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Evaluating the Use of Digital Creativity Support by Journalists in Newsrooms

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ABSTRACT

This paper reports the evaluation of a new digital support tool designed to increase journalist creativity and productivity in newsrooms. After outlining the tool's principles, interactive features and architecture, the paper reports the installation and use of the tool over 2 months by 12 journalists in the newsrooms of 3 newspapers. Results from this evaluation revealed that tool use was associated with published news articles rated as more novel but not more valuable than published articles written by the same journalists without the tool. However, tool use did not increase journalist productivity. The evaluation results were used to inform future changes to the digital creativity support tool.

Author Keywords

Journalism; creativity; digital support; evaluation; newsrooms

CCS Concepts

• Human-centered computing → Interaction Design; Empirical studies in interaction design

THE CRISIS IN JOURNALISM

A free press is needed to ensure that citizens of democracies have access to the information needed to hold governments to account. Communicating this information is a key part of democratic decision-making, to increase the likelihood of transparency and decisions consistent with people's sense of justice. In the tripartite system of modern democracies, a free press is sometimes called the fourth estate, alongside the legislature, executive and judiciary [6]. Discovering angles, such as personal stories, with which to communicate information effectively can enhance democratic decision-

making, as recent *Brexit* stories about elected local politicians being denied UK citizenship demonstrate.

However, the digitalization of news production and consumption has led many news businesses to become uncompetitive [13]. Reduced incomes from newspaper sales and the failure of news businesses to transform and operate more competitively [39], due in part to some journalists rejecting changes to newsroom practices that conflict with their professional values and/or disrupt their autonomy and work [15], have resulted in fewer employed journalists. As a consequence, journalists who continue to work in these businesses often have less time to research, investigate and write articles. To manage, they often use subsets of familiar information sources to create articles [27] – subsets that can reduce the number, diversity and creativity of angles used to communicate information.

Different forms of digital tool to support journalists to discover and examine information from multiple sources have been developed. Some support journalist creativity, albeit indirectly. For example, the *Story Discovery Engine* used artificial intelligence algorithms to support investigative reporting [8], and *Tell Me More* mined the web for similar stories reported by different sources and extracted text that offered new information in the form of quotes, actors and figures [21]. Other tools were developed to support journalist productivity, for example by automating parts of the reporting process [10] and analysing the increasing amounts of available open and big data with data visualization techniques [17]. However, these tools were not adopted in newsrooms. Instead, to seek to improve journalist creativity and productivity, news businesses have set-up in-house media labs and created start-up incubators and accelerators to connect with new technologies [12,33].

In response, this paper reports the evaluation of a more direct form of digital creativity support for journalists to discover novel and useful angles on new stories when working in newsrooms. To support the productive discovery of these

new angles, the digital support was designed to integrate into journalists' existing work tools and processes, and to support journalists quickly to discover dissimilar ideas in different search spaces. To investigate whether this more direct digital creativity support would be effective in newsrooms, an evaluation of the support's use in 3 local newsrooms was undertaken, to determine if its use by journalists was associated with the development of more novel and useful articles.

However, newsrooms continue to be difficult environments in which to introduce digital innovations. Factors shown to impede the uptake of digital innovations include decreased newsroom autonomy, a newsroom work culture that is closed to innovation, lack of management support for journalist training and setting up the conditions for successful uptake, the irrelevance of the new technologies, and the absence of innovative individuals (e.g. [42]). Consequently our research also investigated whether these factors influenced the adoption and use of the digital creativity support.

RELATED WORK IN DIGITAL CREATIVITY SUPPORT

Unlike in journalism, digital creativity support tools have been implemented for professionals in other creative industries such as the performing arts, music, and film and television (e.g. [1]). Examples of the digital support include *StoryCrate*, a collaborative editing tool developed to drive users' creative workflows within a location-based television production environment [5] and *Trigger Shift*, which appropriated information technologies into performance art in theatre [18]. Bespoke digital creativity support tools have also been developed to support early collaborative design tasks (e.g. [4,11,20,37]). Studies have also investigated how existing technologies such as social media platforms afforded collaborative creativity in creative domains [14,24]. By contrast, as the introduction revealed, few digital tools to support the creativity of journalists had been developed, even though journalism is one of the creative industries. Therefore, selected principles and algorithms from these existing tools were used to develop the new tool to support journalist creativity.

Most evaluations of digital creativity support tools that have been reported are controlled studies of short periods of use (e.g. [4,40]). Although valuable, these studies reveal little about the impact of the longer-term uptake and use of such tools. The design of such tools also requires findings from longer-term evaluations related to learning, uptake, integration into their existing work tools, and fit with work cultures.

THE INJECT TOOL

INJECT is a digital tool that was designed to support journalists to discover creative angles on new news articles, and to discover these angles more productively than with existing digital tools. It was built to support human-centred creative cognition [23], a process in which idea generation about new angles took place concurrently with information search. To support a journalist to discover new angles more

productively, INJECT automatically retrieved news information with creative strategies that codified the expertise of experienced journalists [29]. And to increase a journalist's creativity capabilities, INJECT presented the retrieved information with interactive creative guidance to support the journalist to generate new angles on news articles. The designed-for outcome was new articles that were more creative, i.e. both novel and valuable [28] because of the inclusion of validated information new to the journalist, generated more quickly and hence productively than before.

To ensure INJECT's usability and effectiveness, journalists were included throughout its development process. Journalists were interviewed to discover problems, requirements and constraints. Paper-based then digital wireframes of the tool were developed and presented to professional journalists. New releases of the working INJECT software were tested for their usability and impact, first with journalism students who had no direct relationship to the authors, then with professional journalists working in magazines, regional newspapers and as freelancers. Further releases of INJECT were then deployed for prototype use in newsrooms. During some of these deployments, journalists used a bespoke digital platform to report software bugs and new requirements. More details are reported in [29,31].

As reported in [31], INJECT was implemented as a permanent sidebar on the right side of the text editor, based on the *Google Docs* Add-on sidebar feature. To work within the sidebar constraint (a fixed width of 300px), it was implemented with features to generate candidate news angle topics directly from text already written in the larger editor window, as well as with icons with mouse hover-box descriptions to control the sidebar, and mouse hover-boxes to present information quickly in context. As well as the sidebar for *Google Docs*, INJECT was implemented as a sidebar with the same dimensions for the *Wordpress*, *Adobe InCopy* text editors and content management systems that use the *TinyMCE* text editor. It was also implemented as a separate web application that a journalist could reshape as the sidebar. A new example of the sidebar in a *Google Docs* text editor window being used to write an article about mass tourism at the Venice carnival is depicted in Figure 1.

To support idea generation about new angle topics on articles, INJECT searched news information using 6 predefined types of angle elicited from experienced journalists. A journalist clicked 1 of 6 icons also shown in Figure 1 to invoke 6 corresponding creative strategies to search for information about: (1) quantitative data associated with the new article; (2) people associated with the new article; (3) events associated with the article's background; (4) comical information associated with the article; (5) future consequences of the article, and; (6) published visualizations of data and information associated with the article. Each of these strategies implemented the codified expertise of experienced journalists [29] using natural language parsing, word sense disambiguation and query expansion algorithms

to search information in over 12million (and growing) indexed news articles from over 300 news sources written in 6 different European languages. Furthermore, to support journalists to discover new topic angles using more context-specific sources, INJECT also indexed and retrieved news information from available local news archives.

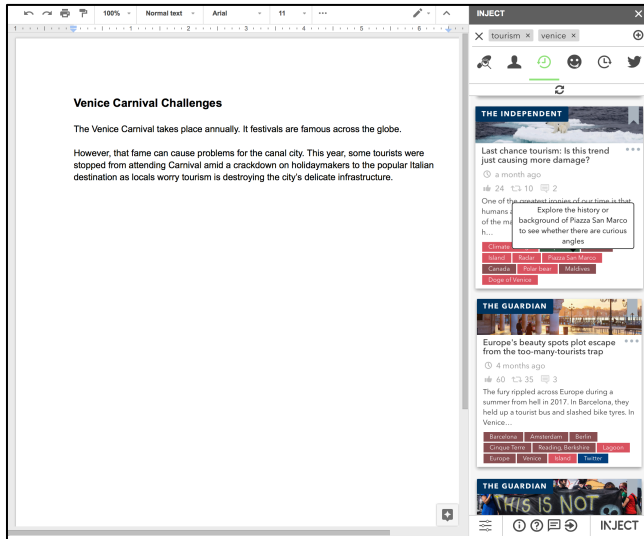


Figure 1. The INJECT sidebar providing creative guidance to a journalist writing an article about the annual Venetian carnival, for example about the trend for last-chance tourism and/or background of the Piazza San Marco

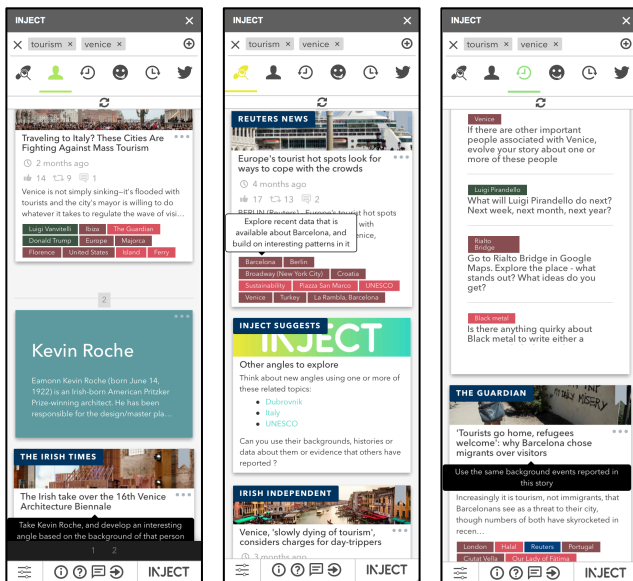


Figure 2. Examples of INJECT sidebars generated for a news article being written about the Venetian carnival and tourism

To present structured information about places, things, people and organizations that journalists might discover new angles about, INJECT displayed entities extracted automatically from retrieved news articles in colored rectangles, as shown in Figure 2. Moreover, when the journalist placed the cursor over each entity or the article title, INJECT pre-

sented a pop-up creative spark generated for that entity or title. Each spark was a codified creativity heuristic designed to encourage the journalist to undertake deliberate creative thinking. Examples of these creativity sparks in the pop-up windows are depicted in the 3 INJECT sidebars in Figure 2. In response to feedback from journalists who confused the roles of INJECT and Internet search tools such as *Google* search, some INJECT features were redesigned to minimize similarities. New types of information card presented possible new angles on stories to journalists without reference to individual news items, as shown in the middle sidebar in Figure 2. Each card displayed 3 entities extracted from retrieved news stories. Other changes included article word-clouds, the creativity sparks in list form, and automatic referencing of the article. The journalist could also invoke a separate *Google* web search within INJECT to follow up seamlessly after the discovery of new ideas for angles on news articles with Google searches to retrieve more detailed information to complete the articles.

To deliver the described creativity support to journalists, INJECT's architecture was designed with 3 layers:

- A user interaction layer that enabled different interfaces, such as the sidebar plug-in for Google Docs;
- A data layer of an index of, in April 2019, 12million published news stories discovered using RSS feeds from 300+ news sources. Another 500,000 indexed stories were added to the index each month. INJECT's journalist team selected these 300+ sources to represent political perspectives and reduce the risk of echo chambers. The data layer also included a database of over 50,000 political cartoons. In addition, INJECT accessed information from Wikipedia but did not search it, so it was not part of the data layer;
- An application layer of software services that supported journalists to generate news stories more creatively and productively: 1) the creative search service manipulated topic descriptions from the text editor to generate queries and implemented the different creative search strategies; 2) the news extraction service collected and indexed information from the 300+ news sources prior to creative search; 3) the creative sparks service generated creative sparks that were tailored to entities extracted from news information; 4) the concept card service that allowed individual journalists to edit and maintain personalised sets of concept cards, and; 5) the persistence service that provided search session storage and retrieval capabilities. The news extraction and creative sparks services pre-generated news information content for the sidebar, to reduce the impact of the Add-on's performance constraints.

For example, the news extraction service collected and indexed news information using public RSS feeds to the 300+ news sources and tailored machine learning and natural language processing algorithms. It uploaded this information from the feeds every 30 minutes and stored it in a PostgreSQL database as metadata, with raw article data text

as strings and a URL link to the source. It removed non-news content such as navigation links and adverts. It detected and extracted the people, location organization and event entities. It applied advanced natural language parsing to determine noun and verb phrases. And it uploaded each processed news article into an external Elasticsearch Cluster. More details of this and other services are also reported at more length in [31].

The technical installation of INJECT in any newsroom involved 3 activities: (1) the download and installation of the INJECT sidebar plug-in for each different text editor in use in the newsroom on the desktop computer of each journalist who used INJECT; (2) the optional technical adaptations of the sidebar to fit with other desktop tools and the local work practices of the journalists, and; (3) optional bespoke software coding to integrate INJECT with local news information archives, and the implementation of new queries to retrieve all article information from the archive databases at run-time.

EVALUATION OF INJECT IN 3 LOCAL NEWSPAPERS

The INJECT tool was deployed in the newsrooms of 3 local newspapers in Norway. The evaluation of this deployment provided first-hand data about the benefits from and barriers and constraints to INJECT use. Each of the 3 local newspapers was an established newspaper title in Western Norway, employed less than 40 staff and had print circulations of between 6,000 and 9,000. Two of the newspapers published 3 print editions per week and the other published 5, and all 3 also maintained online digital editions.

The INJECT tool was installed into the daily work practices of 4 journalists at each of the newspapers for 2 months in the first half of 2018, for use in the Norwegian and English languages. The newspaper editor at each of the newspapers selected the journalists to use INJECT, based on their workloads and roles. Each of the journalists was trained onsite to use the INJECT tool but did not receive training in creative thinking techniques. None reported knowledge and/or experience with any structured creative thinking techniques. At the start of the evaluation, the INJECT tool had indexed 2.7m English-language articles, which rose to 3.2m at the end of the evaluation. At the start of the evaluation, the tool had also indexed 260,000 Norwegian-language articles, which rose to 300,000 at the end. INJECT also searched the 50,000 digital cartoons. Moreover, the journalists requested that INJECT also generated creative guidance specific to their localities using over 100 years of articles printed in the 3 newspapers. After discussion with the third-party organization that maintained this digital archive, the tool also indexed 62,160 Norwegian-language articles from the archives published between 2015 and 2018.

All 3 newsrooms used the *Adobe InCopy* text editor, so the *InCopy* version of the INJECT sidebar was made available. However, a different third-party organisation that was contracted by the 3 newsrooms did not integrate it into the editor. Instead, all of the journalists were set up to use the web

application version shown in Figure 3 in a separate browser window.

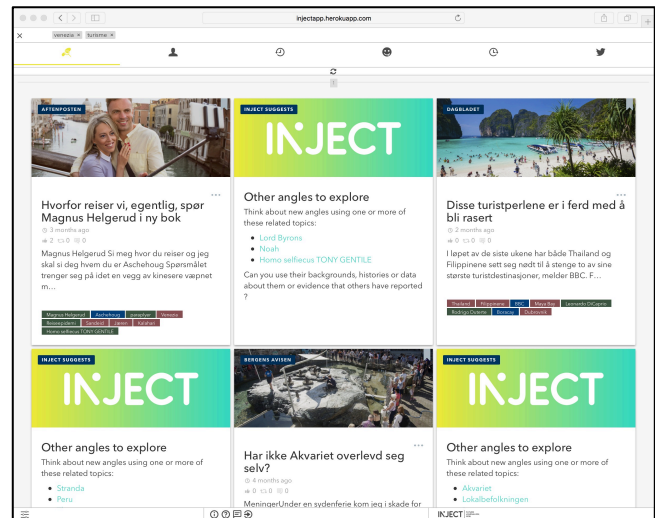


Figure 3. The INJECT web application version providing creative guidance in Norwegian to a journalist writing an article about the Venetian carnival

The evaluation investigated whether journalists in the newsrooms produced articles that were: (RQ1) more novel and valuable with support from the INJECT tool, and; (RQ2) written more productively with this support. These qualities of novelty and value mapped to the requirements for news to be surprising and relevant revealed during a review of key qualities of news reported in 2016 [32]. It also investigated whether: (RQ3) factors such as increased newsroom autonomy, a work culture open to innovation, management support to train journalists and set up success conditions and the presence of innovative individuals [30] influenced the use and the effectiveness of the INJECT tool.

The Evaluation Method

To investigate RQ1 a sample of articles produced by the journalists with and without INJECT's support were rated by 7 judges with journalism expertise and/or knowledge of the newspapers' regions. Three of the 7 judges were domain experts in journalism – associate professors of journalism at higher education institutions. The others were the head of information at a regional institute in business and trade, two local business leaders in tourism, and a retired legal stenographer. All lived in the regions covered by the newspapers. Each judge was assumed to be able to rate 40 articles accurately in the available 3-hour period, so each rated 20 articles that journalists had written with support from INJECT and 20 written without it in the same period 12 months earlier. A random number generator algorithm at random.org was used to select the 40 articles, and numbers of articles proportionate with the total number of articles written by each journalist with the support of INJECT were selected. The 40 articles were then randomly ordered in a questionnaire using another algorithm at random.org, anonymized and presented with two 1-7 scales to capture each judge's

novelty rating and value rating of each article. An example of one of the questions asked in Norwegian on the questionnaire was *Kor verdifull er artikkelen for den lokale offentlegheita den er skriven for?* meaning *how valuable is the article for the local public domain that it is written for?* Novelty and usefulness are oft-used measures to evaluate creative ideas and products (e.g. [28,40]), and human expert judgment has been shown to be an effective source of these novelty and usefulness measures (e.g. [19]). The journalists also recorded a digital log during the evaluation period to report the forms of support that INJECT provided to write each article.

To investigate RQ2, the journalists used the digital log to estimate the time spent using INJECT's support. In addition, one researcher visited the 3 newspapers to interview the 12 journalists based on these log entries. Quantitative data about published news articles such as word counts were also investigated, but other direct measures of journalist productivity such the numbers of words written per hour were not, due to obvious threats to validity of the data arising from the diverse contexts in which INJECT might be used in newsrooms.

And to investigate RQ3, the researcher who visited the 3 newspapers interviewed the journalists and their editors and newsroom managers at each of the 3 newspapers about enablers and barriers to INJECT use.

The Evaluation Results

INJECT was used in all 3 newsrooms, and no major technical problems were reported. A total of 72 published articles were written with INJECT's support by 10 of the 12 journalists. In interviews, one of the other 2 journalists reported not using INJECT because of a lack of time due to short deadlines and simultaneous tasks, and the other was reported to be out of the office frequently and not available to use INJECT. These interviews also revealed that the 1 journalist from each newspaper involved in the earlier co-design of INJECT wrote the largest number of articles with it, and that the editors in each newspaper trusted these "super-user journalists" to encourage INJECT use by the other journalists. By contrast, no newspaper editors used the tool. In interviews the editors report that use of the tool was not part of their roles, and that there was little time for them to learn and use it.

The effect of INJECT use on article creativity was investigated. Analysis of the articles written with and without its support revealed that the expert ratings of the novelty of articles written with INJECT were significantly higher than of the articles written without it. A Mann-Whitney test revealed that the novelty ratings were greater for the articles written with the support of INJECT (Mdn=3) than without the support (Mdn=2), $U=6997.5$, $p<0.0001$. INJECT use was associated with an increase on the novelty of articles, albeit from low average ratings that indicated that most non-INJECT articles were rated as not very novel.

In contrast there was no significant difference in the ratings of the value of articles written with and without INJECT. A Mann-Whitney test revealed that the value ratings were not greater for the articles written with the support of INJECT (Mdn=5) than without the support of INJECT (Mdn=5), $U=9156$, $p>0.05$. The average value rating of all of the articles was 4.7 out of 7. The lowest and highest average value-rated articles were 3.71 and 5.86, indicating that all of the articles were rated as having at least some value. This result was perhaps unsurprising, given that all of the articles had passed through the newspapers' editorial process and been published, which indicated value.

The journalists recorded digital log entries for 64 of the 72 articles, and these entries revealed that INJECT was used to generate new information for 34 of the 64 articles. They reported uses of INJECT to discover new angles on articles such as (translated from the original Norwegian): "*The idea for the article came from a [creativity spark]. I used INJECT to find exciting ideas about how I could approach the case*". Similarly, the journalists reported that it provided inspiration: "*Got some inspiration for what others wrote about the 'Utøya 22 July' film by Poppe*". The journalists also used INJECT to discover new sources of information: "*INJECT helped me see other things that were written about Ingrid Brandseth*", background information such as: "*It gave me a new source and a lot of background information and facts. INJECT actually gave me more stuff than I needed, so the rest will be saved for the next occasion*", and other articles on the same theme: "*This is an article about UKM. INJECT showed me how other journalists have written about the event earlier*". Journalists also reported that new sections were added to articles: "*Received feedback about the problem based on a few reports in the National Newspapers (Dagbladet) on urban issues. Resulted in a section of my case*". Overall, the analysis of the log entries revealed that increased article creativity might have been associated with more diverse uses of INJECT than it had been designed for – not just to discover new angles, but also to include new information directly into the article once the angle was established. Moreover, during the interviews, some journalists agreed that it was difficult to know where inspiration came from: "*Ideas can pop up everywhere. Was it INJECT, or did I see it on Facebook?*".

In contrast, for 25 of the 64 articles, the log entries revealed that INJECT failed to retrieve information that the journalist deemed relevant (e.g. "*Did not help, did not find what I was looking for*"), or only retrieved information already familiar to journalists (e.g. "*Did not help me. Was looking for inspiration for a new title or angle, but did not think it was anything fitting*"). These latter responses highlighted technical challenges associated with retrieving information that is not only relevant but also novel to journalists.

Given that the increase in article novelty ratings appeared to be associated with the use of INJECT to write some but not all articles, patterns of INJECT use were investigated. The

totals of articles published with INJECT's support varied by newspaper and by journalist, see Table 1. In the newspaper that generated the most articles with this support, all 4 journalists published articles. However, in the second newspaper, 2 of the 4 journalists generated all but 1 published article, and in the third, all but 2 of the articles published.

First newspaper	Second newspaper	Third newspaper
13 articles	9 articles	7 articles
12 articles	8 articles	4 articles
11 articles	1 article	2 articles
5 articles	0 articles	0 articles
Total: 41 articles	Total: 18 articles	Total: 13 articles

Table 1. Totals of articles written with INJECT support that were published by each of the 4 journalists in turn in each of the 3 newspapers

Interview responses revealed possible explanations for these variations. The 4 journalists in the first newspaper were all young, new to the newspaper, worked more autonomously, and were open to using new technologies at work. They also supported each other to use the INJECT tool, and self-organized in the absence of formal structures: *"the leadership could have delegated tasks, and instructed the staff about who should be part of it"*. By contrast, the journalists at the second newspaper were more experienced and varied – a specialist in desk news writing, a photojournalist, and 2 news journalists. During the evaluation the 2 news journalists continued to access and work with municipal documents from regular local sites to inform most of their work. The photojournalist spent less time in the newsroom, and demonstrated the obvious need for journalists to be present in the newsroom to use INJECT.

By contrast, the 4 journalists at the third newspaper were also seasoned journalists, each with at least 10 years of journalism experience, and all with established approaches to writing articles. One reported: *"have worked here about the same length of time. The culture that was here when we came in has been upheld and recreated by us"*. Willingness to use INJECT was low: *"We seem to have certain stubbornness against using INJECT and other tools like it. We don't learn to use new data programs voluntarily, and especially not programs that don't work optimally when we start using it"*. Moreover, the absence of INJECT use was associated with lower article novelty. The average expert ratings of the novelty of articles written with and without the tool's support by the more experienced journalists in the third newspaper was the same, at 3.0, whereas average expert ratings of the articles written by less experienced journalists at the first newspaper rose from 2.6 to 4.0. Both an openness to change and a willingness to innovate appeared to influence INJECT's use, and this use was associated with the generation of more novel articles.

The journalists used INJECT to write certain types of article. Almost half (34) were about social issues and over another quarter (21) about culture issues. In contrast, the journalists wrote few articles with INJECT's support about

politics (3), crime (2), sports (2) and economy (4), even though the majority of articles written by the journalists during each month were not of these types. During interviews, the journalists reported that INJECT was more effective for writing research-based journalism such as features, portraits and other long form genres. One said: *"For our everyday news we always have too many stories already. But during the magazine meetings we are required to come up with ideas from scratch, and ideally it should be something we haven't written about before. So there we really need to be creative, and INJECT can be useful"*. Another reported a need for INJECT 4 times a year, to write for each of the 4 magazines for the 4 seasons that required long-form feature stories with the careful building of angles. Moreover, the third newspaper that used INJECT's support to write the fewest published articles was also the newspaper that published the lowest proportion of feature stories in its editions.

Although results revealed that INJECT use was associated with increases in the novelty of articles of certain types, the results revealed little evidence of increases in the productivity of the journalists. Of the expert-rated 40 articles, the 20 written with INJECT contained more words than the 20 without it. An unpaired t-test revealed a significant difference in the numbers of words written to describe an article with the support from INJECT (Mdn=652, SD=393) and without support from INJECT (Mdn=414, SD=211) conditions; $t = 2.08427$, $p < 0.05$. However, according to log entries, the time that journalists reported to prepare each article varied from 0 to 200 minutes, and averaged just over 40 minutes, and the time to write each article varied from 5 to 420 minutes, and averaged was just over 85 minutes. The journalists did not perceive these times to be lower than required to prepare and write articles without INJECT support.

Neither did the interviews reveal any evidence of increased productivity. Indeed, some journalists reported a neutral or negative sense that use of the INJECT tool was a chore rather than an opportunity. The journalists in the third newspaper reported that they could not become more efficient with tool designed to support their creative thinking: *"The way our newspaper is run, INJECT is a tool that increases the time spent writing an article. Maybe we could get better stories if we cultivated just the right functions and drilled all journalists until they used it"*. Another said: *"No, because it takes time to use INJECT. It takes away time that we could have spent on writing the story"*. They contrasted INJECT with other types of digital tool such as *"template based news writing"* that might make their work more efficient. However, the journalist in the second newspaper who did not use INJECT reported that if it had been integrated as the toolbar in the *Adobe InCopy* text editor, it might have been easier to remember to use.

That said, some journalists reported that INJECT both replaced *Atext* or other news aggregators and enhanced their

access to the newspaper's own archives. One reported: *"I have used INJECT to check if others have written about the same topic, or about something that happens locally now. Although I don't necessarily feel creative, I can look at how they wrote or collected information, how they have illustrated the story, and more. I could also have used the internal archive, but sometimes INJECT gave me good alternatives from current news mixed with archive materials"*.

During the interviews one journalist identified another possible role for INJECT: *"Productivity is looking for the right things when you are out on an assignment, and not spend too much time on it. This relates to how well prepared you are"*. On a related theme, other journalists reported creative activities that took place outside the newsroom, for example: *"I wrote about drug addiction in Stord, and I hung out for a whole day in a billiard hall just to get on a speaking basis with people, and I remember I thought this was very creative"*. These interviews revealed that the journalists reported that INJECT did not support important activities such as preparing for assignments or for creative thinking outside of the newsrooms. As a result of the original user-centred design process, INJECT had been introduced as a desktop tool and provided no specialist support for tasks outside of the newsroom, even though one version of INJECT was a responsive web application usable with mobile web browsers. These results revealed that opportunities to use INJECT capabilities outside of newsrooms had been missed.

Furthermore, the interviews with the newspaper editors and managers revealed that none used INJECT during the evaluation. This lack of use might have been perceived as a lack of leadership – a role filled instead the super-user journalists. In interviews, the journalists revealed that their use of INJECT led to new skills and competencies. It is possible this made it more difficult for editors to provide the leadership, training support and success conditions needed to extend use of INJECT in the 3 newsrooms.

The Evaluation Conclusions and Discussion

Returning to the research questions, the results revealed that journalists in the newsrooms produced news articles that were: (RQ1) more novel but not more valuable using the support from the INJECT tool, and: (RQ2) not written more productively using this support. The more novel articles were more often feature rather than news articles that journalists had more time to write. Responses during interviews (RQ3) revealed that increased newsroom autonomy, a work culture more open to innovation and the presence of innovative journalists were associated with greater INJECT use. By contrast the management support to train journalists and set up success conditions at all 3 newspapers were reported to be lacking.

The answer to RQ1 warranted more analysis. Although the articles were not rated as more valuable, all were still published in the 3 newspapers, which indicated that all had sufficient value for their purpose. One interpretation was

that the articles written without the tool's support also had value but had lower novelty, i.e. the articles were not creative. By contrast, the articles written with the tool's support had increased novelty but not increased value. Therefore, in a strict sense, these articles were more novel rather than creative, but still had sufficient value to publish. Trade-offs between outcome novelty and value have been reported during creative processes (e.g. [19]). By contrast, the results from the evaluation revealed that journalists' uses of the tool increased novelty and maintained value.

Furthermore, the content analysis of the log entries provided evidence that journalists used INJECT to discover ideas that were both more similar (e.g. *to add new sections to an existing article*) and dissimilar (e.g. *to discover new angles for an article yet to write*) to their original topics. Whilst discovering more dissimilar ideas is often associated with less productive idea generation [35], the exploration of possible similar ideas related to the original topic with the INJECT tool also did not appear to be more productive. Indeed, the increase in article novelty required more time from the journalists to write the articles, in spite of the automated information retrieval algorithms. And the high volume of journalist work needed to publish articles for regular deadlines offered little time to explore the tool. Therefore, further INJECT development appears to be needed to reduce the tool's burden on journalists, although the use of INJECT to replace news aggregators and access news archives reveals one possible role – a more productive one-stop tool for accessing news information but for different purposes.

The journalists' uses of INJECT to discover new angles and information content to write feature articles were achieved without any explicit creativity training. Amabile's componential theory of creativity [2] argues that a person needs domain knowledge, motivation and creativity skills to generate creative outcomes regularly, so the detected increase in article novelty without explicit training in creativity skills demonstrated INJECT's potential. This finding was considered important. Not only did the newspapers lack resources to allow journalists to take time off from frontline reporting, but also motivating journalists who had chosen to work in the creative industries to learn new creative skills was challenging. Furthermore, the results revealed that creative thinking skills conflicted with journalist practices established during training to read newspapers, visit libraries and ask questions to discover new angles on stories – a social process that led to conversations with people rather than individual work with creative thinking techniques and tools.

The journalists who were more open to technologies and changes in working practices made greater use of INJECT, and the newsroom most open to innovation used the tool to write the largest number of articles. Other journalists were reluctant to change their work practices in order to adopt and exploit a tool that sought to automate some elements of their professional work, a finding consistent with journalist

resistant to change that conflicts with their professional values reported in [12] and a factor shown to impede digital innovation in newsrooms [42]. This resistance was more pronounced with more experienced journalists who had established work practices.

Of course, threats to the validity of these evaluation results exist. The journalists wrote the articles with INJECT's support after gaining one extra year of professional experience. And the articles written with INJECT's support were more recent, and hence new to the experts. Both of these factors might have influenced the ratings for novelty. Furthermore, not all of the experts had expertise in journalism. However, the log entries did provide self-reporting evidence of INJECT use to improve articles. Furthermore, the journalists might have chosen to write different types of article with and without INJECT, although an analysis not reported in the results revealed no difference between the totals of articles of different types written with and without the tool were found. Nonetheless, the results from the evaluation need careful interpretation. Repeat evaluations of INJECT in other newsrooms are planned.

Other Factors Influencing the Evaluation Results

In addition, two other factors identified during the research team's installation and implementation of the tool in the 3 newspapers also appeared to influence the results. The first was important newsroom dependencies on third-party organizations for technical support, which led to the failure to integrate the INJECT sidebar into the text editors used in the newsrooms. Although INJECT was available for the text editor sidebar in use in the local third-party organization that supported *Adobe InCopy* did not implement the sidebar in it. Innovations such as INJECT fell outside of the existing contract, and were not prioritized or supported. The technical and contractual dependencies that smaller news organizations have on external ones could be interpreted as an extended form of the increasingly institutionalized and distant relationships between journalists and technologists already observed in smaller Norwegian newspapers [22]. One consequence was that the technical requirements of the 3 newspapers conflicted with the usability preference expressed by the journalists to work with just one tool. And because these needs were not met, some reported not using the web application version when writing stories.

The other factor was the digital formatting of the news archive belonging to the 3 newspapers, which also imposed constraints on the support that INJECT offered to the journalists. Only 3 of the last 100 years of the 3 newspaper's publications were accessible to index. Earlier print editions of the newspaper had only been scanned and stored as full PDF pages, which did not enable full INJECT indexing of individual articles. This failure of the newspapers to hold all of their archives in formats that enabled cost-effective indexing limited INJECT's access to and use of the archives, and conflicted with the newspapers' expectations.

EVOLVING THE INJECT TOOL AND ITS USE

The evaluation revealed that INJECT tool use was associated with an increase in novelty of articles written by journalists who used it. In hindsight, this result was perhaps surprising given the many barriers to the tool's uptake and use that were uncovered. Therefore, to increase the likelihood of future successful INJECT uptake and use, new tool features will be added to encourage journalists to use INJECT to discover content to include in articles. An example of these features is one-click automated referencing of article content. Future versions will also reposition INJECT as a one-stop shop for news information, differentiate between information use to discover new angles on new stories and add to existing stories based on one of these angles. Local news archives will be used more to support this second role.

The web application version of INJECT will be extended with new sidebar features such as topic extraction from text editor content. Other features that are planned include automated reminders to journalists to use INJECT during certain tasks, and new algorithms to generate candidate angles on future stories before journalists start to write them, based on news event schedules published by media businesses and calendars of local events. The responsive web application version will also be extended to support mobile work outside of newsrooms. Furthermore, some journalists reported using the INJECT tool to prepare angles and questions for offsite interviews, so the new version will be extended with an interactive feature with which to generate questions with which to support preparation for interviews based on variations of the INJECT creativity sparks.

WIDER IMPLICATIONS FOR DIGITAL CREATIVITY SUPPORT IN JOURNALISM

The reported research demonstrated how a new digital creativity tool supported journalists to discover new angles and content which to write feature articles. Articles written with the support were rated as more novel than other articles written without the support. The tool also has the potential to be a one-stop shop for news information.

However, the tool's support for writing feature articles exposed its lack of support for hard news articles. News reporting is the main purpose of most news organizations. INJECT's lack of support for it revealed that, in its current form, the tool contributed little to overcoming the journalism crisis resulting from digitalization of news production [13,39]. One implication is that supporting journalists to think creatively and discover new angles will require more intervention into the work of journalists, to demonstrate that use of creativity tools can maintain their work autonomy and need not disrupt their professional values [15].

Indeed, the results revealed that the use of INJECT sometimes decreased journalist productivity. The evaluated design did not provide journalists with the simultaneous creativity and productivity gains obtained by professional users in domains such as manufacturing [30]. Unlike INJECT, this other tool automatically generated new creative content

that the users could adapt more quickly than generate and write themselves. Therefore, one more ambitious direction is to integrate INJECT's digital support into tools for template news writing which frame the numbers and locations of fixed paragraphs with word lengths, to generate new content of the required length and form that journalists can adapt rather than write themselves. However, although similar to automating parts of the reporting process [10], such interventions are likely to be resisted by journalists [42], and raise legitimate concerns about journalist deskilling and barriers to autonomous working [32].

The evaluation also identified new opportunities to enhance journalist skills. Digital innovations often require journalists to acquire new skills. Data journalists, for example, are now expected to have programming, data analysis and visualization skills [7]. During training to use the INJECT tool, few of the journalists reported knowledge and/or experience with any structured creative thinking techniques, even though they worked in the creative industries [9]. Creative thinking skills are essential to produce creative outputs regularly [2]. If journalists will require these skills to write novel articles based on new angles as part of their regular work, then journalist education and training might need to change. Super-user journalists as creativity facilitators in newsrooms open to innovation can support more creative thinking. Other forms of tool can support this creative facilitation, for example to connect less and more experienced colleagues for creative work [26] and support collaborative idea generation [3], especially in specialist areas such as science journalism [41].

Indeed, journalism can be framed using creativity theories. It is the search for and critical analysis of information [34], so information processing theories of creativity that describe it as systematic search for information leading to the idea generation (e.g. [36]) can be used to describe journalism search and analysis activities, and uncover opportunities for creativity support. Other theories that describe creative processes as social ones, in which people collect, relate, generate and donate knowledge in repositories [38] can inform new uses of collaborative creativity based on news archives in newsrooms.

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