Evaluating TweetBubble with Ideation Metrics of Exploratory Browsing

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ABSTRACT

We extend the Twitter interface to stimulate exploratory browsing of social media and develop a creative cognition method to establish its efficacy. *Exploratory browsing* is a creative process in which users seek and traverse diverse and novel information as they investigate a conceptual space. The TweetBubble browser extension extends Twitter to enable expansion of social media associations—`@usernames` and `#hashtags`—in-context, without overwriting initial content. We build on a prior metadata type system, developing new presentation semantics, which enable an integrated look and feel consistent with Twitter.

We show how exploratory browsing constitutes a mini-c creative process. We use prior ideation metrics as a basis for new ideation metrics of exploratory browsing. We conducted a mixed methods crowdsourced study, with data from 54 participants, amidst the 2014 Academy Awards. Quantitative and qualitative findings validate the technique of in-context exploratory browsing interfaces for social media. Their consistency supports the validity of ideation metrics of exploratory browsing as an evaluation methodology for interactive systems designed to promote creative engagement.

Author Keywords
information-based ideation; social media; browsing

ACM Classification Keywords
H.5.2. Information Interfaces and Presentation (e.g. HCI): UI

INTRODUCTION

We develop an exploratory browsing interface for Twitter, *Tweetbubble*, and a creative cognition method to evaluate it. Exploration, be it of the moon or the World Wide Web, is a fundamentally creative endeavor. Creativity researchers identify a spectrum of creative acts, spanning from mini-c to Big-C [21]. They define *mini-c* creativity as, "the novel and personally meaningful interpretation of experiences, actions, and events" [3]. They consider empirical studies of mini-c creativity as essential to supporting learning and expression.

Likewise, according to Boden, exploratory creativity arises through traversing a structured conceptual space [4]. We thus define *exploratory browsing* as a creative process through which users seek and traverse diverse and novel information as they use the web to investigate a topic or conceptual space. Exploratory browsing of a structured conceptual space helps users develop new perspectives [4, 44, 27]. In this paper, we investigate mini-c creativity that arises through experiences with exploratory browsing interfaces.

Evaluation of exploratory browsing interfaces is an interesting research challenge. Kerne et al. derived ideation metrics of curation for measuring creativity in the curation products people assemble through engagement in information-based ideation tasks [22]. They took a creative cognition approach [14], extending methods developed for engineering design [35]. They developed elemental metrics—Fluency, Flexibility / Variety, and Novelty—for measuring creativity in the digital objects that people collect, and holistic metrics—e.g., Emergence and Exposition—for measuring creativity in the whole. Their research addresses the spectrum of mini-c to Big-C ideation activities and resulting creative products.

The present research alternatively investigates processes of mini-c creative ideation in exploratory browsing. As the user does not assemble a whole curation in exploratory browsing, only Kerne et al.'s elemental ideation metrics are applicable. We reformulate these elemental metrics to address creative processes and so derive *ideation metrics of exploratory browsing* for evaluation of exploratory browsing interfaces.

Twitter constitutes a conceptual space for exploratory browsing. The Twitter microblogging service is a vital medium for news, politics, scholarship, and other social discourse [25]. Twitter provides mechanisms for making *social media associations* within a tweet: `#hashtags` are used to collectively organize and categorize social media content on topics, spontaneously creating *folksonomy* [29]; `@username` references enable user-to-user exchanges [18]. Hashtag and username references provide a basis for exploratory browsing.

To support exploratory browsing, we developed the Tweetbubble Chrome extension, which subtly transforms the prior Twitter interface. While the prior interface (Figure 1a) replaces initial content on activating a social media association, Tweetbubble's new affordances (Figure 1b) enable in-context expansion (Figure 2). We *hypothesize* that through this technique, users will explore significantly more diverse and novel perspectives than default Twitter interface users. Compari-

Figure 1. Social media association interfaces for Twitter. (a) Prior Twitter interface. Clicking `@username` and `#hashtag` overwrites content in the current window. The user experiences a loss of context. **(b)** TweetBubble interface prepends expansion affordances (+ sign in circle) to `@username` and `#hashtag` associations. Cursor arrow points to Ellen's `@username` feed association. Dashed lines delimit the hashtag `#oscars`. Clicking would afford in retrieval and presentation in the current context, without overwriting initially rendered content.

son is performed by applying ideation metrics of exploratory browsing to data from a crowdsourced study.

The present hypothesis and interaction technique are based on recent findings by Qu et al. [33]. Their metadata type system enabled dynamic exploratory browsing interfaces, which simultaneously present multiple web pages as connected metadata summaries. This allows traversal of hyperlinked associations while maintaining context. In their study, computer science students preferred to browse research papers using the exploratory interface, in comparison to traditional browser tabs and windows. The exploratory interface also helped deal with disorientation and digression and supported comparison. The present study alternatively investigates the impact of dynamic exploratory browsing interfaces, on mini-c creativity, in everyday engagement with social media.

Measures of diversity and novelty have previously been utilized in studies of various creative contexts: e.g., prototyping web ads [11], collaborative ideation [24, 37], and game modding communities [16]. Flexibility and novelty in exploration and engagement are key factors in various creativity models [14, 35, 8]. Flexibility of thought processes is vital in exploratory browsing of Twittersphere, as people develop mutual understanding of a topic. We provide further basis for Fluency, Flexibility, and Novelty metrics in the next section.

Our contributions include: (1) validation of in-context exploratory browsing as an interface technique for social media; (2) ideation metrics as an evaluation methodology for exploratory browsing interfaces; (3) new presentation semantics to enable mimicking the look and feel of diverse, yet specific social media in generalized exploratory browsing interfaces; (4) the use of browser extensions for evaluation of interface design.

We begin with a survey of prior work across fields. We then show how the TweetBubble exploratory browsing interface

system is developed by extending a prior metadata type system [33]. Next, we motivate and present a crowdsourced study, with data from 54 participants, conducted amidst the 2014 Academy Awards. We gather mixed methods data. We derive ideation metrics of exploratory browsing. We find that the TweetBubble exploratory browsing interface results in increased Fluency, Flexibility, and Novelty. We draw on grounded theory methods to also show how our interface promotes creative exploration of social media. We discuss implications for exploratory browsing interface design and evaluation of their support for mini-c creativity.

BACKGROUND

We first consider prior work on evaluating information-based ideation, focusing on ideation metrics relevant to exploratory browsing. We follow with brief surveys of (1) interfaces and design principles for exploring associations, and (2) technologies for injecting scripts into web pages.

Evaluation of Information-Based Ideation Environments

Information-based ideation (IBI) is a paradigm for investigating open-ended tasks and activities, in which people generate and develop new ideas while browsing, searching, and collecting information [22]. Users perform exploratory browsing and search as part of engagement in IBI.

For evaluating exploratory search systems, White and Roth [44] suggested measuring information novelty, encountering sufficient information, and extent of topic space covered. However, they did not provide methods for these measures.

Building on Guilford's factors of creativity [17], engineering design researchers measured ideation in solutions to design problems [35]. Extending this, Kerne et al. derived a quantitative methodology for evaluating IBI support tools through a battery of *ideation metrics* [22]. Among these are elemental ideation metrics:
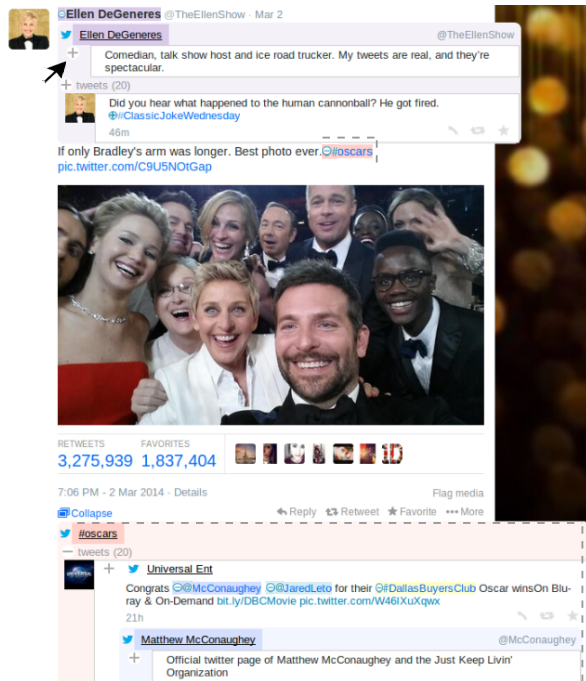
Figure 2. In-context expansion of social media associations with the TweetBubble Chrome Extension. `@username` and `#hashtag` feeds are now rendered without replacement of initial content. Cursor arrow is now pointing to the expansion of Ellen's `@username` feed. Dashed lines delimit the `#oscars` association and the expansion of its feed.

Fluency is the number of ideas. According to Darwinian theories of ideation, the more ideas a person considers, through survival of the fittest, the more likely it is that one idea will survive and grow to achieve creativity.

Flexibility / Variety is the number of categories of ideas. It addresses exploration of alternative interpretations. Flexibility measures the span of the solution space explored during ideation. Flexibility in thinking describes the cognitive process of trying out a Variety of different ways of looking at a problem. Variety provides opportunities for more remote associations, and more remote analogies, both of which are likely to lead to creativity.

Novelty is the rareness of an idea. It can be measured with statistical infrequency, which requires an appropriate norm for the space of possible ideas. While potentially difficult to assess globally, Novelty is straightforward to measure in the context of a controlled experiment, by building a master list and inverted index of all ideas generated by all participants. Then, count the number of participants that presented each idea. The lower the count, the higher the Novelty. The Novelty metric is analogous to information retrieval's inverse document frequency (IDF) measure [34].

Kerne et al. applied ideation metrics to measure creativity in the curation *products* that people author through engagement in IBI activities, by collecting, organizing, and annotating. The present research applies these metrics instead to creative *processes* of exploratory browsing.

Figure 3. Presentation semantics enable highly detailed metadata expansion. The rendering of Ellen's `@username` feed is customized with `concatenates_to`, `navigates_to`, `hide_label`, `use_value_as_label`, `show_expanded_as_always`, and `label_at` (See Tables 1 and 2).

Interfaces for Exploring Associations

We survey interfaces and design principles for supporting users in exploring associations. We pay particular attention to Twitter.

Wilson et al. found that in knowledge discovery tasks, interfaces that visually present associations help users assess how individual elements fit into a domain [45]. Web Summaries [9] extract and present metadata summaries from hyperlinked web pages. However linked summaries are presented in a separate Web Summaries window. Consistent with Wilson et al.'s findings, Web Summaries users reported spending too much time switching between regular browser and summary windows [10].

Fluid links [47] is an interface technique that presents brief representations of linked content below hyperlink anchors through interline expansions. The present in-context exploratory interface also interjects linked content.

We observe that Twitter's `@username` and `#hashtags` links are a lightweight mechanism for providing what Chi et al. call 'distal information scent' [7] in tweets, based on emergent trending topics and social networks. Suh et al. found that tweets containing `#hashtags` are often retweeted [40]. We interpret this to mean `#hashtag` content is significant to users' exploration, thus contributing to mini-c creativity.

TweetDeck [43] is a popular Twitter interface that can concurrently present multiple `@username` and `#hashtag` feeds in separate columns. Associations among Tweets are not visually presented across feeds.

Injecting Scripts into Web Pages

We developed a Chrome web browser extension to customize Twitter. Chrome extension technology enables selective injection of "content scripts" into web pages. This is similar to Greasemonkey [1], but enables broader deployment. Chrome plugins are self-contained packages, which users, such as the microtask workers in our study, install through the Chrome Web Store. Chickenfoot [5] also enabled end users to automate, customize, and integrate web applications.

Semantics	Description
layer	order of the metadata field; higher value means higher in order
hide / always_show	visibility of the metadata field; always_show is used to override the hide attribute
navigates_to	hyperlink metadata field to the specified destination
style_name	css class name to be applied to the metadata field
shadows	show this metadata field instead of the specified field
is_facet	metadata field can be used as a facet

Table 1. Presentation semantics previously defined in the Meta-Metadata language for metadata types.

Semantics	Description
label_at	positioning of label w.r.t. value of metadata field
concatenates_to	concatenate the metadata field to another
use_value_as_label	use value of another metadata field as label for this field
hide_label	visibility of the label of metadata field
show_expanded_initially	show the composite / collection field expanded initially
show_expanded_always	show composite / collection field expanded without affordance for collapse
style	element-level directive for conditional application of presentation semantics, based on these properties: is_child_metadata, is_same_metadata, is_only_element, is_top_level

Table 2. New presentation semantics in Meta-Metadata provide finer-grained control of rendering to enable seamless integration of exploratory browsing of @usernames and #hashtags social media associations within the Twitter interface.

EXPLORATORY BROWSING SYSTEM DESIGN

We briefly present the the TweetBubble exploratory browsing interface system design. The TweetBubble runtime, as a *Chrome extension*, is constituted by a content script that transforms the Twitter interface. In order to help users understand, work with, and think about conceptual spaces formed by Twitter social media associations, a dynamic exploratory browsing interface requires multiple feeds to be rendered within a single web page. TweetBubble uses the browser's JavaScript's XMLHttpRequest to retrieve social media association web pages in the background.

To facilitate extraction and presentation from associated @username and #hashtag feeds, we extend the *Meta-Metadata* language for metadata types, a component of the open-source *BigSemantics* framework [20]. Metadata types defined with Meta-Metadata integrally describe data models, extraction rules, and presentation semantics, for semantic representation of linked web pages [33], such as Twitter feeds. We used the types to build a look and feel consistent with Twitter. *Presentation semantics* enable detailed customization of the visual interface for particular metadata types.

We present a small use case, including details of new presentation semantics that enable customizing the look and feel of Twitter social media in the exploratory browsing interface. We follow this with the details of present interface design.

Mini-Scenario

We develop a small use case to demonstrate how user experience is facilitated through the type system's integration of presentation semantics. Janet clicks on the @TheEllenShow's expansion affordance (Figure 1b). Presentation semantics for the twitter_microblog type direct the in-context rendering of the @username feed (Figure 2, Figure 3: detailed). Janet then expands the newly rendered Twitter account information, to see details such as description, number of tweets, fol-

lowing, and followers. Presentation semantics again direct rendering. Likewise, Janet continue to expand the @username and #hashtag contained within the newly rendered tweets.

Prior presentation semantics provided important fundamental constructs (see Table 1). However, our goal was to seamlessly integrate TweetBubble into Twitter, mimicking its look and feel. This required us to provide more fine-grained control in Meta-Metadata. We developed new presentation semantics: positioning, expanding, collapsing, concatenating, and changing labels of the fields (Table 2). Figure 3 shows how TweetBubble is able to mimic @username feeds using the presentation semantics from Table 1 and 2.

The navigates_to directive hyperlinks the title to the URL value, affording press, to browse the original web page in a new tab (Figure 3). The hide directive eases the user's visual load by specifying to not directly render the URL field. We position labels below values, Twitter style, using the label_at directive in conjunction with the tweets, following, and followers fields. Meanwhile, concatenates_to renders these fields in the same horizontal span. The show_expanded_always directive renders complete metadata for each tweet, without any expand / collapse affordance. Applying the use_value_as_label directive renders the twitter microblog's photo as the label of each tweet.

Interface Design

TweetBubble interjects affordances for in-context expansion of @usernames and #hashtags into Twitter. Affordances also get interjected in the expanded @usernames and #hashtags metadata; their activation creates nested metadata expansion branches (Figure 4). This provides the ability to simultaneously view multiple feeds, form associations, and make comparisons. A palette of related colors is used to connect a social media association and its expansion as metadata.
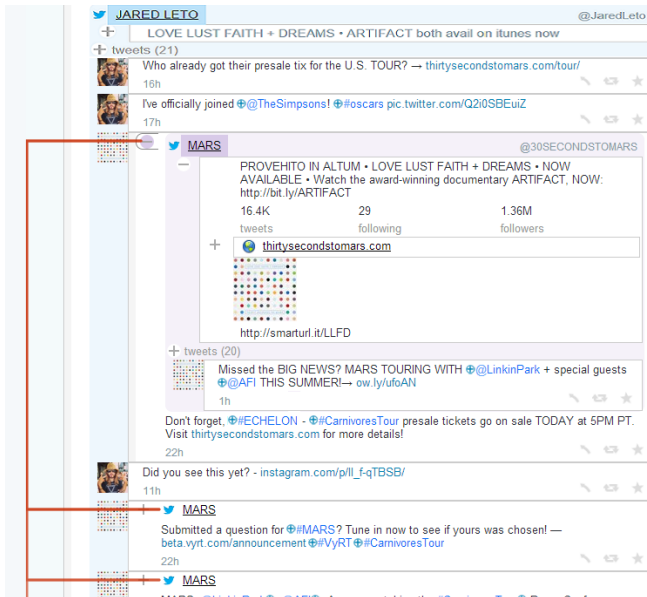
Figure 4. Nested in-context expansions of `@usernames`, `JARED LETO` and, in his retweet, `MARS`, facilitate understanding of associations and seeing the big picture. Redundant tweeter name and handle information within tweets rendered in these expansions are suppressed by presentation semantics: the `style`, `hide`, and `is_child_metadata` (see Tables 2 and 1). When social media associations recur, (here, those from the retweet of MARS), connection lines visualize recurrences.

Repetitive information becomes a problem as Twitter feeds and tweets are recursively expanded. More feeds are presented at once than in default Twitter. TweetBubble addresses the repetitive information problem by using presentation semantics, on each tweet, to suppress otherwise redundant display of tweeter name and handle. Further, to help orient the user, when s/he activates an `@username` field in a retweet, the interface draws red lines to visualize recurrent references to that `@username` in other retweets (Figure 4).

TweetBubble provides interaction consistent with Twitter. In Twitter, after expanding a tweet to see prior social discourse actions—*reply, retweet*, and *favorite*—pressing the background collapses. TweetBubble extends the mapping of press background to collapse all expanded information, streamlining navigation. Consistent interaction also includes affording social discourse actions with each tweet. We form tweet action URLs, using Twitter's unique ~18-digit tweet identifier, extracted via metadata types.

EVALUATION: ACADEMY AWARDS

We chose the 2014 Academy Awards as a context, or domain, for study of TweetBubble's support for creative exploratory browsing of social media. Baer and Kaufman develop the case for conceptualizing creativity 'as something that transcends content domains' [2]. Their Amusement Park Theoretical Model of creativity connects work in specific domains to general assessment and investigation.

With regard to general phenomena of creativity, ideation metrics, especially Flexibility / Variety, make sense for measuring creative exploration. The basis for this lies in the definition of

mini-c creativity, which involves meaningful learning and understanding. In social media, as in life, understanding diverse points of view provides a cognitive basis for comparison, synthesis, and mutual understanding. This constitutes the basis for a general assessment and investigation of creativity, in the Amusement Park Theoretical Model.

Various domains provide specific meaningful contexts for general investigation into mini-c creativity. People invest time and energy into that which they experience as meaningful. Learning and understanding about the Academy Awards is no more or less meaningful than domains more useful to society, such as citizen science and molecular biology.

Thus, the popularity of engagement in social media during the Academy Awards identifies this domain as a site for the investigation of support for mini-c creativity by an exploratory browsing interface. During the 2014 Academy Awards, over 5 million people sent 19.1 million Tweets and over 37 million people viewed those Tweets [15]. The mix of who tweeted included movie and fashion participants, press, and fans. Twitter users could experience large and diverse cross-sections of tweets. Encountering diverse and novel perspectives in a domain, such as this, results in mini–c creative ideation.

Study Design
We conducted a between-subjects study with Twitter interface as independent variable. As described, the TweetBubble extension condition offered affordances to expand `@username` and `#hashtag` social media associations. The control condition was the default Twitter interface, in which clicking a social association link overwrites initial content. Across conditions, the apparatus logged how users explored encountered information.

The study asked users to browse a trending Twitter topic for 15 minutes, based on their own interests, starting from the `#ERedcarpet` or `#oscars2014` page. The Red Carpet event attracts a fashion-oriented audience. Celebrities walk up to the Oscars, wearing outfits from prominent fashion designers. We first published 12 Mechanical Turk HITs with `#ERedCarpet`, around 3pm PST, when the TV broadcast of Red Carpet started. This was followed by 38 more HITs for `#ERedCarpet`, a couple of hours later. As the main Academy Awards event began, around 7:30pm PST, we published 50 HITs with the topic `#oscars2014`. Overall, there were 59 male and 41 female participants in the 3 sets. Participants were given pre- and post-questionnaires.

The HITs specified that participants should be regular Twitter users (having used Twitter at least once in last one week). We didn't strictly validate this, instead relying on participants' self-reports. We took care in the study design to eliminate confounds. We included sanity and attention checks [30, 23], independent of the Twitter interface condition.

In the pre-questionnaire, sanity check questions validated participants' interest in the topics. The sanity check questions were: (1) Who of the following is not nominated for Best Actress or Best Supporting Actress? Response choices were (a) Meryl Streep (b) Jennifer Lawrence (c) Miley Cyrus (d) Sandra Bullock; and (2) Which of the following is not known as a

Metric	TweetBubble μ	SE	Control μ	SE	p <
Fluency	8.76	2.007	1.137	0.431	.0000186
Flexibility	6.84	1.614	1.103	0.421	.0000746
Flexibility (User Type)	3.6	0.881	0.759	0.267	.00000352
Novelty	0.599	0.118	0.288	0.096	.001744

Table 3. Ideation metrics of exploratory browsing for `@username` associations. All were significantly higher in the TweetBubble condition.

Metric	TweetBubble μ	SE	Control μ	SE	p <
Fluency	5.6	1.473	1.517	0.755	.00397
Flexibility	3.32	0.888	1.068	0.509	.008859
Novelty	0.269	0.065	0.16	0.064	.084316

Table 4. Ideation metrics of exploratory browsing for `#hashtag` associations. All except Novelty were significantly higher in the TweetBubble condition.
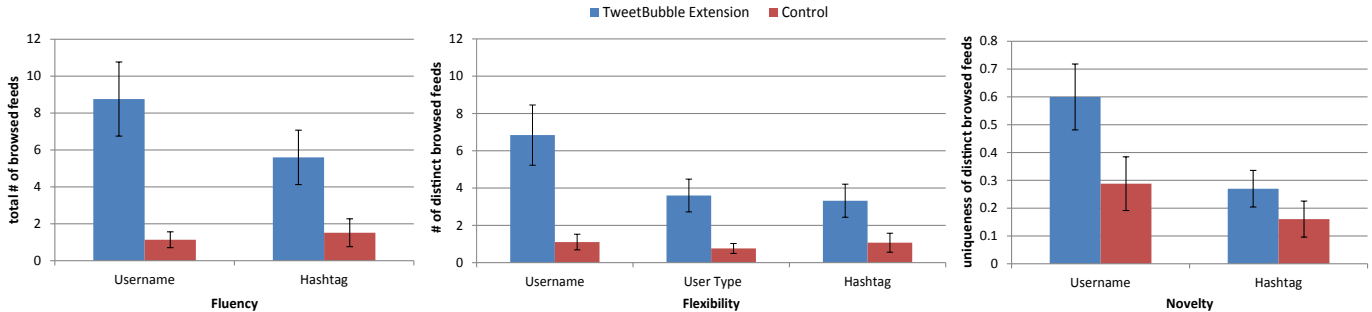

Figure 5. Mean Fluency, Flexibility, Novelty of `@username` and `#hashtag` feeds that users browsed. The TweetBubble Extension interface condition (in blue) resulted in significantly more creative exploratory browsing than the Control condition (in red) for 6 out of 7 ideation metrics. Error bars show standard errors of the mean.

dress designer? Choices were (a) Vera Wang (b) Estee Lauder (c) Alexander McQueen (d) Christian Dior. For the Red Carpet study we wanted fashionistas. Through sanity check questions, we weeded out more average people. We discarded 17 and 15 responses respectively from the TweetBubble extension and control conditions, based on the responses.

In the post-questionnaire, an attention check question and an open-ended summary question served to validate participants' engagement. We followed prior practices in formulating the attention check: 'How many times in the last 5 minutes have you had a heart attack while riding a unicycle in the Alps?' [30]. Based on these responses, we discarded in total only 1 participant, from the TweetBubble extension condition. We also eliminated 13 participants post hoc because of logging problems—7 in the TweetBubble extension condition and 6 in the control. This leaves 25 participants in the TweetBubble condition and 29 participants in the control.

We gathered and analyzed mixed methods data. We developed and applied a quantitative method for measuring the creativity of exploratory browsing engagement with Twitter. We collected and analyzed qualitative data about users' social media experiences.

Method: Ideation Metrics of Exploratory Browsing

Exploratory browsing of Twitter is a mini-c creative process, involving personally novel interpretation of social media associations. We thus derive new ideation metrics of exploratory browsing by recontextualizing Kerne et al's elemental metrics of curation [22]. We shift application of the metrics from the products of information-based ideation to its processes of exploratory browsing. We rework prior methods for computing elemental ideation metrics—Fluency, Flexibility, Novelty—to derive new ideation metrics for creative engagement in exploratory browsing of Twitter social media.

Define the the set of types $M = \{username, hashtag\}$ of Twitter social media associations. Using type m from this set, $o_{m,i}$ refers to each feed a user browses, of each type.

Then, we express the set of all social media `@username` and `#hashtag` associations traversed in a user's exploratory browsing process, which corresponds to Kerne et al.'s set of all found digital media objects in the product that a user curated [22]:

$$c = \{o_{m,0}, o_{m,1}, ...\}; \forall m \in M \qquad (1)$$

Then, $Fluency_m(c)$ will be the total number of feeds the user browsed, of type m

$$Fluency_m(c) = ||o_{m,i} \in c||; m \in M \qquad (2)$$

Note that recurrent browsing of any particular feed is aggregated in this Fluency measure.

Flexibility will be the total number of distinct `@usernames`, `#hashtags` browsed. This means that instead of becoming aggregated, any recurrences of browsing a particular feed do not contribute to the Flexibility measure. To compute Flexibility, form the set of all distinct feeds of type m, $DistinctFeeds_m(c)$, from collection c of all the

`@usernames`, `#hashtags` a user browsed.

$$DistinctFeeds_m(c) = \bigcup_{o \in c} o_{m,i}; m \in M \qquad (3)$$

$$Flexibility_m(c) = ||DistinctFeeds_m(c)|| \qquad (4)$$

We also categorized user feeds into types. We compute $Flexibility_{user\_type}$, drawing on Kerne et al's site type granularity. For this purpose, we extend the categories of Twitter users established by Wu et al.: *celebrities, media, organizations, and blogs* [46], adding: *fashion, professional*. We separate *organizations* into categories: *community, activist*. We performed manual classification to assign types to the 179 `@username` feeds browsed by study participants. The resulting mapping is defined by a *UserType* operator.

$$Flexibility_{user\_type}(c) = ||\bigcup_{o \in c, m=username} UserType(o_{m,i})||$$
$$(5)$$

To compute Novelty, build an inverted index that shows for each feed f, of type m, the number of users who browsed it.

$$Occurrences_m(f,C) = \{c | c \in C \wedge f \in DistinctFeeds_m(c)\}$$
$$(6)$$

$$Novelty_m(f,C) = \frac{1}{||Occurences_m(f,C)||} \qquad (7)$$

Then, Novelty of feeds browsed by each user, of type m, can be computed as aggregated mean of Novelty scores for `@username` or `#hashtags` feeds that the user browsed.

$$Novelty_m(c,C) = \frac{\sum_{f \in DistinctFeeds_m(c)} Novelty_m(f,C)}{||DistinctFeeds_m(c)||}$$
$$(8)$$

Results: Ideation Metrics of Exploratory Browsing
We used this method to compute ideation metrics of exploratory browsing. Results across conditions of the Twitter interface independent variable were compared with t-tests, assuming unequal variances. We found that all ideation metrics of exploratory browsing were significantly higher for `@username` social media associations in the TweetBubble extension condition (Table 3). For `#hashtag` associations, Fluency and Flexibility significantly increased in the TweetBubble condition (Table 4). Figure 5 graphs the results.

Qualitative Results
TweetBubble condition participants were asked, via questionnaire, how clicking on related content, seeing it on the same page, and thus simultaneously browsing multiple feeds affected their experiences. Drawing on grounded theory methods [6], we performed a qualitative analysis of resulting data. We first performed open coding of a set of participant responses. This resulted in 25 codes. We followed with focused coding of remaining responses. We aggregated codes into 5 categories: 'Reduces Disorientation and Digression',

'Helps Explore Related Content', 'Connecting Perspectives to Gain Broader Understanding', 'Fluid and Effective', 'Too Much Information?'.

Reduces Disorientation and Digression
Participants reported that TweetBubble helped them focus. They liked that the original context of reading is maintained when browsing related content. This helped them stay oriented and on topic. They reported having more information at their fingertips. Participants were able to decide whether or not they want to further explore linked content. These findings match those of Qu et al. [33] and Zellweger et al. [47].

P99: *"Being able to see everything on one page kept me much more focused."*

P5: *"I liked the pop outs with more info without losing my place in the feed."*

P3: *"It made it more cohesive and allowed me to keep a train of thought instead of getting so hopelessly sidetracked by having new windows constantly."*

P47: *"It gave more information as to what that person or group was about, this is a very nice feature as it allows one to determine whether or not they may be interested in checking out someone."*

Helps Explore Related Content
Without going back and forth between windows, participants found themselves more engaged. They reported easily and efficiently viewing and discovering more content, exploring more Twitter users' feeds, following online conversations better, and building more in-depth understanding of topics. TweetBubble introduced them to more diversified content, often missed when using the default interface.

P37: *"...the more you have to go back and forth, the less interested I am in staying and learning/reading about topics, because it is too time consuming. So having everything all together made me interact a lot more than I would've before."*

P99: *"It helped me delve into the subjects more. It also kept me more engaged in browsing the Twitter feed."*

P91: *"It allowed me to see more of the conversation and subject."*

P67: *"It made my experience so much quicker, with so much more content. I was amazed by how easy it was to see tweets between two of my favorite celebrities."*

Connecting Perspectives to Gain Broader Understanding
Participants reported new ability to see relationships across topics and perspectives. They more readily saw diverse viewpoints. Exposure to contrasting viewpoints enabled them to connect perspectives, and so gain broader understanding. This corresponds directly to mini-c personally novel and meaningful interpretation.

P47: *"This allows one to understand how the system connects related topics and to see how and why they are linked together"*

P21: *"You get to see many different points of view, professional and civilian. You could get quick quips or detailed facts. It allows for a much broader reading experience."*

P33: *"It gave me a broader view of the topic all in one area, instead of being segmented across several pages. Made it a lot easier to understand as a whole."*

Fluid and Effective
Users found the experience of the TweetBubble interface to enable more fluid and effective navigation of Twitter.

P41: *"You could see more viewpoints and different opinions on it more readily."*

P69: *"...the fluidity of the page was really nice."*

P75: *"It made it easier to just see the tweets in a descending ladder format."*

Too Much Information?
A few participants felt overwhelmed, as the number of expansions increased.

P59: *"The extension made the @usernames and #hashtags open up a tree menu which ended up being confusing and cluttered. I understand how it can link topics and users together, but it is too messy."*

P61: *"I still jumped between pages a lot, but I am still only getting used to TweetBubble."*

DISCUSSION
We frame investigation of exploratory browsing by delineating the everyday contextual role of social media in society. We derive implications for design and evaluation of exploratory interfaces: social media interfaces, exploratory browsing as mini-c ideation, ideation metrics of exploratory browsing, browser extensions as design laboratories, and metadata types integrating presentation semantics.

Everyday Contextual Role of Social Media
Popular social media, particularly Twitter and Facebook, have attained such a pervasive role in the conduct of society, that, drawing on the work of Linder et al. [26], we call them *everyday*. An indicator is how the medium of television—e.g., The Tonight Show, news, and sports—positions Twitter in leading roles, framing discourse. Similarly, personal lives and business relationships are extensively built and expressed through Twitter and Facebook. Everyday use refers to people's engagement with these platforms for a panoply of meaningful events in their lives. Thus, how people engage in exploratory browsing of social media is very significant, on a societal level. We compare interfaces for everyday exploratory browsing of social media.

Exploratory Browsing Interfaces for Social Media
According to Marchionini, browsing is an approach to information seeking that is informal, opportunistic, and iterative [28]. One respondent in Lindley et al.'s study addressed this for social media: "There's always something" engaging to

pursue [27]. Users iteratively compare, analyze, and synthesize information. They develop new perspectives. Our qualitative and quantitative study data validate the present approach to social media exploratory interface design and development. Qualitative study data matches the findings from prior work, corroborating the suitability of interaction technique for exploratory browsing.

An exploratory browsing interface should provide means to explore related content, while maintaining originating context. It should depict browsed chains of association. The role of information visualization here extends beyond that of providing 'insights': it enables synthesis and ideation [22, 41]. In the study, users began from the same #hashtag search pages: #ERedCarpet or #oscars2014. With the TweetBubble extension, they discovered significantly more diverse and novel content, as compared to the participants using the default Twitter interface. This shows that the TweetBubble's in-context expansion of social media associations promotes users' exploratory browsing. It provokes discovering associations, stimulates users to learn about diverse perspectives on a topic, and so promotes flexibility in thinking.

Exploratory Browsing as *mini-c* Creative Ideation
Exploratory browsing of @username and #hashtag social media associations constitutes a form of mini-c creativity, because people encounter and learn about new perspectives. Beghetto and Kaufman emphasize the importance of mini-c creativity in education, in K-12 and beyond [3]. The Amusement Park Theoretical model [2] connects domain specific creativity to general assessment and investigation. In the present research, the domain is the Academy Awards, as experienced through Twitter social media. We use these established models of creativity to motivate generalization of our findings of the significance of exploratory browsing interfaces, which maintain context, to support creative experiences in diverse forms of education and social media.

Fallon and Timberlake demonstrate how widely used hashtagging has become in popular culture [13]. The preponderance of @username and #hashtag references in meaningful tweets (such as those retweeted [40]), highlights their role. The diversity and novelty of people's exploration, through @username and #hashtag social media associations, constitute measures of the extent of their mini-c creativity. Diversity and novelty are central in creativity models [17, 31, 42, 14, 38, 35]. We thus took a creative cognition approach [35] and reworked ideation metrics of curation [22], to compare interfaces designed for exploratory browsing of social media.

Ideation Metrics of Exploratory Browsing
For evaluation of systems for casual information seeking, Elsweiler et al. demand new metrics [12]. We found that ideation metrics [22] provide a means to measure efficacy of an interface in stimulating creative exploration. To measure creative exploration in browsing social media, we recontextualized prior ideation metrics, in terms of the @username and #hashtag associations that Twitter users explore. This methodology can generally be applied to interfaces designed

for exploratory browsing, exploratory search, and information visualization, to compare interface conditions based on diversity and novelty in experiences of creative exploration.

Previously, think-aloud protocols, double stimulation, and microgenetic methods have been used to gather and analyze data to evaluate mini-c creativity [3]. Like microgenetic methods, our approach captures incremental contributions to each user's creative ideation. Ideation metrics aggregate units of mini-c creative engagement. With TweetBubble, the aggregated measure correlates to the synthesis of different perspectives in context of each other, valuable towards creative cognition and visual analytics research of developing new ideas by combination of individual elements [22, 41].

We recall that exploration, of the moon or the web, is by nature creative. In tandem with ideation metrics of exploratory browsing, the present mixed-methods research collects qualitative data in order to categorize user experiences and connect them with measurable effects of mini-c creativity. This cross-validation confirms the methodology of recontextualizing ideation metrics from products to processes, a novel quantitative approach to evaluation of exploratory browsing interfaces' support for mini-c creativity.

We investigated a particular everyday social media context, the 2014 Academy Awards, in order to study how interfaces support people in creative exploratory browsing. To engage typical users with TweetBubble dynamic exploratory browsing interface, we directly embedded it into Twitter. Users of the TweetBubble interface performed significantly higher on 6 out of 7 ideation metrics of exploratory browsing (the 7th was close). Qualitative data mirrors the quantitative results. This grids the claims of validity both for the exploratory browsing interface, and for the method of using ideation metrics of exploratory browsing as the basis for interfaces.

Browser Extensions: A Technique for Design Evaluation

Browser extensions serve as *interface design laboratories*. In conjunction with recruiting micro-task workers, validated by reliability measures [30, 23], the browser extension approach facilitates elicitation of feedback on interactive system design, utility, and performance of an interactive system's design. Both quantitative and qualitative data can be fruitfully gathered in browser extension ideation laboratories. Users become involved in the design of new technologies, while researchers gain valuable insights from their feedback. Browser extensions have the capacity to serve as technology probes [19], when their use is open-ended and extended. Researchers can study new interaction techniques via browser extensions to enable data collection over extended time periods.

Metadata Types Integrating Presentation Semantics

The metadata types in the Meta-Metadata language integrate data models, extraction rules, and presentation semantics, providing a strong foundation for dynamic exploratory browsing interfaces. Presentation semantics enable customizing generalized exploratory browsing interfaces to match the look and feel of specific websites. This integration enables construction of a consistent and integrated user experience through detailed visual reproduction of linked web pages.

The present research extends these semantics to enable mimicking Twitter social media. The type system's re-use of data models and presentation semantics will facilitate future work that extends this technique to other social media, such as Facebook, Reddit, Pinterest, and Google+.

CONCLUSION

TweetBubble stimulated exploratory browsing of the Twitter social media associations during the Academy Awards study. We derived new ideation metrics of exploratory browsing, extending prior research, which enable quantitative comparison of the interfaces, in how they support users' mini-c creative experiences. We found that the TweetBubble dynamic exploratory browsing interface users performed significantly higher on 6 out of 7 metrics of Fluency, Flexibility, and Novelty. Users reported that with the TweetBubble interface, the gaining of perspectives, introduction to new people and topics, and following of conversations becomes more easy, engaging and efficient. The metrics match the user experiences.

What is the significance of these findings? Social media, particularly Twitter, have attained an international transformative impact, playing a catalytic role in social movements, such as Arab Spring, [39] and politics, such as U.S. presidential debates [36]. They cut across individuals, communities, and organizations, redefining participation, communication, and awareness. Social media content is vast and fast moving. With increased exploratory browsing of Twitter, not only will users make more connections across @usernames and #hashtags, tweeters will also get better reach for their social media posts. Both the producers and consumers of information gain as diverse and novel perspectives are shared, growing mutual understanding. We identified the Academy Awards as a meaningful cultural context for this purpose. The Amusement Park Theoretical Model can similarly be invoked, to interpret and generalize mini-c meaningful learning and mutual understanding in contexts of crowdsourced community participation, such as expressions of solidarity and mutually supportive content filtering during Arab Spring.

Using Boden's notion of exploratory creativity, and Kaufman et al.'s mini-c creativity, we identified exploratory browsing as a form of creative experience, and so of information-based ideation. Creativity is vital to personal well-being [4, 21]. Creative innovation is vital to economic growth and national interests [32]. Ideation is a cornerstone of participatory democracy. Thus, techniques for building interfaces that promote creative engagement in exploration of social media, and methods for evaluating these interfaces, have great potential to significantly impact how social media transforms the world. Ideation metrics of exploratory browsing are applicable in visual analytics, where exposure to diverse and novel perspectives contributes to novel and meaningful interpretation, and so to creative synthesis. Exploratory browsing interfaces have the potential to play a leading role, as humans engage in information-based ideation activities, which, in turn, are the heart of humanity's potential to transform the raw material of our digital society and super-abundant information resources into connectedness, well-being, and success.

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