and increased financial returns.

Both the original and the new model recognise the four main components of a business model: the resources of a firm, value proposition, market characteristics and revenue model (cf. Seppänen and Mäkinen, 2007). In the service-logic model, the component of market characteristics (i.e. customer interface in Osterwalder's model) is replaced with value co-creation, and the resources of a firm (i.e. infrastructure in Osterwalder's model) with the resources of the ecosystem. This way the traditional value chain –thinking is replaced with a view according to which customers and various groups of partners are important actors in both value co-creation and resource integration from the ecosystem. Applying the two concepts increases the understanding of the transformation taking place in the media sector from a traditional manufacturing logic towards service-logic. (Viljakainen, Toivonen and Aikala, 2013) The key components of the two concepts and their interdependence are presented in Figure 1.

Value proposition crystallises the way in which a company aims to contribute to the value creation of the customer, and consequently to generate value and new resources for itself (Demil and Lecocq, 2010; Vargo and Lusch, 2011). In traditional product manufacturing a value proposition often acts as a proposal for a specific type of offering whereas in service-thinking the role of value proposition is to offer an opportunity for partners in the ecosystem to integrate resources in value co-creation (Frow et al., 2014). Hence, the value proposition in service-logic business model acts a mediator in the continuous interaction between ecosystem resources and value co-creation emphasizing that value is created *with* the customer, whereas Osterwalder's model relies on the value-chain thinking where firms create value *for* the customer (illustrated with arrows in Figure 1). Service solutions deliver desired outcomes
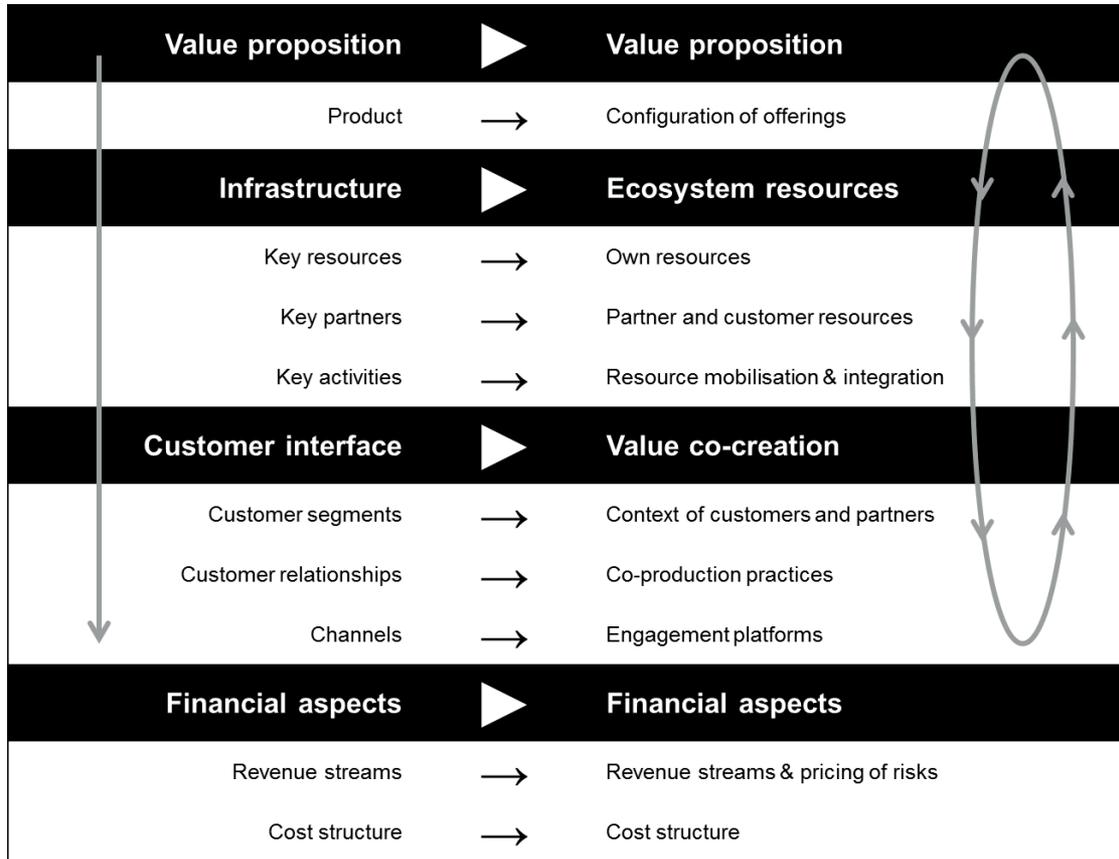
Figure 1: Transformation from a traditional manufacturing logic to S-D logic business model

for customers and often include products and services gathered from different vendors (Lightfoot and Gebauer, 2011). The configuration of offerings is therefore tightly linked to value proposition; a successful customer experience is planned by the service provider (Edvardsson, 1997; Ramaswamy, 2011).

Resources of a firm in the traditional manufacturing model consist of key internal resources, key partners, and key activities. However, when business is transformed to the offering of customer-centric solutions the locus of attention becomes resource integration from networks that cross traditional industry borders since no single organization is able to possess all the necessary resources to deliver complex services (Frow et al., 2014; Normann and Ramirez, 1993). This means that resources are mobilised and integrated from ecosystems in which service providers operate fostering innovation (Nenonen and Storbacka, 2010; Read et al., 2009). Ecosystem is a term that is used to describe the interdependence, adaptation and evolution of the different actors (customers, suppliers, competitors, partners, allies, regulators, etc.) in business networks. Ecosystem thinking shifts the focus away from product and services per se back to the value propositions; value must be created not only for the customer but for

all actors who engage in resource integration (Frow et al., 2014). The service-logic business model therefore deviates from the traditional canvas by acknowledging that resources are more or less valuable depending on how they are being used; using of resources is separated from having resources (Vargo and Lusch, 2004).

Within market characteristics the canvas model looks at customer segments, customer relationships, and distribution channels, emphasizing a value-chain view. The service perspective focuses on the context of customers and partners, the engagement platforms, and co-production practices highlighting the active role of customers and stakeholders and the facilitation of this role. The context of customers and partners refers to the situational factors that determine the service-related experience (Lusch, Vargo and O'Brien, 2007). For the service provider this understanding enables customer segmentation based on the use value of service, rather than seeing customers as targets to whom value is sold. Engagement platforms describes the means (e.g. offering, websites, physical stores, online communities) that facilitate the co-creation of value by allowing on-going interactions among firms, their customers and network partners (Ramaswamy, 2011). Co-production practices refer to the actual service process, in which the cus-

tomer relationship is active: customers engage themselves with the firms' production processes (Auh et al., 2007; Lengnick-Hall, Claycomb and Inks, 2000).

The financial issues in service-logic recommend the increasing of efficiency through effectiveness instead of making efficiency primary (Vargo, 2009). In other words, while the focus in traditional manufacturing perspective is on maximizing profits, the service-logic perspective emphasizes the provider's ability to learn: getting better at creating phenomenal customer experiences inevitably lead to greater financial returns (but not necessarily profits). Although a service perspective emphasizes the total financial benefit gained by different stakeholders in service delivery (Fielt, 2012), the service-logic business model concept looks at the business opportunities primarily from the focal company perspective.

3. Data and Methods

This study uses qualitative research, because it enables us to study the phenomena that is constantly changing and evolving in depth (Gephart, 2004). Given the research setting with the aim is to understand how things take place in real-world, a multiple case study research was carried out (Eisenhardt, 1989; Yin, 1994). A multiple case study research strategy enabled us to find patterns across the different organization to improve the validity and generalizability of our empirical findings (Kvale, 1996).

Overall, 50 people were interviewed from three Nordic countries: Finland, Denmark, and Norway. Each face-to-face interview lasted from 60 to 90 minutes. We applied a semi-structured interview method, where the interview themes were decided beforehand but respondents given a great deal of freedom in their responses (Bryman and Bell, 2011; Fontana and Frey, 2005). Also archival material and statistical data on the industry's general development were used from public sources. The majority of the interviewees were from top management and management positions, and the companies they came from were both international media conglomerates as well as small and medium sized enterprises. The sample consists of media firms, media buying organizations, media research organizations, as well as organizations representing the interests of different media. The media firms in this study are largely magazine publishers with media brands that reach large audiences operating both inside and outside their home markets.

The research process and data analysis followed an abductive research process with systematically going back and forth between theory and data. This is particularly suitable when the aim is to discover something new (Dubois and Gadde, 2002). A coding tool was not used, because the aim was to gain a holistic understanding of the phenomena taking place based on the interviewees' responses. The technique used in data analysis was a modification of a matrix format using constructs and occurrences to derive meanings from data (Huberman and Miles, 1994). This technique is applicable when the aim is to reduce and derive meanings from vast amount of data. Our analysis procedure followed the steps introduced by Bryman and Bell (2011) of handling interview transcribes four times using two separate researchers.

4. Research results

In the reporting of our findings, we apply the structure of our service-logic business model (Figure 1). The following sub-sections have been organised according to the four main components of this model; (1) the value proposition; (2) ecosystem resources; (3) value co-creation; and (4) the financial aspects. The analysis uses the framework to highlight the on-going changes in the media sector towards service thinking (cf. Demil and Lecocq, 2010). The overview of our empirical findings discussed in the following chapter is presented in Table 2.

4.1 Value proposition and configuration of offerings

Traditionally mass media products (goods and services) have presented the core unit of exchange for media, and their value has been determined by the journalistic authorities: media firms. The focus has been on maximizing product – and consequently audience – sales. The bigger the reach, the higher the product and advertising revenue. As business is transformed from product manufacturing to the offering of customer-centric solutions, our findings confirm that the focus is increasingly put on the value proposition. A value proposition has increasingly become the centre of attention because media firms must be able to provide new value to their customers by answering the specific customer needs and solving specific customer problems in smaller niche markets. The role of the value proposition is to communicate the opportunity for business partners and other stakeholders in the ecosystem to integrate resources and co-create value, rather than function as a proposal for a specific type of offering. For example, a magazine for women in their

Table 2: Summary of the empirical findings of this study

Value proposition	

Configuration of offering	• Emphasis of stronger value propositions in smaller niche markets
	• Simultaneous exploiting old business while exploring new business:
	  – Reconfigure of current offering with product-oriented services
	  – Extend current offering with use- and result-oriented services
	  – Reconfigure service delivery with new partners

Ecosystem resources	
Own resources	• Media professionals key source of innovation and competitive advantage • Strong brands core resource in ecosystem transactions and revenue logic
Partner & customer resources	• Partnerships within and cross traditional media industry borders • Partners' products, services, channels, brands, and competencies tapped as resources
Resource mobilization & development	• From autonomy and silos to cooperative and coopetitive relationships • Breaking loose from traditional industry practices and proprietary knowledge • Changing corporate cultures towards openness and fostering of innovativeness
Value co-creation	
Context of customers & partners	• Emphasis on the value of media in context away from pure exposure and reach • Focus on how to concretize, measure, and monetize B2B and B2C service experience
Co-production practices	• Producers, customers, and partners actively shaping their experiences • Jointly creating the service through experimental development
Engagement platforms	• Empowerment and engagement of people in online communities and offline events • Different platforms create one story around a strong value proposition
Financial aspects	
Revenue streams	• Revenue gathered from a greater number of smaller service streams • Mark-up and fixed fees in product-oriented services • Monetization of usage, performance, or agreed outcome in use- and result-based services
Pricing of risks	• Complex services expose media firms and their partners to increased risks • Risks to be identified, measured, managed, and incorporated to offering price
Cost structure	• Declining product business driving towards cost-reductions and standardization • Cost structure depend on selected service strategy

thirties promising to solve the problems of women in their thirties, and a fashion magazine offering not only the latest trends but also means to buy the fashion items. Hence, media brands today increasingly promise to solve specific problems and provide benefits to the specific needs, rather than offer quality content created by journalistic authorities.

In declining legacy markets, media firms now face the challenge to innovate new business while making sure not to cannibalise the old business. Hence, to enhance the value proposition of their existing offerings which

still brings the majority of turnover, media firms have three options: (1) to reconfigure the offering; (2) to extend the offering; and (3) to reconfigure value delivery. Reconfiguring the current offering refers to the efforts to increase its value for existing customers. For example, media firms providing special advertising solutions to marketers or solutions that facilitate the shopping of advertised products to consumers. Product-related services such as these seem very common in the media sector, and are gathered around the same old value proposition. The second option refers to extending the offering with a more comprehen-

sive value proposition, where products and services are seen more as vehicles for service provision rather than the end output itself. For example, extending the time period for online media content and services access (such as content archives), increasing the scope of activities by offering offline events on special topics for consumers and partners (i.e. event production), or guaranteeing and monetizing service outcomes such as reaching advertising targets. Digitalisation enhances the opportunities for media to increasingly innovate these use- and result-oriented services. The third option refers to the reconfiguration of the value delivery system, and partnering with organizations that have specialized capabilities to cover own competency gaps. For example, a health magazine publisher partnering with a private health clinic for delivering a more comprehensive value proposition to readers. Consequently, expertise in the configuration of offerings is becoming more increasingly important, because customer satisfaction is pursued via multiple channels with multiple stakeholders.

4.2 Ecosystem resources

As the offered solutions in media business are becoming more comprehensive to enable the answering of new customer needs, products and services are integrated from different vendors to overcome the competency gaps of single media firms. At the same time the competencies of media professionals have become increasingly important. Knowledge and skills are the key competitive advantage for organizations in service-thinking; being empowered to value co-creation they are the main sources of innovation. However, are findings also found signs of some unfavourable developments. Because of competitive pressures and declining product markets, media professional are increasingly seen as replaceable workers that produce standardized products.

Our findings show, that resources necessary to deliver a service are increasingly mobilised and integrated from ecosystems in which media firms operate, where relationships are built long-term and emphasize collaboration and interaction rather than transactions. Not only are partners' products and services becoming potential resources, but also their channels, brands, and competencies. Hence, media are moving away from the tendency to operate autonomously in silos into new cooperative relationships that cross traditional media industry borders. It also means media firms are entering into paradoxical coopetitive relationships of simultaneously cooperating and competing with other media. These relationships are however quite hard to manage, since they require transparency and the sharing of information. The media markets are accustomed to operate in silos with proprietary knowledge, which is most visible in audience informa-

tion systems and the way in which media advertising is bought and sold. These practices are necessary to be changed when entering service-thinking, which is not only a technological, but also a legal, economical, and political process affecting all the institutions that monetize them.

The findings of this study indicate that media firms' growth strategies are increasingly centred on brands, because they enable the exploiting of old legacy business while exploring new business opportunities. Brands and branding are departing from the focus on a single offering to the emphasis of value propositions in ecosystem transactions. Similar findings are also made in other studies (see e.g. Galbi, 2001). A strong media brand with a strong value proposition is increasingly the core resource for media firms, because it increases commitment among both consumers and business partners. Strong brands not only benefit the media firm enabling the monetization of new product-, use-, and outcome-related services, but also the customers who expects their specific needs to be satisfied. This seems to be a rather good development for media firms, since according to our interviews the significance of editorial content is diminishing among advertisers requiring new ways to acquire commitment.

Relevant to the adoption of service-thinking is also an observation of changing corporate cultures. It seems media firms are becoming more open and fostering transparency in communication and work practices, which are relevant when entering service business. Traditional R&D activities practiced behind closed doors are transferring into experimental development in service relationships, and the timespan of launching new products and services is becoming radically shorter. Media firms are aiming to fail faster, which is seen necessary to boost entrepreneurial spirit. According to our findings media companies are increasingly fostering innovation, such as rotating people across editorial rooms and co-developing ideas with users and advertisers.

4.3 Value co-creation

Our findings indicate there is a transfer from authoritarian journalist power to the appreciation of customer engagement in media business – people are empowered to become active in communities. For example, crowdsourcing (i.e. outsourcing part of the work to unknown people) and professional amateurs (e.g. bloggers) are becoming a norm in content creation. Within this transformation, the acknowledgement of the customers' context and the creation of phenomenal experiences that suit that context have come to the fore. This is a fundamental change when entering service thinking: focus is shifted from value-in-exchange (i.e. price per unit sold) to value-in-use

(i.e. a good experience in the use context). A great example is audience information systems that increasingly focus on peoples' touchpoints to media and the role of different media in peoples' lives rather than sole exposure to media (vehicle). Hence, the concretization, measurement, and monetization of the service experience have become central in many ways both in B2C and B2B markets.

Adapting to service-thinking suggests that providers stop considering themselves as producers of value that is embedded in products (i.e. goods and services), but rather see customers and other stakeholders in business networks as co-creators of value. Hence, the emphasis on 'channels' through which value is delivered to customers in the traditional business model canvas is replaced with the idea that service providers create and maintain engagement platforms where producers, customers, and partners are active in shaping their experiences and co-produce the service. Good example of engagement platforms are the online and offline media communities (the latter referring to events) where people and professionals interact on topics related to the media brand's strong value proposition, generating a more intimate relationships between people and the brand. Hence, media firms not only create and manage the engagement platforms, but also develop various co-production practices (i.e. the processes in which the actual service is developed). The different platforms are vehicles through which the one story is build, emphasizing the different role of different media in individuals' lives. The aim of media producer is thus to promote an engaging overall experience across the array of media options, which continues well beyond the actual product purchase.

4.4 Financial aspects

The findings of this study indicate that the revenue in media firms is increasingly collected from services, rather than from a dualistic model of monetizing products and audiences. This is a typical feature in an ecosystems nature of markets. Media firms are aiming to provide attractive value propositions and service offerings to different customer segments despite the growing cost pressures due to declining product markets. Hence, revenue is gathered from a greater number of smaller streams.

Media firms' service offerings are becoming more comprehensive as they gradually move from product-oriented services priced with a mark-up or fixed fee (e.g., special advertising solutions, enriching and monetizing customer register data, on-demand printing, or selling batches of magazines for businesses), towards use- and result-oriented services that are priced based on product usage, performance, or jointly agreed service outcomes (e.g. using own website to drive traffic to another website, monetizing content archives, offering freemium services, brand licensing, building customer account for access to use all products and services, or taking over customers' marketing activities). Within this transformation media firms are taking over activities previously performed by the customer, and the relationships is shifted from transaction-based towards relationships-based.

As media firms begin to offer more comprehensive services, it not only changes the way in which products and services are priced, and the cost structure of the firm, but also increases the risks. This is particularly the case when firms partner with others to overcome their own resource shortages. Innovating the business model by extending the scope of existing offering or reconfiguring the value delivery system exposes media firms to new risks that must be properly measured and managed, as well as incorporated to the offering price. For example, partnering with a private health clinic for creating new value for health magazine subscribers increases the publisher's operational and financial risks that must be properly identified, communicated, managed, and priced.

5. Concluding discussion

Technological advances and digitalisation are enablers for business model innovation in the media sector; they provide the means to offer new value to customers. This is important due to expiring business models that focus solely on monetizing media products and audiences (Küng, 2007). Because of declining legacy business and the commoditization of product markets, media firms are increasingly turning to services to provide new growth, differentiation, and increased competitiveness (Picard, 2005; Rolland, 2003). Media firms seek to exploit the old product business that still brings the majority of turnover, while exploring new business opportunities in the service sector.

The business model framework is used in this study because not only does it help to explore and explain how a business works (i.e. used as a static model), but also how business is transformed (i.e. used as a transformational model) (Demil and Lecocq, 2010). This study focuses on the latter approach, using a service-logic business model framework (Viljakainen, Toivonen and Aikala, 2013; Viljakainen, 2015) to explain the transformations taking place not only in the business model itself, but also in the context of the media sector where business is increasingly geared towards service(s). The business model concept is used, because it facilitates the exploration how this sector is

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simultaneously adapting to a new managerial mind-set where service (singular) is considered as a process of using professional competencies for the benefit of others, and a new competitive strategy offering product-, use-, and result-oriented services (plural) in addition to material products. Two theoretical frameworks are used in this study: the former transformation is viewed through the lens of service-dominant logic (Vargo and Lusch, 2004), and the latter through servitization (Vandermerwe and Rada, 1988).

The findings on the transformations taking place in the media sector are reported in this study under the four generally accepted business model components: value proposition, the resources of a firm, market characteristics and revenue model (see e.g. Osterwalder and Pigneur, 2009; Seppänen and Mäkinen, 2007). The configuration of offering is tightly linked to the value proposition (Edvardsson, 1997; Ramaswamy, 2011). In the media sector this means that actual media offering is increasingly gathered and commercialized around strong brands with strong value propositions. A value proposition becomes the locus of attention, because it enables media firms and their partners to offer new value to new customers in smaller niche segments. With decreasingly legacy business, media firms aim at exploiting the traditional mass media product business while exploring new business opportunities with products-oriented services (e.g. special advertisement solutions or solutions that enable the purchase of advertised items), use-oriented services (e.g. cashing content archives or B2B and B2C event production), and result-oriented services (e.g. taking over activities previously performed by media agencies to offer increased marketing ROI).

Service-thinking emphasizes mobilization and integration of resources from the ecosystem rather than separating resources and activities of the service provider from partner resources (Frow et al., 2014; Lightfoot and Gebauer, 2011). The core of this thinking is that resources are to be seen as more or less valuable depending how they are used, instead of focusing on resource ownership (Vargo and Lusch, 2004). The findings of this study suggest that media firms' knowledge and competencies in value co-creation, as well as strong brands are increasingly seen as core organizational resources, and sources of innovation and differ-

entiation. They are key in partnering within and across the traditional media sector. Building cooperative and coopetitive relationships enable media firms to tap on resources that media firms lack themselves, especially when it comes to more complex use- and result-oriented services. Building new partnerships however necessitates breaking down the silo-based business, changing corporate cultures and openness, as well as breaking away from traditional industry practices and processes with increasing information transparency. As value is increasingly co-created in media business, the focus is shifted from production of output and value-in-exchange (i.e. the price per media exposure) into the role of media in creating good experiences and value-in-use (i.e. the value of service in the customer's use context) (Vargo and Lusch, 2004). The role of the media firm, then, is to build and manage the engagement platforms where value co-creation takes place. Online communities and offline events are good examples of engagement platforms where customers not only experience the service phenomenologically, but also co-produce the service together with others and the media firm. Hence, the different media platforms are increasingly seen as vehicles to build a story that creates an overall good experience.

With a decreasing legacy business that relies on a dualistic revenue structure (i.e. product and audience sales) the new business model increasingly monetizes services that encompass smaller revenues made with an increasing number of partners. Product-oriented services are often priced with a mark-up or fixed fee, use-oriented services based on access to usage, and result-oriented services based on jointly predefined service outcomes (Gaiardelli et al., 2014). Transforming the business towards more complex services not only changes the relationship with the client, but also exposes media firms to more risks that must be properly managed and priced (cf. Visnjic and Neely, 2013).

The findings of this study illustrate how the journey from traditional product manufacturing towards service business and more comprehensive service solutions increases complexity in media business. Entering into services is however seen as a gateway into new competitiveness and growth in this sector, because it allows media firms to create new value for their customers, and hence, business model innovation.

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Attitudes of the European printing industry towards innovative combinations of print and digital

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Abstract

The present study reports a European industry survey of the state and future of innovative printing. In this study, we have defined innovative printing as printed electronics, printed intelligence, printed functionalities, combining print with digital (e.g. providing digital solutions for Quick Response codes or augmented reality), and similar products and services. Experiences and inputs from industry representatives were collected through a survey to provide viewpoints on how print media and packaging could be developed and used in the future and how the industry can utilize this knowledge from the academia for the benefit of their customers and the consumers. Based on the results, it may be concluded that (1) European printing companies do see a possible future in innovative printing, (2) besides the possibility of increased costs, the lack of market demand is the most important factor preventing companies embracing this technology, and (3) in general the approach and vision of the industry is similar across all of Europe. However, Western European printing houses appear to be more active in the field of innovative printing as defined here, whilst in Eastern Europe the technology is currently focusing on special effects and personalized printing, suggesting a possible delay in the implementation of innovative printing technologies as a whole.

Keywords: innovation, printing, Europe, prospective study

1. Introduction and background

Innovation has long been recognized as a key element of economic development. Today there is a great need for understanding the state of the printing industry and providing further direction on this topic that entails both technological and strategic dimensions (Intergraf, 2011). This is due to digitalization and digital transformation and their effect on the consumption of printed products and innovations in printing production. In printed electronics, for example, many segments are not profitable despite having more than ten years of development; however there are some profitable sectors identified such as electroluminescent displays, sensors and conductive inks (Das and Harrop, 2015). Information technology (IT) innovations, such as the Internet, social media, mobile phones and apps, cloud computing, big data, e-commerce, and the consumerization of IT, have already had a transformational effect on products, services, and business processes around the world (Bojanova, 2014). Everything that can be digitalized will be digitalized (CEPI, 2015a), this affects dramatically all businesses and entire industries – and the printing industry is not an exception.

No organisation can opt out from the digital transformation taking place at the moment (Viljakainen, 2015). Companies need to build their own business strategy for digitalization – how to react and benefit from it and what are the concrete actions they should take. Potentially, digitalization will strengthen the existing business, create new business and increase the

value of the products and services (Nurmi, 2015). The winning companies and industries will be those most quickly able to adapt to the digitalized world and fully exploit its opportunities (CEPI, 2015a). The outlook is to move from producing one single product (e.g. a newspaper) towards services and a new value creation and also to relationship building (Viljakainen, 2015; Chan-Olmsted, 2000). For example media companies are increasingly adopting service based strategies as a way to differentiate a firm from its competitors and create new value for their customers. Technological development has led to changes in media consumption habits and eventually it also affects customer needs. The media are experiencing demassification and moving away from homogeneous mass audiences into niche markets (Viljakainen, 2015).

The academic literature concerning innovation is plentiful; many research contributions exist that characterize different aspects and originate from different disciplines, as summarized by Connolly, Gauzente and Dumoulin (2012). They state that in the economic literature the focus has been 'technology push' (attempts to commercialize and increase diffusion of the innovation) rather than a 'demand pull' (user need for the technological innovation). Uncertainty and perceived risk play are important considerations in the perspective of potential adopters and the benefits compared to the existing status quo are not always obvious. Unknown consequences due to the innovative change and general inertia and resistance to change also add to the perception of risk and uncertainty. As far back as 1964, Bright observed that 'Anyone introducing a technological innovation is implicitly or explicitly predicting acceptance and a rate of adoption. Yet a fact of technological history is that many innovations are subject to frustrating delays and deliberate resistances to adoption' (Bright, 1964, p. 171).

Nowadays, the European printing industry has around 120 000 (mainly small sized) companies, employing around 750 000 people for a turnover of about € 85 billion (Eurostat, 2015). According to CEPI (2015b), its members produced 91 million tonnes of paper and board in 2014, out of which 40.5 % is printed. Next to paper and board mills, there are around 630 companies active in the pulp, paper and board industry in Europe (i.e. printers and converters), generating a turnover of approximately € 75 billion and more than 180 000 workplaces (CEPI, 2014).

While the paper and board industry is struggling with stagnation or very slow growth in some countries, many printers are currently facing overcapacity problems, price competition and replacement of print by digital (Intergraf, 2011) which they try to overcome by cutting costs, investment in new technologies and equipment. All respondents of the Intergraf study agreed that the

main investment in the near future needs to be put into gaining new knowledge. New opportunities are seen in the maturing of several important innovations which emerged with time, such as digital printing, printing on demand, 3D printing, augmented reality, and printed electronics. Numerous aspects of printed electronics, important for developments in paper and board as well as printing industry, are discussed in the literature (e.g. Bollström et al., 2014; Pettersson et al., 2014; Määttänen et al., 2010). Adoption of new technologies enables increased productivity, new markets, products and services and opens up opportunities to integrate services along the value chain, and eventually even reduces costs (PMG, 2012).

According to Vehmas et al. (2011), printing houses have not been willing to move to completely new business areas due to large investments and R&D needed for old printing machines to produce totally new products and the risk is seen to be too high to enter new customer markets. There are limited drivers for significant change and new business cannot therefore evolve. However, many actors in the European printing industry recognize the need to develop. Three approaches to survive in the future have been identified in the study: (i) efficient web printing production via flexible production and effective materials usage; (ii) added value for the printed product; (iii) printed non-media products. In all cases customer service, cooperation throughout the print production chain and open communication are needed to succeed.

To be successful, novel innovative solutions must take into account opportunities provided by new technology, but they cannot lose sight of the customers and users (Thomke and von Hippel, 2002). User involvement and co-design have a central role when developing e.g. novel digital services for customers (Vehmas et al., 2015). The shared roles of companies, cooperation partners and stakeholders is also essential – ecosystem thinking has been shown to be very useful e.g. for sharing and piloting the novel innovations. A report by Aistrup (2009) states that collaboration is important as companies cannot handle the cascade of complex knowledge and they should cooperate in complementary innovation networks to expand value rather than simply improving their existing value share.

In addition to digital transformation, also environmental awareness influences the innovations within paper and printing industry. The discussion on mineral oils in packaging has led to an increase in interest in organic printing inks. This focus can also be seen in printed electronics; both organic inks and renewable base materials are part of recent innovations. As an example, Burgués Ceballos (2014) states that 'the challenge of our generation is to move towards a cleaner and sustainable energy model', and illustrates this by

the development of organic solar cells including green solvents and sustainable processing to enable industrial scale-up.

In this study, the goal was to gain a better understanding of the industrial viewpoint, while also promoting discussion between industry and academia on the benefits that may arise from combining print and digital. Because the term 'combining print and digital' turned out to be perceived ambiguously during a preliminary stage of an investigation, the focus of the study was defined as 'innovative printing', referred to meaning printed electronics, printed intelligence, printed functionalities, combining print with digital (e.g. providing

digital solutions for QR codes, augmented reality …), etc., and used throughout the study. Several examples already exist where successful combinations have been applied e.g. through the use of image recognition, augmented reality or printed electronics to bring interactivity into fibre based products. Experiences and inputs are gathered and collated within the study to provide different views on how print media could be developed and used in the future. This should lead to an understanding of how the industry can utilize the information for the benefit of their customers and how the academia can effectively support these efforts, and to an increase in the industry awareness of the possibilities for innovative printing.

2. Methods

A questionnaire was set up to assess industry's opinion on innovative printing, specifically referring to printed electronics, printed intelligence, printed functionalities, and combining print with digital.

Eleven countries representing the different parts of Europe and having the different printing industry characteristics have been selected by convenience for the study, out of which four were categorized as Western European (Finland, The Netherlands, Portugal and United Kingdom) and seven as Eastern European (Czech Republic, Hungary, Lithuania, Poland, Serbia, Slovenia and Slovakia). The questionnaire was distributed to printing companies in their local language in order to overcome any language barriers and to maximize their understanding. In addition, the English version was distributed to respondents in several other countries (including Belgium, Germany, Ireland, Italy, Norway, and Sweden) that were originally not included in the study. The responses from these countries and from Poland are jointly marked as "Other" in the following text as the number of responses per country was too low to analyse them separately. The decision as to which countries were analysed separately (10 countries) and which responses were grouped as "Other" (from 7 countries) was based both on the absolute number of responses and on its ratio to the number of enterprises listed within Printing and reproduction of recorded media category according Statistical Classification of Economic Activities in the European Community, Rev. 2 (Eurostat, 2015), for given country.

2.1 Survey instrument – questionnaire

The questionnaire consisted of six "open and closed" questions (see the Appendix). The first question was designed to define the companies based on for example company size and printing technology. The second question concerned their use of innovative printing techniques, and questions three and four tried to iden-

tify the most important limitations in developing such printing solutions including a discussion of any competitive and financial advantage. Question five gave the opportunity for the industry to express their interest and opinion concerning cooperation with the academia. Finally, the last question requested the opinion of the industry as to which are the fastest growing markets in the area of innovative printing. Intentionally, the questionnaire remained brief in order to increase responses and willingness of companies to participate. Various ways were employed for gathering results (as summarized in Table 1) to optimize the effectiveness of the study and to receive the maximum amount of responses, especially in countries where the target group was relatively small. More detailed answers were possible in personal or phone conversations, on some occasions. In all cases, however, the questions remained the same.

2.2 Sample size and characteristics

The study aimed at a well spread sample size across the European countries. A total of 217 companies participated out of which 77 % originated from five countries (Czech Republic, Hungary, The Netherlands, Portugal and Serbia) as presented in Figure 1a. Size variation of the companies is presented in Figure 1b. Predominantly, the sample was random, and distributed to any printing operation although in some cases it was known beforehand that the printers are working on innovative printing.

Respondents were asked for their industry type by means of an open question. The answers were analysed and grouped into categories. With respect to the aims of the study, *Digital printing*, *Security printing* and *Innovative printing* were treated separately. This separation was done to stress that our interest was especially in innovative printing as defined above and not in digital printing or security printing as such. In addition,

Table 1: Survey instrument where A – Posted on a web portal, B – Link distributed by e-mail to general contact addresses, C – Link distributed by e-mail addressed to company representatives, D – With a previous phone contact with the company representative

Country	Online questionnaire	E-mail questionnaire	Phone conversation	Personal conversation
Czech Republic (CZ)	✓ (B, C)		✓	
Finland (FI)	✓ (C)			
Hungary (HU)	✓ (A, C)			
Lithuania (LT)			✓	✓
The Netherlands (NL)	✓ (A, C)			✓
Portugal (PT)	✓ (D)	✓ (D)		
Serbia (RS)	✓ (D)		✓	
Slovenia (SI)		✓		
Slovakia (SK)	✓ (A, C)			
United Kingdom (UK)	✓ (A, C)	✓		
Other	✓ (A, C)	✓		
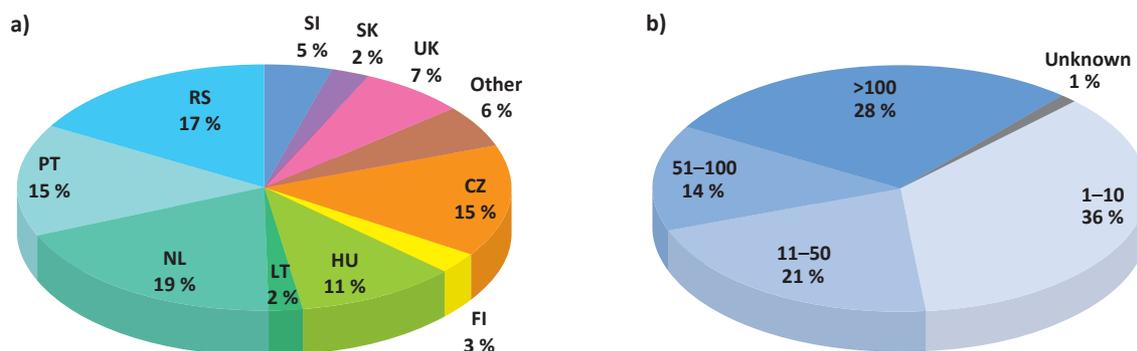
Figure 1: Respondents' country of origin (a) and number of employees amongst the respondents (b)

there was a separate group for *Packaging*, covering packaging production and printing. The *General printing* category groups all the other types of printing production, from commercial printing over books, magazines and newspaper printing to textile, decoration and other printing. Furthermore, the *General trade* category represents sales offices, wholesalers and all kinds of printing industry suppliers, while *Services* include advertising, marketing, mailing, e-commerce, design, media and publishing. The final two separate categories are dedicated to *Paper and board production and converting* and to *R&D and education* including consultancy. The *Other* category mostly encompasses brand owners and other manufacturing. In *N/A* respondents who did not specify the industry type are classified or where the specification is not clear.

2.3 Representativeness of the sample

The total amount of responses is considered to be insufficient for quantitative analysis. However it was decided that it would probably be impossible to reach the target number of respondents from each country, as the target responders were busy industry personnel. Nevertheless, as the authors monitored the survey progress it appeared likely that a larger sample size would give similar results as the patterns in the current results for 217 respondents are very close to those obtained with half of this number at an earlier stage of the research. It can be concluded that the survey results are a fair representation of the printing industry throughout Europe. The method of assessing the representativeness of a sample is very similar to the method that Greener (2008) recommends. In cases where there are concerns with the representativeness of the sample, it is possible to test the statistical difference between the sample and a larger data set. When no relevant statistic difference exists, the representativeness of the sample is more robust (Greener, 2008). Further, the relative sample size in individual surveyed countries has a good correlation with the number of enterprises listed within the "Printing and reproduction of recorded media" cate-

gory according to Statistical Classification of Economic Activities in the European Community, Rev. 2 (Eurostat, 2015), with the exception of responses from the countries grouped under Other, UK responses and partly the Czech Republic responses.

With regards to the size of the companies, the respondents came mainly from small companies with 1–10 employees (36 %). Nonetheless, other categories of company size are also sufficiently represented. In absolute numbers, Serbia, The Netherlands, Portugal and the Czech Republic had the highest representation of smaller companies (1–10 and 11–50), while the larger companies were mainly from Hungary, and from the Czech Republic (Figure 2).

The respondents also provided a diverse representation of industry types, ranging from different areas of printing, through packaging and paper & board, to general trade, services, R&D and education. Figure 3 shows the variety of printing technologies that the survey participants employ. This clearly identifies digital printing (named in general or as electrophotography or inkjet printing in particular, in total listed by 134 respondents) along with offset lithography (used by 128 respondents) as the most popular printing techniques. From the main printing technologies, gravure printing is shown as the technique that the participants use the least. Further, the respondents listed the use of pad printing, sublimation printing, letterpress, intag-
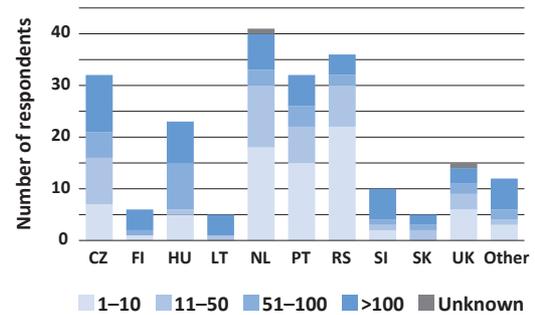
Figure 2: Representation of the participating companies per size (number of employees) per country

lio, heat transfer printing, plotters, nozzle deposition, slot-die coating, CNC (Computer Numerical Control) cutting, laser engraving and cutting, hot embossing, and hybrid technologies. In case of 10 % of respondents, the question concerning the printing technology employed was not applicable or they did not answer.

In respect to the substrates used, the most common was printing on standard paper grades, employed by two thirds of respondents, followed by plastics and flexible foils, card and board, specialty papers and other. Slightly more than one third of respondents use special printing inks, generally various "effect inks" were listed when specified, with conductive inks being the least common.
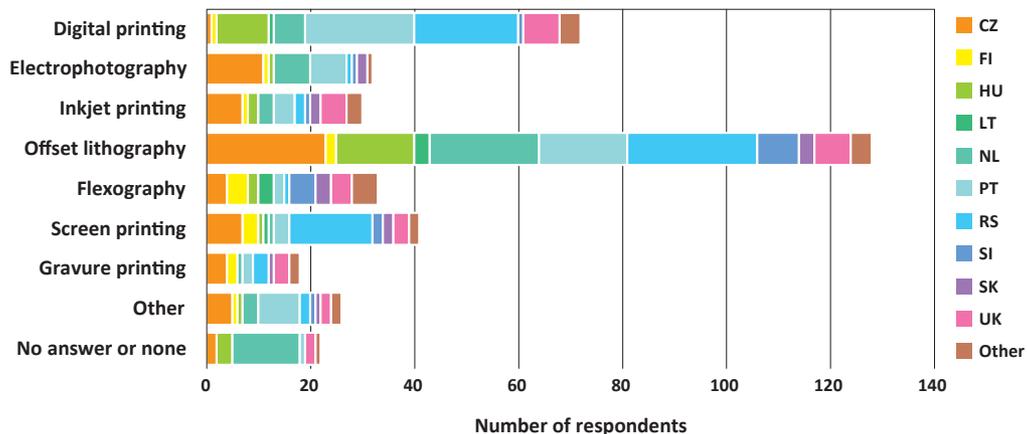

Figure 3: Printing technologies employed by the respondents

3. Results and Discussion

3.1 Involvement in innovative printing

During the past years, the printing industry has experienced many changes, such as consolidation and closing overcapacity. However, printing houses still have a strong belief that printed media products will prevail,

but they also understood that some changes need to be implemented to survive (Vehmas et al., 2011).

Based on the results from this study, 41 % of the respondents offer innovative printing, while 48 % not yet do so (Figure 4). The results indicate that print-
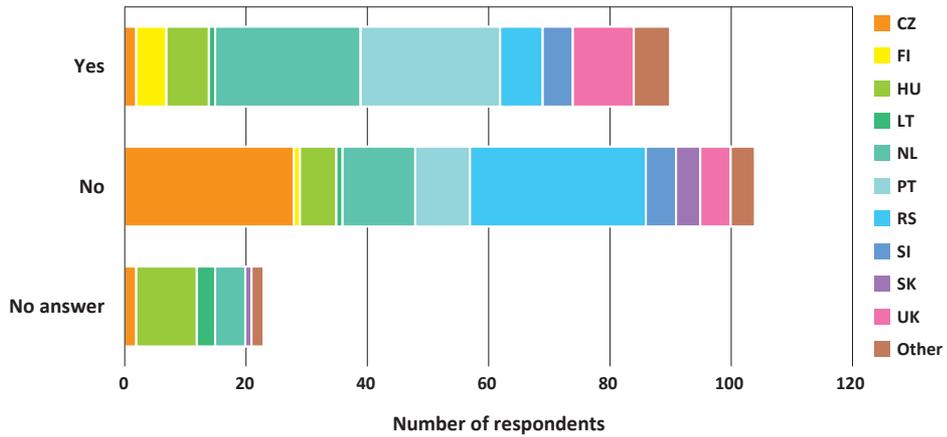
Figure 4: Responses to the question 'Are you involved in innovative printing?'

ing houses in Western Europe are more active in this field, with 66 % of respondents claiming involvement in innovative printing, while innovations utilized today by printers in Eastern Europe mainly comprise "special effect" and personalized printing and only 20 % of respondents declared the implementation of innovations related to combining print with digital, printed functionalities and similar. The result shows a considerable delay in implementing technologies related to printed functionalities and combining print with digital in Eastern Europe.

When analysing the responses in more detail, the products listed as innovative in some cases do not conform to the definition of innovations surveyed, and vice versa – some respondents listed products fulfilling the definition although they did not claim involvement in innovative printing. There is no clear reason why this was the case; it might be that the term is ambiguous and more discussion on the term or demonstrators are needed to increase understanding. If these definition corrections are considered, the splitting into Western and Eastern countries becomes less obvious and, in total, only 21 % of respondents are active in innovative printing. It is

possible that the real number can be higher due to the reluctance to list the innovative products, possibly due to confidentiality issues. On the other hand, it is also important to note that – with only a few exceptions – the innovative products are not the respondents' core business, regardless of the location of the company.

When examining the declared involvement in innovative printing from the viewpoint of company size (Figure 5a), the most active are the biggest and the smallest ones with 48 and 47 %, respectively. If the above mentioned corrections based on listed innovative products are applied (Figure 5b), the pattern is similar, but the differences across individual company sizes are less pronounced and the values representing respondents active in innovative printing are close to 20 % for all sizes.

The engagement of enterprises in innovative printing was also analysed from the perspective of the type of industry (i.e. how the respondents characterized themselves) in order to assess whether certain industries are more prone to using innovative printing (Figure 6). By examining Figure 6a it is possible to determine an
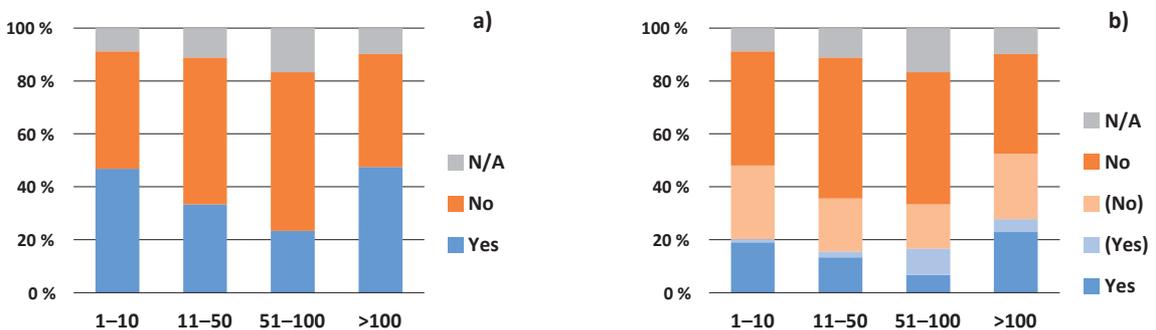

Figure 5: Responses to the question 'Are you involved in innovative printing?' according to company size (number of employees) (a) and these claims corrected on the base of innovative products listed by respondents – designated in round brackets (b) where (Yes) indicates a negative answer but innovative products, and (No) indicates a positive answer whilst the products listed show no innovative printing
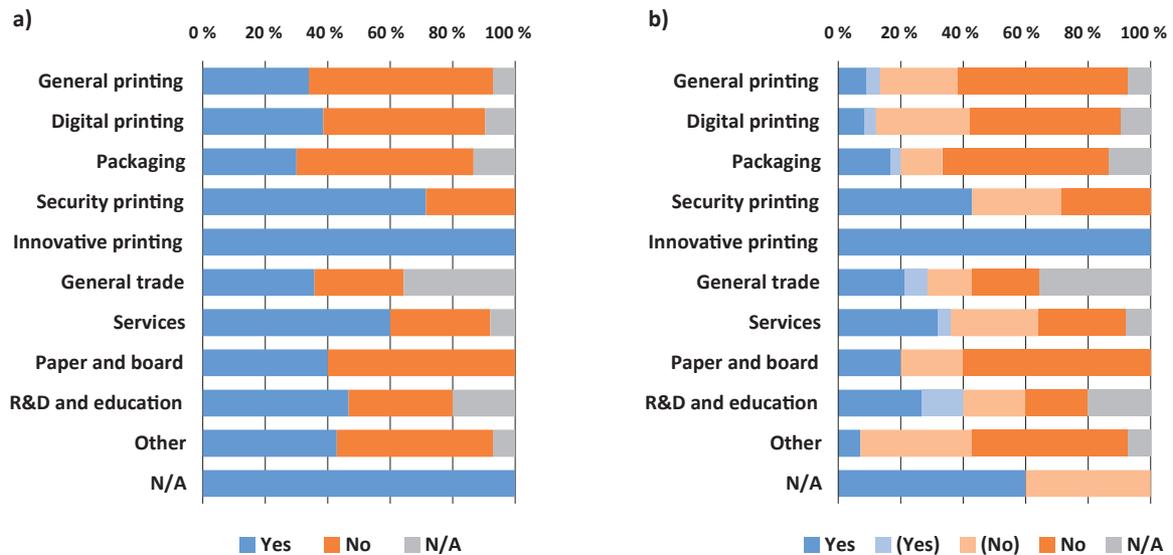
Figure 6: Responses to the question 'Are you involved in innovative printing?' according to self-stated industry types (a), and these claims corrected on the base of innovative products listed by respondents – designated in round brackets (b), where (Yes) indicates a negative answer but innovative products, and (No) indicates a positive answer whilst the products listed show no innovative printing

irregular distribution of the use of innovative printing among different industry types. The data show a higher involvement in innovative printing by companies who categorize themselves as offering Innovative printing, Security printing or Services with percentages of 60 and more. This is not surprising because these companies are considered to be forerunners compared to the others, and they know better to which category to put their products as they are more familiar to the definitions. Along with Innovative printing category, also all of the respondents who did not specify which industry they represent claimed involvement in innovations. On the other hand, General printing and Packaging industries register the lowest rates (circa 30 %) of engagement with innovative printing.

Especially in the case of packaging, the result was not expected, as there are some examples on the market especially on innovative printing and packages. When again applying the above mentioned corrections based on the listed innovative products (Figure 6b), the companies classified as Other and Digital as well as General printing are the least active in implementing innovations with circa 10 % response. However, Packaging industry remains on a very low level in Figure 6b as well.

Among the products of the companies dedicated to Innovative printing, products such as transistors that can be used for displays or sensor applications, smart packaging and labels, toys, microphones, (biological) sensor strips, strain gauges, photonics, batteries, NFC (Near Field Communication), hybrid structures with conventional electronics, light emitters, freshness indicators,

safety gas detectors, printed batteries, printed antennae, printed sensors, printed thermogenerators and other printed electronics were listed. It must be pointed out that only five respondents fall into this category, which highlights the versatility of their production. In case of respondents without a clearly specified industry type, e.g. RFID labels and products with electronic properties were listed. Overall, the implementation of innovations combining print and digital was very rare.

3.2 Limitations to innovative printing

The perception that companies have of the limitations of these innovations seems to be generally homogeneous throughout the participating countries. The most important limitations to utilizing the possibilities offered by technology development are the increased costs, related namely to new equipment, new skills or training of employees, and the lack of market demand (Figure 7). In this context, the costs on customer side were mentioned as well as previously identified by Vehmas et al. (2011). The lack of market demand was stressed by many respondents as the key factor. The responses of the participants showed that in the great majority of cases, the companies expressed that their customers are exerting little or no pressure for innovative printing.

About one third of the respondents (35 %) did answer that the specialties are beneficial to the company's turnover through gained competitive advantage and increased margins, while slightly more respondents answered they are not (38 %) and 27 % left this question unanswered.
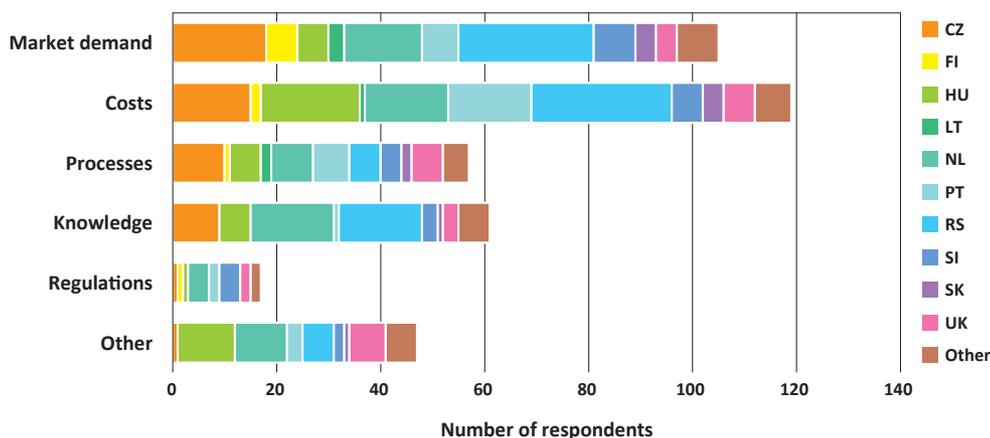
Figure 7: Limitations to use innovative printing as perceived by the respondents

3.3 Future potential

The last question of the survey, asking about the fastest growing markets in this sector, was answered by two thirds of respondents – however, often expressing their uncertainty. Therefore, in addition to the one third who did not respond at all, almost 40 company representatives were simply answering that either they do not know, have no opinion/idea or are not sure, or in some cases replied they don't see any potential growth. A typical answer being '*I do not see really innovative products on the market – just in the research companies.*' [country: SI; number of employees: 51–100; main technology: offset lithography and flexography; in the following text, the company characteristics are given in the same format]

When analysing the input from the rest of the respondents to this last question of the survey, some answers were nonspecific, for example '*Exciting, offering new added value opportunity to those who engage.*' [USA; > 100; N/A (supplier)] From the other respondents, packaging and labels were mentioned most often, sometimes specified as functionally enhanced, smart, small scale, personalized, many times as food packaging, also for pharmaceutical industry, cosmetics, alcohol and supermarkets. [CZ, LT, NL, PL, PT, RS, SK, UK; all size categories; various printing technologies or their combinations or N/A (R&D)] Printed electronics was the second most frequent one, where e.g. printed active circuits, flexible electronics, biosensors, printed photovoltaics, the wearables market for flexible displays, RFID or product identification in general, as well as NFC were listed among markets perceived as growing. [CZ, FI, NL, PT, SI, SK, UK; all size categories; various printing technologies or their combinations or N/A (R&D)] Further, security issues, such as product security properties and protection and authentication documents were named in a few cases. [CZ, FI, PT; 1–10, 11–50, > 100; various combinations of all main printing technologies except screen printing]

Applications, which were listed only once, comprise e.g. special effect inks, hydrophilic, conductive or heat resistant coatings, graphene/silicene applications, nano taggants and medical industry products. In addition, the production and use of intelligent paper (paper with intelligence inside or on the surface that can be read by smart phones) was listed by one respondent, as well as cloud printing, augmented reality, QR codes, valued information and big data tools, or more generally digital media and multichannel communication. On the other hand, one response says '*While ago I thought AR but that doesn't seem to get popular due to lack of standards.*' [NL; 1–10; N/A (services)] Several respondents mentioned different marketing applications, among which printing technologies, 3D printing and inkjet, or generally digital printing appeared more often.

Some company representatives see the general limitations of growth, mostly connected to the lack of market demand and financial issues, on the side of customers, and this attitude does not depend on company size or country of origin: '*It exists only in specific contracts or work.*' [PT; > 100; offset lithography, digital printing], '*It will take some time that our customers accept novelties.*' [SI; 11–50; flexography], '*It all depends on the financial power of customers, which however is weak.*' [PT; 1–10; N/A (equipment sales)], '*We think that some of technologies are going to appear quite soon on some products. But of course, depending on financial means, that users will devote for development and usage.*' [SI; > 100; offset lithography, screen printing, flexography, digital printing], and '*The cost of new technologies always ends up having an important enemy, which is the policy final product prices that somehow sabotage their swift use.*' [PT; 11–50; offset lithography, digital printing]

Other respondents answered concerning innovative printing and its consequences for companies: '*Faster is better as it will allow greater supply, greater demand and consequently an improved productivity and competitive prices.*' [PT; >100; offset lithography, digital printing], '*All growth*

must be accompanied by a great knowledge in order to be well supported and consistent. Good training is essential.' [PT; 1–10; N/A (trade and services)], 'This market is a very competitive market, due to the short margins. We always have to be up-to-date to be competitive.' [PT; 1–10; N/A (services)], 'As anything that grows too rapidly, we run the risk of not creating enough competences that can generate true gains and added value.' [PT04; 1–10; digital printing], and 'The field of printed electronics is very interesting. We have to follow trends while in the near future this is going to be our reality. The most important thing is to get appropriate personnel and to find market interesting products for appropriate price. This is the most important for starting new technologies.' [SI; >100; offset lithography, screen printing, flexography, intaglio] These answers show that the attitude towards knowledge as the base of innovation is the same for small and large companies and different industry types.

Both optimistic and pessimistic expectations were presented – 'All growth is always interesting because it implies the emergence of niche markets and new opportunities.' [PT; 1–10; digital printing, offset lithography, gravure printing], and in contrast 'Not a lot as everyone starts a new trend and we all end up in the same boat again!' [UK; 1–10; offset lithography, digital printing] Two answers dealt with situation in particular country, one of which belongs to the first group of none or negative responses – 'In Hungary we don't feel that this is growing.' [HU; >100; offset lithography, flexography, digital printing] The second one gives more information: 'The Portuguese market is very small and the demand for this type of solutions is reduced. Today when we are sought for the use of special inks, use of smells or even

the customization of documents, when the customer becomes aware of the price, it backs down most of the times. Universities will have to play a major role in developing solutions and above all work in partnership with the industry in performing tests in real scenarios.' [PT; >100; offset lithography, digital printing]

Finally, two respondents provided the most informative answers. One says that 'Printed intelligence, in my viewpoint, should be developed and classified in technologies that allow the facilitation and help of informing the consumer about the product/sub-product in itself and its real advantages, and that it will only be valid if the cost/benefit is justifiable, with the exception of people or groups with limitations of a physical or mental nature, in which these technologies allow to facilitate their connection with and their use of the products even if the costs are higher.' [PT, 1–10, flexography, gravure printing] The opinions of the second one include 'There is a broad front of growth and it would be foolish for any company to be all things to all men. … Electronics is ubiquitous, it is in every corner of our lives and we do not even think of it as electronics any more … we merely see its function not its technology. Printed electronics is creeping into corners where conventional electronics has not yet ventured or is not suited e.g. disposable applications on biodegradable substrates for food packaging, smart paper …' [UK, 11-50, digital printing, screen printing] This respondent also made an interesting point that working with customers to develop their products is a good business model 'as many sellers of electronics do not actually manufacture their own products and we believe this will cascade into printed electronics. Other companies are specializing in areas such as transistors, photovoltaic arrays and specialized products such as toys and biosensors. The big markets will not be available to
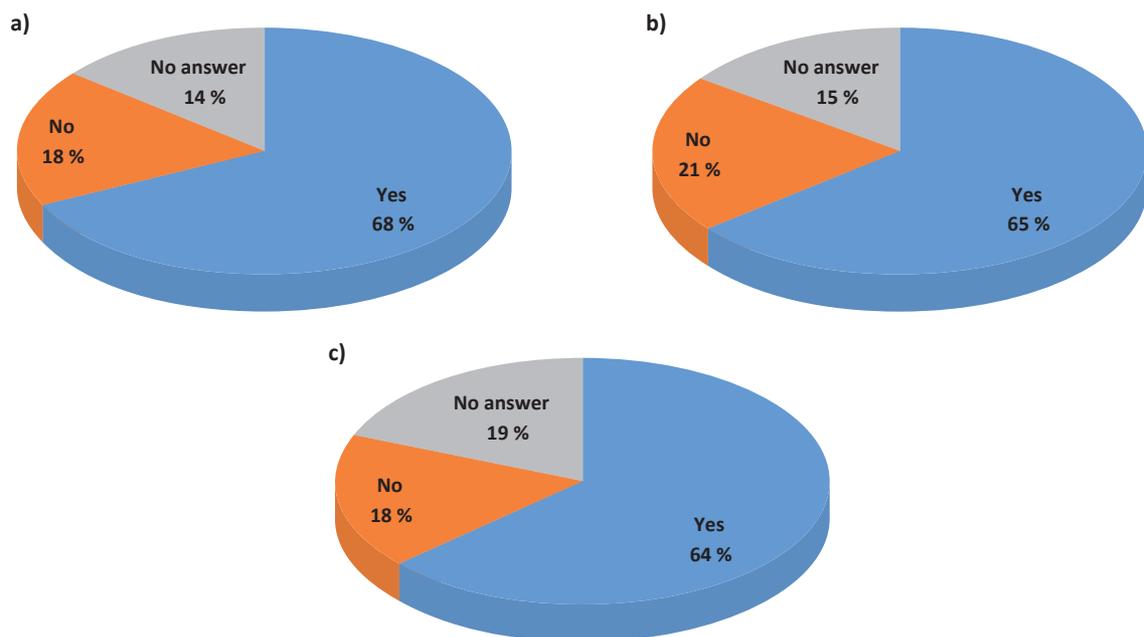

Figure 8: Respondents' attitude towards cooperation with academia – interested in training seminars and short courses (a), in research partnership (b), and in measurements (c)

small companies and will be dominated by the likes of Samsung and Apple who will use the technologies in their own products such as televisions, smart phones etc. However, there will be a supply chain that we can all plug into to develop more specialized products using printed electronics techniques.'

3.4 Cooperation with academia

Printers across Europe are open towards cooperation with academia (see Figure 8), for example by local meetings to discuss relevant topics. The majority of the respondents are interested in training and short courses, would like to participate in research partnerships and believe that the academia plays a valuable part in terms of the availability of specific measurements.

The companies' attitude towards a possible cooperation with academia was examined also from the viewpoint of their size (Figure 9). As it can be seen in Figure 9a, the interest in training seminars and short courses is more important in smaller companies. Although 61 % of companies with over 100 employees demonstrated their interest, all other categories with less than 100 employees had a percentage of 70 or higher interest in academia. Additionally, the number of negative answers increased with the company size from 11 % up to 25 %, most probably due to the group having internal training. With respect to research partnerships, the results are well in line with the earlier mentioned report by Aistrup (2009), arguing that collaboration

is important, is confirmed by the results displayed in Figure 9b. In this case, both positive and negative answers show the companies with 11–50 employees as the most interested, with 73 % and 11 %, respectively. In case of the other-sized companies, around 60 % of the respondents answered positively and approximately 20 % negatively. This may be explained on one hand by the limited (especially human) resources in small companies, more prohibiting them from participation, whereas large companies more often have their own R&D departments, or sometimes don't want to participate due to intellectual property issues. Similarly, the part that academia plays in concrete measurements (Figure 9c) was more valued by companies in the middle categories (11–50 and 51–100 employees) with 69 % and 77 % respectively.

The fact that a significant amount of companies claimed their willingness to closer cooperate with academia might show that the developments and diffusion of innovations are still at the pre-competitive stage. When cross-analysing these answers, only 18 % of respondents did not express any interest in cooperation, while 33 % answered selectively (17 % interested in one option only and 16 % in some combination of options), with 49 % of respondents being at least partially open to all options. Overall, the answers indicate that a great majority of respondents (no matter the extent to which they are aware of new technologies) would welcome more information on this subject.
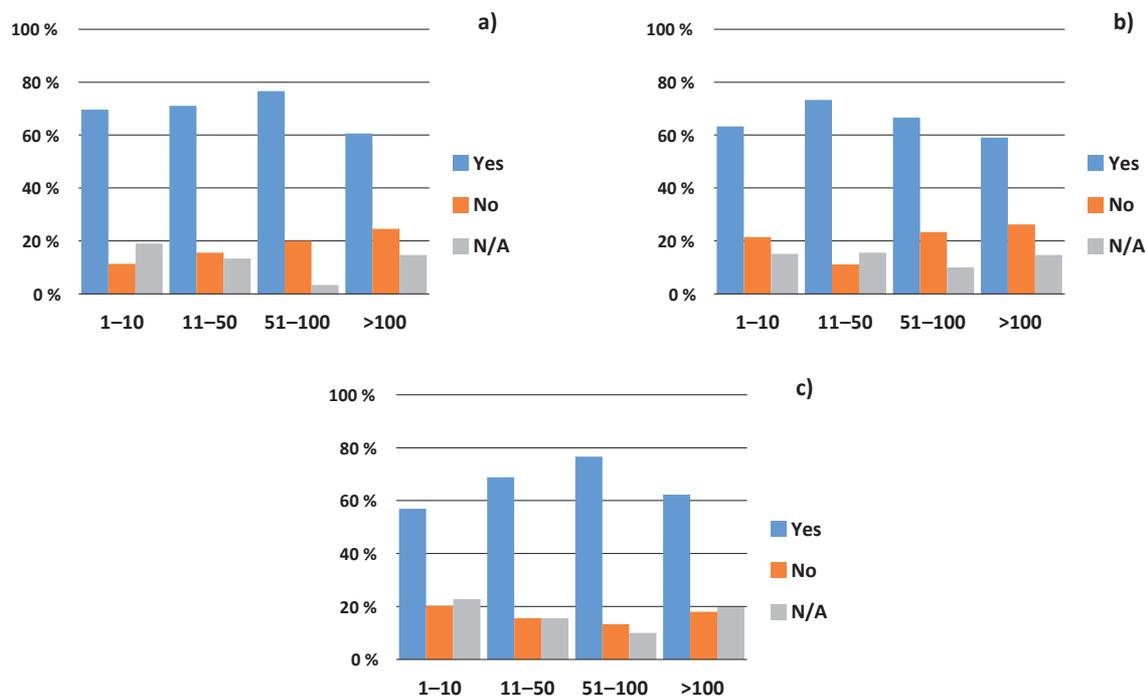

Figure 9: Attitude towards cooperation with academia according to company size (number of employees) – interested in training seminars and short courses (a), in research partnership (b), and in measurements (c)

3.5 Further remarks

The manner of execution of this study – a combination of questionnaire and personal conversation – was shown to work best. Even though personal conversation is subjective, it gives more detail and background information to the answers than an online questionnaire allows. The split between the countries' representation seems to be, predominately, the result of different possibilities to reach the target group, and in part also the different instruments for administering the surveys. In addition, since the printing industry is not the same in each country, it is impossible to target the same amount of responses in each country; on the contrary, it might be considered counterproductive. Finally, some participants just seemed more active and willing to answer. Particularly, participants from Portugal and Slovenia were more open to share their outlook for the future of innovative printing when answering the last question of the survey.

4. Conclusions

This study shows that a combination of lack of market demand with the perception that innovative printing is expensive and complex may be the crux of the investment in this area by the European printing industry. Altogether 217 industrial respondents took the time to reply to the questionnaire, which shows their commitment to the subject and innovation in general. In contrast to the much discussed opinion that the innovative printing market is open mostly for specialized and agile companies outside printing sector or only to the strongest but at the same time flexible printers, it was shown that innovations more or less related to printed electronics and combining print with digital are considered also by some traditional printers belonging to SMEs. Despite all the limitations associated with innovative printing, one of the main conclusions is the fact that companies are manifesting their interest in education in this area, as well as their willingness to take part in research partnerships. This predisposition towards innovative printing, might, in the long term, work in favour of academic collaborations.

Furthermore, even though all countries differ in the progress they made in innovation or technology, the approach and vision of the industry in general is very similar across Europe. New technology is not the bottleneck. The challenge is to fit new technology to future requirements and business concepts. R&D and cooperation between different partners is needed to reach future goals. Partnerships also outside the printing industry are needed. Digital transformation and technological development enable new value creation and development of innovative products and services for the customers and call for openness in the value networks created. Since most of the respondents use paper and board as a substrate, this willingness to innovate also creates new opportunities for the European paper and board industry.

Cooperation of academia and within different companies in the value network is needed both in innovation adoption and in environmental engagement, as also shown in the discussed comments of the respondents pointing out that working with customers to develop their products is a good business model. For example, industry organisations and larger companies of the supply chain could support the micro companies. Also, improved communication e.g. by promoting best practices is essential in the printing industry where the most of the companies are very small. In case of complex innovation, active support of strong players is crucial to influence the pace of adoption.

Acknowledgements

This activity driven by participants of COST Action FP1104 will continue to strengthen the cooperation between printing industry and academia and to gather in depth feedback on the survey results. Within COST Action FP1405, focusing towards active and intelligent packaging, industry will be continuously motivated to invest and develop. This will also enable the researchers to revisit the current studies, get more in-depth feedback on drivers for change, and focus on patterns, relations or discrepancies among the results.

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Appendix

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COST FP1104 WG4
Questionnaire

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Introduction to this questionnaire:

This questionnaire is set-up to assess your opinion on innovative printing. Innovative printing is referred to meaning printed electronics, printed intelligence, printed functionalities, combining print with digital (e.g. provide digital solutions for QR codes, augmented reality …), etc. Focus point is the communication between academia working on these topics, and industry to implement the new technologies.

1.	Please, can you share with us some information on your company?
	
	    Company name or organisation:
	
	Number of employees:
	  • 1–10
	  • 11–50
	  • 51–100
	  • >100
	Industry type:
	
	What printing technology do you use?

2.	Are you involved in innovative printing (e.g. printed electronics, printed intelligence, printed functionalities, combining print with digital such as provide digital solutions for QR codes, augmented reality, …)? Do you use special/functional inks for printing (e.g. IR, thermo chromic, conductive, thermo luminescence, scratch and sniff, scented inks, …)? What type of substrates do you print on (e.g. plastic, standard paper grades, specialty paper grades, 3D objects, …)? What are your final speciality products? (Such as RFID antenna, smart labels, holograms, time and temperature indicators, biological sensor strips, freshness indicators, safety gas detectors, other printed electronics, …)

3.	What are the most important limitations to develop or start to develop innovative printing solutions in your company?
	  • Lack of market demand
	  • Costs (new equipment, new skill sets or training of employees, etc.)
	  • Processes (the complexity of the manufacturing process)
	  • Knowledge (lack of information on technology developments)
	  • Regulations
	  • Other (please specify):

4.	Have you increased your margins due to these innovative technologies and do they give you a competitive advantage?
5.	Would you be interested in training seminars and short courses in these areas from academia? Would you be interested in becoming a partner in research efforts? Can academia help with specific measurements?
6.	What are your feelings on the fastest growing markets in this sector?

Please return the questionnaire to:

Topicalities

Edited by Markéta Držková

Contents

News & more

Impressions of drupa 2016 – and what's next

Probably the most important thing that can be said now, when 11 days of drupa 2016 became a history, is that the overall feelings about the fair are positive, which communicates the optimistic message for the whole industry. According the reports, more than 1800 exhibitors from 54 countries were satisfied with business deals and promising contacts, contributing to a positive spirit for the global print industry. The re-positioning of drupa and its focus on future themes with strong growth potential have paid off.

We are not an exception – also our experiences are positive and our impression is that drupa returned to the level we remember from the past (whereas this was not the case in 2012). This year, drupa was more realistic and grounded. The position of slightly reduced market of the printing industry and suppliers, taking into consideration past effect of the crisis and changes in consumer perceptions and habits, is much more clear now. New challenges are open in packaging, digital printing and digital communication in general, with some emerging fields like 3D printing and printing on objects. There was almost nothing present from traditional prepress – it seems that the starting point for modern prepress and print workflow is the final page layout in PDF. On the other hand, plenty of solutions for cross-media publishing and repurposing the data for different output were presented both by big and small companies. As for the printed electronics, some solutions were presented, nevertheless, the printing industry as a whole still seems to be on the sidelines, in spite of the related research conducted in many print institutes for long years all over the world.

So what's next? At least for the drupa as such, one thing which changed is clear. Although everyone could read "See you at drupa 2019" on the first days of the exhibition e.g. on drupa 2016 badge strings, the return to four-year cycle was decided and promoted later during the fair, based on the numerous demands of exhibitors. The next drupa will be held in Düsseldorf again from 23 June to 3 July 2020.

World Editors Forum appeal to editors: Adopt new principles to rebuild trust in journalism

The Board of the World Editors Forum, at its meeting at the World News Media Congress that took place from 12 to 14 June 2016 in Cartagena, Colombia, approved five principles to help rebuild trust in professional journalism. The Ethical Journalism Network has endorsed the five principles and the World Editors Forum is now asking editors around the world to embrace the principles as a way to take journalism to the next level.

1. In a world of hyper-information, credibility, independence, accuracy, professional ethics, transparency and pluralism are the values that will confirm a relationship of trust with the public.

2. Next-level journalism is distinguished from other content by the vigilant and diligent questioning and verification of material circulating on social media. It acknowledges social media as a source of information for further fact checking and as a platform for leveraging professional content.

3. The mission of journalism at this next level is to positively serve society by providing high-quality verified information and to establish news brands as a trusted certificate of origin for content.

4. A requirement of next-level journalism is that it goes beyond basic facts and enables and encourages analysis, contextual and investigative reporting, and informed expression of opinion, moving from the provision of news to knowledge that empowers.

5. Next-level journalism should be driven by trust and the guiding principles of social relevance, legitimate interest and truthfulness.

Sheet-fed cold foiling on uncoated stock

The US based company Eagle Systems claims to overcome the problems related to cold foiling the uncoated papers, which are porous and have much higher roughness in comparison to coated stock, and promoted its Cold Foil system and matching consumables at drupa 2016, with three units on display to fit 29", 40" and 56" offset presses. The solution was verified by retrofitting a manroland press at the company manufacturing high-end consumer packaging products.

Personalized covers up to A3 format

The overall quality and appearance of various in-house produced presentation materials can be improved by employing the Unibind fully automated or manual personalization systems, comprising the digital UniFoilPrinter, Lay-Flat UniPaper, and the UniCover System for production of book covers or wrappers, introduced at drupa 2016. Unibind solutions are protected by a number of patent applications; the last issued patent is US 9290032 B2 'Method for binding leaves and a binding element and binding device applied thereto' from March 2016.

A 3D printer for multilayer printed circuit boards

Nano Dimension, Israel company founded in 2012, develops advanced systems for additive manufacturing and 3D-printed electronics, based on a unique combination of 3D inkjet, 3D software and nanotechnology-based conductive and dielectric inks. First deliveries of the DragonFly 2020 3D Printer are expected to be in the second half of 2016. The printer is designed to offer a great flexibility to a wide range of research and development, prototyping and custom manufacturing projects. In May 2016, Nano Dimension in collaboration with another Israel company, Accellta, announced a successful printing of viable stem cells using an adapted 3D printer.

ABB in pulp and paper

A few years after acquiring the Kajaani Process Measurements (KPM), one of the leading producers of unique measurement equipment for control within the pulp and paper industry, in 2008, the Lorentzen & Wettre (L&W), traditional supplier of advanced equipment for pulp and paper quality and process measurements, became a member of the ABB group in 2011. Although now in 2016 the businesses are fully integrated into ABB, many products keep L&W and KPM names. The ABB Pulp and paper portfolio comprises systems, solutions and services including L&W and KPM products, quality control systems and web imaging systems.

The most recent examples of the ABB investment in the areas of paper lab testing, pulp analysis and consistency transmitters are L&W OptiTopo and L&W ZD Tensile Tester. The L&W OptiTopo instrument is based on the method developed by Innventia to measure surface roughness and predict printability of paper. Two differently illuminated images of the same paper surface are captured by high-resolution CMOS camera and a height map is then calculated using a photometric stereo technique, revealing the topography of the paper. An area of 1 000 mm^2 is evaluated in a few seconds. The measuring area is 20 times larger than for traditional optical methods and the instrument thus provides more relevant and representative results.

The newly released L&W ZD Tensile Tester from ABB features better ergonomics and improved interface. It provides fully automated measurement of an internal bond strength, i.e. the strength in the paper thickness direction, or Z-direction (ZD) tensile forces. This method measures the maximum force needed to split the sample at a low standardized test speed exactly perpendicular to the test surface. The measurements are made in accordance with ISO 15754, SCAN P 80, and TAPPI T 541 standards. Fast and reliable monitoring of internal bond strength values is important for the production of paper, and especially the multilayered paper products, as it enables to achieve uniform strength across the entire web width. This prevents a number of problems in further processing of the material, e.g. blistering in heat-set web offset printing of highly coated paper, material splitting in offset presses, or poor folding lines or cracks in the outer layer of paperboard after folding.

Another example of ABB solutions in pulp and paper industry is the quality control system applied in production of innovative, sustainable tea bag paper. EcoInfuse™ filtration paper introduced by Burrows Paper provides superior crimping and folding properties needed for dependable tea bag formation and quality. The ABB system helps to assure consistent moisture across the paper machine web, necessary for successful production; annual production capacity of this speciality paper totals over 4 500 tonnes.

To look into the near future, the fully integrated control system is build for SCA Östrand's expanded pulp mill in Timrå (Sweden), planned to open in June 2018. The system is designed to manage the end-to-end production, from the woodyard to the baling line, from one single control room to provide exceptional connectivity and full plant overview of all devices used in the entire process. The ABB solutions in this application are based on automation platform System 800xA and custom-engineered software for pulp processes, including engineering for the control system and optimization of all processes, as well as the design of the control room. The order also includes a simulator for testing the control of all processes in the mill before delivery, and for operator training and process optimization over time.

Bookshelf — J. Print Media Technol. Res. 5(2016)2, 177–182

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Bookshelf

Printed Electronics: Materials, Technologies and Applications

This book summarizes materials, processes and equipment applied in the manufacturing of printed electronics and provides an overview of the principles behind the main types of devices as well as the state-of-the-art in the field. The book is contributed by a multidisciplinary team with diverse backgrounds, ranging from physics over chemistry to electronic engineering, where all authors are active in respective research area. With printed electronics being the main focus, the knowledge in organic and flexible electronics, already covered by other publications, is included only when applicable to making electronics by printing. Throughout the book, the explanation of the principles is supported by practical examples.

After the introductory chapter, defining what is printed electronics and underlining the importance of its development as well as its multidisciplinary nature, the next two chapters describe both organic and inorganic printable electronic materials. The former one starts with organic conductive materials – structural and composite conductive polymers, followed by organic semiconductors of both small-molecule and polymeric character and other organic materials (for insulating layers or sensors). The latter one on inorganic printable electronic materials goes through metallic materials including metal nanowires, transparent oxides, single-wall carbon nanotubes, graphene, silicon and germanium, metal chalcogenide semiconductors, quantum dots and nanoparticle/polymer dielectric composites.

The fourth chapter covers printing processes and equipment applicable for electronic manufacturing, discussing their working principles, patterning, applications, advantages and challenges. Besides inkjet printing, two other jet printing techniques are described – aerosol and electrohydrodynamic jet printing. Further, screen printing, gravure printing and flexography are introduced as direct replicate printing techniques, and offset printing, gravure offset printing and pad printing belonging to the indirect ones. Across the book, inkjet and gravure printing are cited the most, followed by screen printing, aerosol jet printing, flexographic printing and others. Supporting processes are introduced as well – pattern design, surface energy modification, surface coating, embossing and nanoimprinting, which can be used prior printing, and sintering, UV curing and annealing among the post-printing processes.

In the second half of the book, the chapters are dedicated to printed thin film transistors, printed organic thin film solar cells and printed organic light emission and display. For all types of devices, the mechanisms, important parameters, suitable materials, fabrications processes, advances and issues are detailed. The eight chapter deals with encapsulation of organic printed electronic devices to ensure their sufficient protection, especially against water and oxygen, and thus reduce ageing. The concluding chapter discusses application areas of printed electronics up to the integrated smart systems and related future prospects and challenges in materials, printing process and equipment, encapsulation, design and standardization.

Printed Electronics: Materials, Technologies and Applications
Author: Zheng Cui (with contributions from Chunshan Zhou, Song Qiu, Zheng Chen, Jian Lin, Jianwen Zhao, Changqi Ma, Wenming Su)
Publisher: Wiley
1st ed., June 2016
ISBN: 978-1-118-92092-3
450 pages
Hardcover
Available also as an eBook
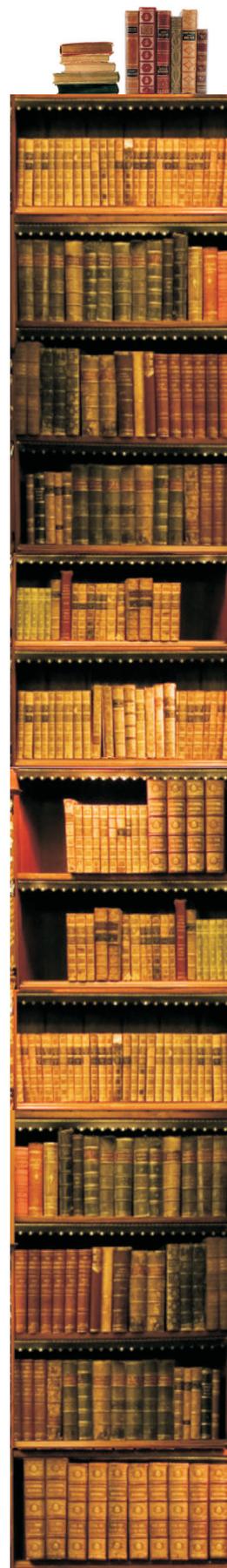
Against Plagiarism:
A Guide for Editors and Authors

Author: Yuehong (Helen) Zhang

Publisher: Springer
1st ed., October 2015
ISBN: 978-3319241586
162 pages
Hardcover
Also as an eBook

The new Springer series named 'Qualitative and Quantitative Analysis of Scientific and Scholarly Communication' started with this volume on fighting plagiarism, seen as the top priority for scientific community. Besides breaking the ethics rules, any form of plagiarism is a waste of time of editors, reviewers, and readers. The broad awareness of the basic rules is necessary to considerably reduce the incidence of plagiarism, either intentional or not, language- or discipline-specific as well as general. The guide describes all kinds of plagiarism, including typical problems such as cut-and-paste, duplication of conference proceedings, self-plagiarism, team plagiarism, and review papers with a high level of similarity. It also identifies various reasons to commit plagiarism, and even more importantly, how to avoid it as an author – and how to detect it and deal with it when being an editor.

A History of the Norwegian
Press, 1660–2015

Author: Hans Fredrik Dahl

Publisher: Palgrave
Macmillan
1st ed., February 2016
ISBN: 978-1137580252
283 pages, Hardcover
Also as an eBook
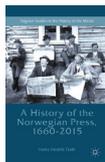
This book begins with the early history and continues with detailed description of the emergence and development of national press in last two centuries, starting as local printed pamphlets and expanding to almost three hundred newspapers published in last decades in Norway. The author points out that newspapers generated the money and power, thus becoming a substantial structure at the core of the modern media system – cinema industry, radio broadcasting, television and the Internet.

Revolutions in Book Publishing:
The Effects of Digital Innovation on the Industry

The authors aimed to fill a gap in the existing literature and examine the evolution of the book publishing industry while accommodating the influences of the digital world. The available data, mostly sparse and dispersed, were collected to get appropriate coherent time series and cross-section data and then analysed with statistical techniques to describe the latest effects of technological innovations on the industry as well as their influence on distribution channels, market structure, and conduct of the industry. The price and non-price competition is investigated, including the role of bidding, advertising, and R&D expenditures. The demand and supply aspects of the book market are discussed, detailing consumption, production and distribution while evaluating relevant categories and time trends. Traditional economic indicators are exploited, including employment, productivity, wages, tax rates, sales, revenues and costs. Printing and publishing as well as Internet technology issues are pointed out. The text is supported by numerous references. Overall, the content of the book is based on the United States market, however, discussed also in global perspective.

Revolutions in Book Publishing:
The Effects of Digital Innovation on the Industry
Authors: Lall Ramrattan, Michael Szenberg
Publisher: Palgrave Macmillan
1st ed., November 2015
ISBN: 978-1-137-57620-0
147 pages
Hardcover
Available also as an eBook
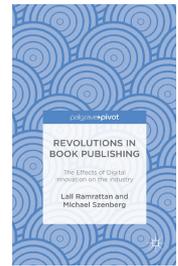
The Media and Public Life: A History

This study of the relationship between media and society analyses the past, present and future of news and public life. The media history is tracked and put in the context through the key moments involving the press, politics, and public, such as the rise of liberal political institutions, the market revolution, the industrial revolution, bureaucratisation and professionalisation, globalization, and the ongoing digital revolution. Enlightened by well-chosen examples, the text is easy to comprehend and offers interesting ideas and well organized, in-depth information for those interested in the topic.

Individual chapters follow 'The printer's newspaper and the national public sphere' in the late 18th century, 'The editor's newspaper and the partisan public sphere' and 'The commercial public sphere' in the first half of the 19th century, 'The industrial media and the culture industries' in the second half of the 19th century, 'Institutionalization, the professional media and the expert public sphere' in the 20th century and 'The late modern press, the digital media, and the network public' today, mostly related to the United States as in case of the above mentioned Revolutions in Book Publishing.
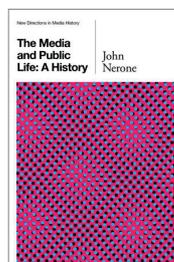
The Media and Public Life: A History
Author: John Nerone
Publisher: Polity
1st ed., June 2015
ISBN: 978-0-7456-6020-2
248 pages
Hardcover
Available also as an eBook

Meggs' History of Graphic Design

This outstanding, award-winning graphic design reference was first published in 1983 and now, in its 6th edition, again revised by Alston W. Purvis, it incorporates the latest key developments in web, multimedia, and interactive design, as well as emerging design trends and technologies.

The in-depth coverage of visual communication spans from the invention of writing and alphabets through the origins and advances of printing and typography up to contemporary design, documenting all important milestones. Five parts depicts the visual message from prehistory through the medieval era, the origins of European typography and design for printing, the impact of industrial technology upon visual communications, graphic design in the first half of the twentieth century and finally the graphic design in the global village of present days.

In current 2016 edition, the timelines that track the evolution and achievements in graphic design, driven by innovators, progressive technologies, and key developments, are presented in even broader historical context. From a geographical perspective, design in Asia and the Middle East is more reflected. The book is traditionally richly illustrated with hundreds of quality images, referencing to comprehensive bibliography and accompanied by supporting materials for both instructors and students.

Meggs' History of Graphic Design
Authors: Philip B. Meggs, Alston W. Purvis
Publisher: Wiley
6th ed., May 2016
ISBN: 978-1-118-77205-8
696 pages
Hardcover
Available also as an eBook
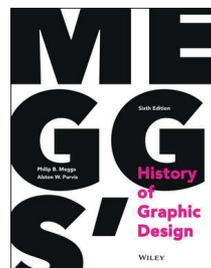
Advanced Graphic Communications, Packaging Technology and Materials

This volume brings the collection of 130 selected papers, presented at the 2015 China Academic Conference on Printing and Packaging. The contributions are organized into nine parts, dedicated to (i) colour science and technology, (ii) image processing, (iii) digital media, (iv) printing and (v) packaging engineering technology, (vi) mechanical engineering and numerical control, (vii) paper, (viii) film, and (ix) ink and related technology. Except two topics, the research is not aimed on China-specific subjects; to give a few examples, 'Prediction of gray balance spectral data in digital printing', 'Comparing the similarity of image in different color spaces', 'The research on modified atmosphere packaging preservation of fresh-cut iceberg lettuce' and 'Preparation and performance of edible screen-printing ink with chitosan' can be listed.
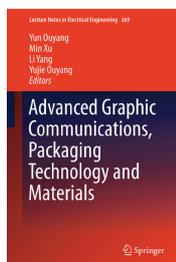
Advanced Graphic Communications,
Packaging Technology and Materials
Editors: Yun Ouyang, Min Xu, Li Yang, Yujie Ouyang
Publisher: Springer
1st ed., January 2016
ISBN: 978-981-10-0070-6
1059 pages, 543 images
Hardcover
Available also as an eBook

How Posters Work

Authors: Ellen Lupton, Caitlin Condell, Gail Davidson

Publisher:
Cooper Hewitt
1st ed., May 2015
ISBN: 978-0910503822
208 pages
Hardcover

Focusing on visual language, this book presents over 330 works from the collection of Cooper Hewitt, Smithsonian Design Museum, organized around various design concepts – 'Focus the eye' with a familiar object dominating the composition, 'Overwhelm the eye' to keep the viewer's eye in motion, the self-explaining ones 'Use text as image' and 'Say two things at once', 'Overlap' to simulate depth, 'Assault the surface' to point to the artifice of the work, 'Cut and paste' to combine fragments into a new whole, 'Simplify' to focus attention on a message, 'Tell a story' with just one image and important details, 'Amplify' a message, 'Communicate with scale' to make the illusion of depth or to create visual tension, 'Exploit the diagonal' to induce a sense of motion and depth, 'Make a system' as a grid can become a strong visual element, and finally 'Make eye contact' because the eyes looking out of a poster challenge the viewer to look back.

Proceedings of the 2nd International Colloquium of Art and Design Education Research (i-CADER 2015)

Editors: Shahriman Z. Abidin, Rafeah Legino, Harrinni M. Noor, Verly V. Vermol, Rusmadiah Anwar, Muhamad F. Kamaruzaman

Publisher: Springer
1st ed., April 2016
ISBN: 978-9811002359
306 pages, 357 images
Hardcover
Also as an eBook

As the i-CADER 2014 proceedings, presented in Bookshelf in 4(2015)4, over 60 papers included in this volume illustrate various opinions and interpretations, mediums and technologies, policies and methodologies in trans-disciplinary research in art and design education.

Bookshelf

3D Printing
(3D-tisk)

Authors: Tadeja Muck, Igor Križanovskij

Publisher:
Založba Pasadena
1st ed., November 2015
ISBN: 978-9616661698
224 pages (in Slovenian)
Hardcover

3D-TISK

The book titled simply '3D-tisk' is the first book in Slovenian language focused on presentation of 3D printing, the technology that is expected to affect many industries and even the society as a whole. The authors with academic (Tadeja Muck) and 3D modelling (Igor Križanovskij) background explain the functional development and current capabilities of 3D printing and discuss its importance at present days as well as in the near and middle future.

The first and largest chapter of the book is dedicated to the in-depth overview of 3D printing, the most important technologies on which it is based, and a short description of existing materials and also applications that are associated with mentioned technologies.

In the second chapter, the virtual ideas that arise in the form of 3D models, converted later into physical 3D objects, are presented. The 3D modelling process and the preparation of final 3D model for printing using the program Blender are described in detail, providing the most important guidelines and warnings, which should be considered to ensure that the final 3D object will meet the expectations.

The third part is the glossary, summarizing and explaining the diverse and evolving terminology in the area of 3D printing, including the most frequently used abbreviations, along with a links to the original interpretation of the corresponding term or name. Finally, the 3D printing in Slovenia is introduced – the companies that are nowadays directly or indirectly involved in this field.

Fundamentals of Illustrative Printing Technology

The handbook describes the approaches, principles and methods of image data processing in traditional and digital printing. The content is based on and referenced to both the latest literature and the author's own investigations in image data transformations for hardcopy production. Special attention is given to the image encoding optimised with respect to particular image processing and printing workflow as well as to the peculiarities of colour perception. A number of fundamental technology issues are discussed in more detail than in available literature – including correct press settings for halftone printing, selection of screen frequency, geometry and orientation, variety of black ink functions for CMYK separations, the tone/colour rendering intents or halftone sharpness estimation. The High Definition Halftone Printing technology, adaptive to tone value gradient, is separately described in the last chapter. The book also provides control tests for all 14 chapters and the Russian and English glossaries.

Fundamentals of Illustrative Printing Technology
(Основы технологии иллюстрационной печати)
Author: Yuri V. Kuznetsov
Publisher: Russian Culture
1st ed., April 2016
ISBN: 978-5-905618-04-8
440 pages (in Russian)
Hardcover

Ю. В. Кузнецов
Основы технологии иллюстрационной печати

The Fundamentals of Digital Printing

This university textbook gives an elaborate insight into the contemporary techniques of digital printing; it is primarily intended for graduate students of graphic technology in Digital Printing course; however, it may be interesting also in other engineering areas and, thanks to its clear and straightforward style, even for undergraduate readers. The text is supplemented by footnotes and comprehensive references. First two chapters introduce the printing process as such, with special reference to digital printing, and the fundamental structure of matter, enabling the formation of virtual printing plates. Next seven chapters explain in detail individual digital printing techniques – electrophotography, ionography, magnetography, inkjet printing, thermography, electrography and digital photo printing, with an emphasis on the most widely used ones, i.e. electrophotographic and inkjet printing. The final chapter describes the techniques that are not yet commercially employed, such as direct imaging, Tonerjet, Elcography and Nanography.

The Fundamentals of Digital Printing
(Osnove digitalnog tiska)
Author: Igor Majnarić
Publisher: University of Zagreb, Faculty of Graphic Arts
1st ed., 2015
ISBN: 978-953-7644-13-0
266 pages (in Croatian)
Hardcover

Igor Majnarić
Osnove digitalnog tiska

Bookshelf

Academic dissertations

Development, Optimisation and Applications of Screen-Printed Electrochemical Sensors

The thesis aimed to develop versatile, reliable and low-cost electrochemical sensors based on the combination of screen-printed working and reference electrodes, which can be readily adapted for the detection of several ionic species. Namely, two electrochemical platforms to monitor pH in saliva and sodium in sweat were explored, consisting of a solid-contact reference electrode based on the use of ionogels and coupled to an ion-selective electrode. The opening chapters of the thesis introduce chemical sensors and summarize the advances and challenges in the design of wearable chemical sensors for non-invasive monitoring of biological fluids. The next chapters describe all steps taken during the research. In the realisation of reliable miniaturised reference electrodes with tailored features, the attention was paid to the choice of materials (the ionic liquid, monomers, cross-linkers and photoinitiators used in the ionogel capping membrane formulation as well as the solid-contact material) and to the creation of a solid-contact layer on the screen-printed carbon electrodes, especially the electrochemical growth of poly(3,4-ethylenedioxythiophene). Similarly, the parameters of the screen printing process and preparation of the pH sensitive membrane were optimised. Higher reproducibility of ion-selective electrodes was achieved with regiorandom poly(3-octylthiophene-2,5-diyl) used as a solid-contact layer. Resulting all solid state pH potentiometric strips were calibrated on bench and then tested in the monitoring of pH in real saliva samples. In the further study of the solid-contact materials, ligand functionalised gold nanoparticles were synthesised, characterised and tested in Pb^{2+} and Na^+ ion-selective electrodes, showing the importance of matching the functionalising group to the target ion. Finally, the potentiometric strips for monitoring Na^+ variations in sweat were developed and integrated into microfluidic chips enabling to harvest sweat samples. After testing on the bench, the device was verified during real-time cycling sessions. In addition, a wearable sensing device for monitoring localised sweat rates through image analysis was proposed.

Doctoral thesis – Summary

Author:
Giusy Matzeu

Speciality field:
Analytical Chemistry

Supervisors:
Dermot Diamond
Claudio Zuliani
Aoife Morrin

Defended:
15 June 2015 at Dublin City University Dublin, Ireland

Contact:
giusy.matzeu2@mail.dcu.ie

Goniospectrometric Analysis of Optically Complex Samples: A Study of Diffraction Gratings, Optically Variable Devices, and Coatings with Special Effect Pigments

This dissertation systematically deals with reliable and feasible characterisation of optically complex, gonioapparent samples – diffraction gratings, optically variable devices and special effect coatings. The method employs the transformation of the bidirectional reflectance distribution function to the goniospectrometric space using so called digital numerical analysis. At first, individual types of samples are described, including overt and covert diffraction gratings, optically variable devices with different complexity and opacity, and coatings with various metal and layered effect pigments. Next, a short overview of the bidirectional reflectance distribution function, measuring devices and geometries used in the study is given; a commercial multi-angle spectrometer featured 45° and 15° illumination angles and 19 measurement angles (8 of which off-plane); a custom built bidirectional spectrometer enabled measuring all azimuthal angles and polar angles up to 60°, with a 2° step in both directions. Numerical models for both diffraction gratings and coatings with special effect pigments are then presented,

Doctoral thesis – Summary

Author:
Nina Rogelj

Speciality field:
Photonics

Supervisors:
Markku Hauta-Kasari
Marta Klanjšek Gunde

Defended:
8 December 2015 at University of Eastern Finland / Faculty of Science and Forestry Joensuu, Finland

Contact:
nina.basic@metas.ch

as well as goniospectrometric space curve calculations, when the spatially undersampled bidirectional reflectance distribution functions are summed over all directions for individual wavelengths in the visible spectral range. The resulting goniospectrometric space curves are at first demonstrated for selected exemplary samples – silicon wafers and papers with different smoothness and also samples with different coating thickness and transparency, followed by a detailed analysis of the results for optically complex samples. In the work focused on diffractive samples, the dependence on grating amplitude and period as well as the effect of spectral and angular resolution are explored. Goniospectrometric space curves of diffraction gratings follow the lines with different slopes and possible interconnections; their length is directly connected to the grating period and amplitude, whereas the slope only to the grating period. The study proved that the spectral resolution of 10 nm is sufficient for goniospectrometric space curve determination and that the curve works best with ten measurement geometries, since angular oversampling reduces its specificity. In case of coatings with special effect pigments, a numerical model for goniometric reflectance was developed, allowing to analyse the influence of different types of pigments, surface coverage, pigment orientation distribution and the substrate properties. The results show that the shape, position and orientation of the goniospectrometric space curve reveal the optical makeup of the coating. In summary, the goniospectrometric space curve, which can be determined using commercial hand-held multi-angle spectrometers, provides desired appearance fingerprint of optically complex samples.

Doctoral thesis – Summary

Author:
Ondrej Panák

Speciality field:
Technology of Macromolecular Compounds

Supervisor:
Marie Kaplanová

Defended:
10 December 2015 at University of Pardubice / FCHT Pardubice, Czech Republic

Contact:
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Optical Properties of Multifunctional Pigment Embedded in Polymer Matrix

The objective of this dissertation was to prepare a multifunctional pigment with two functionalities, namely the thermochromism and fluorescence. The combination of different types of dynamic colour changes in one pigment opens up a new level of protection and genuineness verification. In the first stage of the research, two sets of ternary leuco dye based thermochromic systems varying in the molar ratio of crystal violet lactone as a colour former, bisphenol A as a developer, and 1-octadecanol or 1-tetradecanol as a co-solvent, respectively, were synthesized and characterised. The studied systems show decolouration at increased temperatures and colouration when cooled back, exhibiting hysteresis of the reversible colour change. A number of dynamic colour change characteristics were discussed in relation to molar ratio of components. A newly introduced parameter, the cumulative colour difference representing the path of colour change in CIELAB space, is suggested as the best option to describe the dynamic colour change. The colour change is further discussed in relation to structural changes. The temperatures characterizing the colour change at decolouration limit are closely connected to phase transitions observed by differential scanning calorimetry. The colour contrast correlates with the ratio of integrated intensity of chosen characteristic vibration in infrared spectrum. In the second part, thermochromic and multifunctional pigments were prepared by microencapsulation based on *in situ* polycondensation of melamine-formaldehyde resin using styrene maleic anhydride copolymer emulsifier. The encapsulated pigments exhibit thermochromic behaviour, however, when compared with the bulk thermochromic system, with significantly lower colour contrast and wider temperature sensitive interval. For multifunctional pigments, Uranine or Acid Red 52 fluorescent dye was added during encapsulation. Modifying the polymeric envelope by a fluorescent probe doesn't change the functionality of encapsulated thermochromic system, while strengthening the uniqueness of the pigments. The concentration of 2.3×10^{-5} g per 1 g of polymer is sufficient for detection of modified polymeric shell fluorescence.

Events

Printing of Functional Applications
Summer School

Swansea, UK
11–15 July 2016

Building on two successful summer schools organized at Swansea University within the COST Action FP1104 in previous years, 2016 summer school hosted by the Welsh Centre for Printing and Coating (WCPC) is supported by the COST Action FP1405 ActInPak (Active and intelligent fibre-based packaging – innovation and market introduction). Currently, 30 countries are involved in the ActInPak network, with participants representing over 95 institutes and companies.

The summer school courses again cover the design and applications of printed and coated functionalities including sensor integration on flexible substrates, all major printing processes – flexography, screen printing, gravure printing, pad printing, offset lithography and inkjet printing, along with aerosol jet printing, 3D printing, photonic fabrication, drying, sintering, properties of inks and substrates, and finally the appropriate characterisation methods, such as colour measurement, techniques for electrical or surface characterisation, and suitable analytical methods for chemical measurements. Practical sessions this year include also short workshops on the PulseForge photonic curing by Novacentrix. Two networking events are held at the Bay Campus as well.

ProPak China 2016

Shanghai, China
13–15 July 2016

The 22th international processing, packaging and end-line printing exhibition ProPak China 2016 for all related industries provides dedicated specialised zones for liquid processing, packaging, and materials, as well as dairy, food, pharmaceutical, and cosmetic products processing technology. The range of new technologies is presented – and a number of exhibition strategic partners launch their latest technology developments. The visitors can also attend several specialist technical seminars discussing case studies, production issues and solutions. In addition, professional conference programme is prepared for each day, including the Active and Intelligent Packaging Industry Association Summit 2016 on 14th July, presenting the technology innovations for the food and beverage packaging industry. Speakers introduce, among others, antimicrobial and oxygen scavenging solutions, shelf-life extension technologies, including vacuum packaging, and various condition monitoring possibilities in supply chain, for retailers as well as end consumers – from simple elapsed-time indicators showing the time since opening or mixing, which are automatically activated when opening the container or if being applied by the user, over near field communication data loggers for monitoring the temperature in retail shops to ensure optimum conditions to avoid waste, to the systems based on smart sensors and software managing the sensor data, storing the acquired data in cloud databases and providing tools for data curation to support condition and freshness-based business decisions.

NANOTEXNOLOGY 2016

Thessaloniki, Greece
2–9 July 2016

This annual event that is focused on nanotechnologies, organic and printed electronics and nanomedicine attracts over 2 000 participants and comprises several established events: 13th International Conference on Nanosciences & Nanotechnologies, 9th International Symposium on Flexible Organic Electronics, 10th International Summer Schools, and 6th NANOTEXNOLOGY EXPO 2016, accompanied by numerous workshops and round tables.

Hong Kong Book Fair 2016

Hong Kong
20–26 July 2016

The Hong Kong Book Fair is annually organised by the Hong Kong Trade Development Council. Attendees can join more than 300 events this year, including an industry event International Publishing Forum and a variety of seminars. The 27th edition is also introducing a Theme of the Year to readers for the first time – Chinese Martial Arts Literature.

PackPlus New Delhi 2016

New Delhi, India
27–30 July 2016

The event still grows and this year it will present more than 350 exhibitors from the packaging, printing, converting, processing & supply chain industry, manufacturers as well as services providers, from India and neighbouring countries.

The International Packaging Conclave, in 2016 with the topic 'Print Optimisation and Colour Management in Flexible Packaging', can be joined on 29th July.

BIBF 2016
Beijing International Book Fair

Beijing, China
24–28 August 2016

北京国际图书博览会
Beijing International Book Fair

In 2015, with about 300 000 titles on display, the book fair presented more than 2 000 publishing houses from the mainland of China and 82 countries and regions at new venue, the China International Exhibition Centre. More than 260 000 visitors could enjoy over 1 000 cultural events and seminars.

This year, two new BIBF programs aim to help new exhibitors learn more about the Chinese market and make new business contacts, providing basic information about Chinese publishing industry, rules and regulations and import & export options. Another networking event, the Rights Managers' Salon, is a communication activity targeting on international copyright professionals, bringing together Chinese and foreign rights managers on the first evening of BIBF to make further cooperation easier. Similarly, the 10 + 10 Publishers' Meeting increases cooperation chances between Chinese and foreign publishers, selected to promote books and discuss the latest trends and business opportunities in global publishing face to face.

Many other activities are scheduled, for example the International Digital Publishing Forum with the focus especially on the digital marketing and digital publishing business model that will be held on 26th August 2016.

Digital Print for Packaging USA

Chicago, Illinois, USA
7–8 September 2016

The event organized by Smithers Pira twice a year presents selected technical and commercial applications to maximize profitability for brand owners, converters, printing equipment suppliers and packaging designers operating in the digitally printed packaging marketplace. The 5th edition of Digital Print for

43rd International iarigai Conference
Advances in Printing and Media Technology

Toronto, Canada
24–27 August 2016

This year, the traditional iarigai research conference is scheduled a few weeks earlier than usually and hosted by the Ryerson University in Toronto. The 2016 volume is entitled 'Print and Media Research for the Benefit of Industry and Society' and besides scientific presentations and keynotes it features Industry Day designed specifically for members of the North American printing industry.

After the social programme on Wednesday evening, two days of presentations will start with the keynote on 'Haptic Brain/Haptic Brand – A Communicator's Guide to the Neuroscience of Touch', given by Daniel Dejan. The following sessions on printed functionalities encompass the challenges faced when developing functional applications from biological molecules to industrial printed products, fabrication of low-cost RFID tags and flexible thin-film humidity sensors, providing post-print laser marking functionality by spot application of a transparent nanoclay layer on 100 % calcium carbonate coatings, reaction platforms for enzymatic testing, and improving aerosol jet printing process using a solvent add-back bubbler.

On Thursday afternoon, John Seymour, an applied mathematician and colour scientist, will present his keynote 'Where does the light go, how do we measure it, and why would we want to?' In the following session on colour, the speakers will introduce the optimised inking for cardboard food packaging, colour management of tablet devices, and microscale halftone dots analysis employing a spatial threshold evaluation method. The last session of the day is dedicated to design, investigating whether the visual design elements of selected craft beer packaging communicate their unique flavour profiles, and why brand manuals usually fail to define brand colours as well as how acceptable colour deviations should be determined.

The Friday morning is reserved for talks and workshops within 'Challenging the Status Quo' industry programme. The individual tracks will show how to reduce back-and-forth emails to save the time, what exactly "Big Data" means and how companies can leverage it in their business, as well as how fresh ideas may help to target marketing efforts of the company. Then, the drupa highlights will be shared.

The industry representatives are welcome to stay for an afternoon of academic conference sessions, started by the keynote of David Frohlich: 'Fast design, slow innovation: Audio-photography ten years on'. The session on printing materials will deal with drying temperature influence on morphology of droplets and lines printed by inkjet using silver nanoparticles based ink and related electrical characteristics, and TiO_2 nanostructures for dye-sensitized solar cells; in addition, the importance of properly chosen background colour for the quality of embossed holograms will be presented. Finally, the session on manufacturing and 3D printing offers lectures on the challenges in the fused layer manufacturing of optimised microstructures, 3D printing of model polymeric resins for medical applications, and polyelectrolyte patterns for analyte separation on microfluidic paper-based analytical devices, printed by inkjet.

The iarigai conference will be concluded on Saturday by tours and visit to the Mackenzie Printery and Newspaper Museum that is Canada's largest working printing museum, showing 500 years of printing technology.

7th ICFPE 2016
International Conference on Flexible and Printed Electronics

Yonezawa, Japan
5–8 September 2016

The Eastern Asia conference aimed at the ongoing research and development challenges in flexible and printed electronics, serving also as a platform for exchanging ideas in related technology fields, ICFPE, will be held at Yamagata University in 2016.

Paul Heremans, Holst Centre director, will give an opening keynote speech on 'Flexible a-IGZO Thin-Film Transistors and Applications in Thin-Film Integrated Circuits'. The morning hours are in each of three days of technical programme reserved for plenary lectures – 'Flexible hybrid electronics opportunities and ecosystem development' by Melissa E. Grupen-Shemansky, 'The strategy of JOLED to challenge innovation' by Yoneharu Takubo, JOLED chief technology officer, 'Flexible electronics in ITRI (Industrial Technology Research Institute) by Chih-I Wu, and 'Lithium ion battery – current, past and future" by Akira Yoshino.

The programme then continues with numerous invited lectures from renowned experts, representing research institutes and industry worldwide, organized together with selected oral presentations into four or five tracks, respectively. The sessions cover flexible and printed displays, printed and flexible integrated circuits, fine line process and equipment, organic light-emitting diode lighting, hybrid integration and applications, roll-to-roll process and equipment, organic thin-film transistor physics, printed organic photovoltaics, flexible medical sensors, conductive and functional inks, organic semiconductor materials, inorganic thin-film-transistor technology, paper electronics, chemical and bio sensors, flexible substrate and barriers, frontier energy devices, measurement and evaluation, OE-A: new technologies and applications for printed electronics, and OES (Organic Electronics Saxony) special. The poster session will be held late afternoon on 7th September.

4th International Banknote Designers Conference 2016

Paris, France
12–15 September 2016

This four-day industry event organized by the International Banknote Designers Association addresses banknote design issues and threats, along with the latest technology developments and processes.

Its central theme for 2016 edition is 'Perspectives on Design Evolution and Innovation from Around the World'. The conference programme has been developed by professionals active in banknote design and new series or upgrade projects, who understand the related challenges, priorities, concerns and opportunities.

The conference with the highly technical focus comprises numerous panel discussions, workshops, case studies and presentations. The aim is to enable designers and issuers to make more-informed and objective choices on banknote design, content and project management. The attendees will be provided with up-to-date information on the security features, substrates and integration techniques, counterfeiting trends, threats and challenges, machine readability, perception science and best practices demonstrations.

Packaging in the USA will reflect new digital printing technologies available, and also focus on the economics of digital printing or designing for digital. Pre-conference workshops are scheduled to demonstrate how to adopt inkjet for packaging issues and to provide an insight into the process of developing and refining the "why" behind products and businesses to ensure a more authentic engagement with customers.

The agenda of two conference days features six sessions. The first one will discuss what is really happening in the market and how the digital innovations can be incorporated. The next one will explain the importance of purpose and personalization in consumer engagement, along with the smart packaging utilizing the Internet of Things. The session on evolving technology will present e.g. how inkjet is expected to transform corrugated packaging market or how inline digital printing enhances marketing value and responsiveness to brands. The fourth session will ask how to make digital feasible for packaging or find higher output at low costs, and why consider systems integration, while the fifth one will deal with transitioning from analogue to digital, and the last one will try to forecast "the next big thing".

FESPA Africa 2016

Johannesburg, South Africa
7–9 September 2016

This international trade fair is the region's largest exhibition for the print and signage, jointly organized by FESPA and Practical Publishing. The event is co-located with the 2016 editions of Africa Print Expo, Sign Africa, Africa LED Expo, and Printing SA conference.

Labelexpo Americas 2016

Rosemont, Illinois, US
13–15 September 2016

Also this label and packaging printing event is the largest in the region, displaying the available machinery and materials options, and accompanied by two-day conference.

Packaging Innovations London 2016

London, UK
14–15 September 2016

PI The future of branded and inspirational packaging
PACKAGING INNOVATIONS 2016
14 & 15 September 2016 | Olympia, LONDON

Again co-located with Luxury Packaging London, the 2016 event "for all things packaging" will present more than 170 packaging industry exhibitors to several thousands of brand, marketing, creative and packaging professionals.

The show offers a lot of networking opportunities and hosts a rich seminar programme with speakers representing the leading global brands as well as the emerging ones, along with respected industry thought-leaders. It includes the two-day conference organized in partnership with the world's most popular packaging design website, The Dieline, for the first time in the UK.

FachPack 2016

Nuremberg, Germany
27–29 September 2016

↘ FachPack 2016

This European trade fair for every aspect of packaging with almost 40 years of history and growth gathers more than 1 500 exhibitors to present packaging materials and machines, solutions for package printing and processing, logistics systems, as well as services for the packaging industry, understanding and fulfilling the needs of both packaging industry and consumers.

The programme for 2016 offers the 4th PackBox Forum with short presentations and discussion groups, supported by several industry partners, where e.g. the lecture on new digital material possibilities (smart materials and printed electronics) and digital processes (3D printing and laser cutting) is on the list, as well as new business models with smart shipping containers or the impact of Industry 4.0. Also, five special shows are prepared, including the Theme Park 'Packaging in Medical Technology and Pharmacy'.

Printing for Fabrication 2016
Materials, Applications, and Processes – the 32nd International Conference on Digital Printing Technologies (NIP)

Manchester, UK
12–16 September 2016

This event – formerly NIP/Digital Fabrication – is dedicated to print-based fabrication, functional materials, and applications redefining what it means to print something. Traditional printing technologies are adapted to produce and manufacture functional two- and three-dimensional features for a wide range of applications from packaging to biomechanics. This is made possible through the advances in nanotechnology and material science, essential for development of new toners, inks, and substrates, as well as the new additive manufacturing technologies. The five-days of this established conference are an opportunity for experts, either coming from academic, research and development institutes, or from manufacturing and distribution companies, to meet and discuss each and every aspect of this highly multidisciplinary field.

IS&T imaging.org For the first time, the meeting also hosts the IS&T International Symposium on Technologies for Digital Photo Fulfillment (TDPF) in its 7th edition, prepared in partnership with The Royal Photographic Society. The symposium will offer sessions on the technologies for photo books and other applications – from the image capture through image processing and organizing up to soft or hard copy output, with special focus on the life cycle of photo books, including preservation, cloud-based services and related new print products.

The programme of the Printing for Fabrication 2016 conference will open Kostya Novoselov, 2010 Nobel Laureate, with his keynote on 2D materials that may show a range of different properties, from the most insulating to the most conductive, from the strongest to the softest, while even greater scope can be realised through sandwich structures made up of several different layers of such materials. The state-of-the-art keynote is this year reserved for Tim Weber, presenting HP's Multi Jet Fusion 3D printing technology. Then on Wednesday, Henning Sirringhaus will speak about 'Low-temperature organic and oxide transistors for printable electronics', and Hideki Kyogoku will on Thursday explain the objectives of a Japan national project of 'Manufacturing innovation through development of next generation 3D printers'. As each year, the agenda si full of oral presentations, workshops and demonstrations organised in specialised tracks.

IC-MAST 2016
6th International Conference on Materials and Applications for Sensors and Transducers

Athens, Greece
27–30 September 2016

The conference focus is especially on materials used for sensors and devices that transduce physical properties, including 2D materials, biomaterials, metamaterials, nanomaterials, magnetic materials, and others.

In addition, the participants can during the event attend presentations of editors from several scientific journals and also take part in their round-table discussion. Further, the EU Framework Programme for Research and Innovation (Horizon 2020) and collaboration opportunities in the framework of bilateral cooperations will be presented by invited specialists.

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⊕ Social impacts

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