Footprints of Fascination: Digital Traces of Public Engagement with Particle Physics on CERN's Social Media Platforms

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Abstract

Although the scientific community is increasingly recognizing that its communication with the public may shape lifelong learning of science, few studies have characterized how this communication occurs online. This hampers efforts to serve audiences' informational needs and interests with respect to science. This study set out to explore how users engage with science communication items on different platforms of social media, and which of these items tend to attract large numbers of user interactions. Here, user interactions with five of CERN's social media platforms were quantitatively studied over an eight-week period. Findings indicate that as audience size of a social media platform grows, the total rate of engagement with content tends to grow, in certain measures. However, per user, engagement tends to decline with audience size. Across all platforms, similar topics tend to consistently receive high engagement. In particular, awe-inspiring imagery tends to consistently attract high engagement across platforms, in line with previous studies on emotions and user engagement with online scientific content. To our knowledge, this study provides the first cross-platform quantitative description of public engagement with science on social media. Findings may serve for benchmarking social media analytics for assessing science communication activities and their contribution to lifelong learning of science.

Keywords: social media, analytics, interest, lifelong learning, science communication, public engagement with science.

Introduction

Within the scientific community, recognition of the importance of communicating science to non-technical publics is rising. Concurrently, people are increasingly spending time consuming, generating and exchanging content on social media. However, so far, few studies have characterized how the public engages with scientific information on social media (Brossard & Scheufele, 2013). This study describes one case of such public engagement using a quantitative approach. Specifically, we examined public engagement with content posted on popular social media platforms of the European Organization for Nuclear Research (CERN), an international scientific research organization based in Geneva, Switzerland.

Literature Review

Online environments, such as social networking sites (SNS), provide growing opportunities for lifelong learning, beyond periods of formal schooling in a person's life (Kind & Evans, 2015). Specifically, digital media platforms now facilitate direct communication between experts and the public, allowing non-specialists to become spectators and even active participants in

research scientific research and the social context in which it takes place (Brossard & Scheufele, 2013; Konneker & Lugger, 2013). Educational researchers have begun investigating the learning opportunities afforded by these platforms (e.g., Greenhow, Gibbins, & Menzer, 2015).

How do users learn about science from their engagement with science online? Some researchers have argued that SNS may harbor and even speed up socio-cognitive learning processes (Kind & Evans, 2015; Tsovaltzi, Greenhow, & Asterhan, 2015). However, other researchers take a more skeptical view and suggest that "an organization's *Facebook* page does not seem to be a suitable space to trigger discussions" about science, affording only few opportunities for fans to develop scientific literacy by this approach (Fauville, Dupont, von Thun, & Lundin, 2015, p. 72). Still, it has been argued that scientific stories posted on *Facebook* pages can promote the inclination of individual users to learn about science (Fauville et al., 2015).

What scientific content typically attracts user engagement? Research conducted specifically on online *sharing* of scientific information has indicated that users tend to share pieces of content that are surprising, interesting, otherwise entertaining, positive, useful, or inspiring awe, anger or anxiety. Users are motivated to share such content for a variety of reasons, including: (1) to make themselves "look good" in the eyes of others, and (2) to enhance their social bonds with others (Berger & Milkman, 2012; Milkman & Berger, 2014, p. 13642). However, little attention has been paid to the motives of *other* types of user engagement with online scientific information, *besides* sharing, such as "liking" and commenting on content pieces. Also, the effects of different social media platforms on these behaviors have not been well studied.

Research Questions

1. How do followers engage with scientific information on different platforms of social media?
2. Which scientific information items on social media tend to attract large numbers of user interactions?

Methodology

48 different topics, each featuring a unique image (e.g., an illustration or photograph), were (cross-)posted on five of CERN's social media platforms over eight weeks in 2014 (October 17 – December 11). Each topic belonged to one of the following four categories: (1) News, (2) "Guess What It Is", which featured mysterious images (e.g., images of unusual scientific instruments), (3) "Throwback Thursday", which featured historical images, and (4) "Wow", featuring awe-inspiring images (Table 1). Items (i.e., *Facebook* statuses, *Twitter* tweets, etc.) relating to each topic were posted on one or more of these platforms: Two *Twitter* accounts (in English and in French, ~1.05 million and ~12,400 followers respectively); *Facebook* (~357,000 fans), *Google+* (~59,500 followers) and *Instagram* (~830 followers). Typically, topics were cross-posted on all five platforms. In total, this yielded 214 items. Each item contained either one or two links, yielding 257 links in total.

Table 1. Types of items posted on CERN's social media platforms

	Type	N		Example
		Items	Links	
1.	**News**	94	115	"Don't miss today's CERN60 United Nations event at 16h CEST, webcast via http://webtv.un.org/"
2.	**Guess What It Is**	40	54	"CERN's cooling & ventilation systems"
3.	**Throwback Thursday**	40	44	"High voltage power line pilot installation in 1965"
4.	**Wow**	40	44	"The LHC's @ALICEexperiment is designed to study quark-gluon plasma"
	Total	**214**	**257**	

Users of the respective platforms were either exposed to the items or not exposed to them, depending on their individual usage habits and the technical settings of the particular platform. For all platforms except *Instagram*, three user behaviors were recorded for each *item*: (1) "Likes", "Favorites" (*Twitter*) or "+1" (*Google+*) (hereafter "likes"); (2) Comments or replies (hereafter "comments"); (3) Shares or retweets (hereafter "shares"). In addition, three user behaviors were recorded for each *link*: (4) Click-throughs – The number of clicks; (5) The average visit duration if the link was clicked; (6) The retention rate – The percent of visitors who clicked on the link and did not leave it within a short time after page loading. Because of technical constraints of the *Instagram* platform, only the first two behaviors (1-2) were recorded for that platform ($n_{Instagram} = 32$). User behaviors were recorded using *Engagor* (www.engagor.com) and CERN's proprietary web analytics platform.

Raw data was normalized by audience size of the platform on the date of item posting, and standard z-scores were computed. For instance, if an item on *Facebook* received one standard deviation more comments (per 1,000 followers) than the mean for comments on *Facebook* items, its "comments" z-score was 1. Items with at least one user behavior statistic scoring $|z| \geq 1.96$ were considered "high-engagement" items (if $z \geq +1.96$) or "low-engagement" items (if $z \leq -1.96$). Assuming a normal distribution of user engagement, these thresholds would yield the top and bottom 2.5% of observations.

Results

An average post on CERN's social media platforms received 161.68 likes (SD 358.8), 9.5 comments (SD 31.93), 64.37 shares (SD 143.8), and 93 click-throughs (SD 166.1). For users who clicked on the links in the posts, the mean visit duration on the web pages that the links led to was 16.27 seconds (SD 34.67) and the mean retention rate was 5.45% (SD 8.2%). On average, the most common behaviors found were *Facebook* likes (433.15 Interactions per Item (IPI), SD 674.54), *Twitter* English favorites (122.21 IPI (SD 134.07) and *Instagram* likes (111.84 IPI, SD 39.47). On *Twitter* English, shares and click-throughs were also common with 159.98 shares per item (SD 228.95) and 224.27 click-throughs (SD 209.44) (Figure 1a). However, after controlling for audience size, user interactions were found to be most common on *Instagram* and *Google+*. Some of the most common behaviors found in the study were *Instagram* likes (149 Interactions per Item per 1,000 Users (IPI/kU), SD 54.66), *Instagram* comments (4.62 IPI/kU, SD 5.41), *Google+* "+1"s (4.02 IPI/kU, SD 5.54) and *Google+* click-throughs (1.47 IPI/kU, SD 2.98) (Figure 1b). Visit durations and retention rates were highest for *Twitter* French, at 34.63 seconds (SD 46.42), and 10.92% (SD 12.97%), respectively.

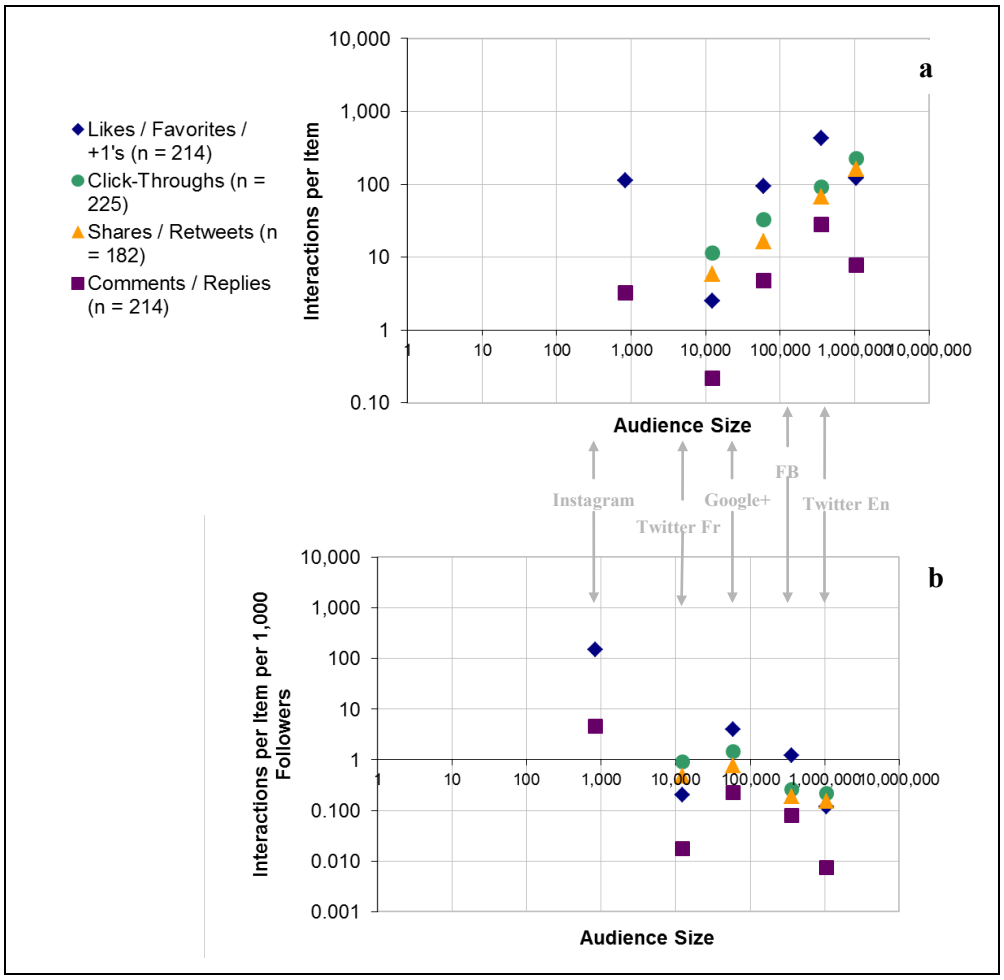

Figure 1. Average rate of user interactions with items posted on CERN's social media platforms, by audience size, without (a) and with (b) control for audience size. FB: *Facebook*.

Platforms with Larger Audiences Attracted Higher Rates of Shares and Click-Throughs; However, Overall, Per-User Engagement Declined

Audience size correlated significantly and moderately positively with shares ($\rho = 0.424$, $p < 0.01$) and click-throughs ($\rho = 0.497$, $p < 0.01$), and weakly negatively for visit duration ($\rho = -0.146$, $p < 0.05$) and retention rate ($\rho = -0.175$, $p < 0.01$). No significant correlations were found between audience size and likes or comments. However, when controlling for audience size, likes, comments, shares and click-throughs occurred less often as audience sizes grew, although correlations were weak ($-0.32 \leq \rho \leq -0.22$ for each of the types of interactions, $p < 0.01$).

User Engagement with Items on CERN's Social Media Fluctuated Strongly Over Time

Figure 2 represents the pattern of user interactions with items posted on CERN's *Facebook* page over the time period studied, normalized by daily audience size. Users typically engaged with items at a constant rate of interactions throughout the study, as illustrated by the cluster of observations near the x axis. In addition, several outliers were found, some with z-scores as high as 5 or more, meaning that for certain items, user behaviors occurred as often as 5 standard deviations more than the means for those behaviors on the respective platforms. (A similar pattern of user behavior was found in most platforms studied; Data not shown.)

Thirty-five (35) high-engagement items were found in the study, comprising over 16% of the 214 items included in the sample. As an example, the six high-engagement items for CERN's *Facebook* page are highlighted in Figure 2. The point labeled "Open Data" in Figure 2, for instance, refers to click-throughs on a links in the *Facebook* announcement that CERN had launched an Open Data Portal to make the data of LHC experiments publicly available. This item received high standard scores on *Facebook* in terms of click-throughs per thousand users (Z = 5.05) and shares per thousand users (Z = 2.47). Hence, it was considered a high engagement item posted on the *Facebook* platform. (Since the distribution was strongly right-skewed, no low-engagement items were found in the study.)

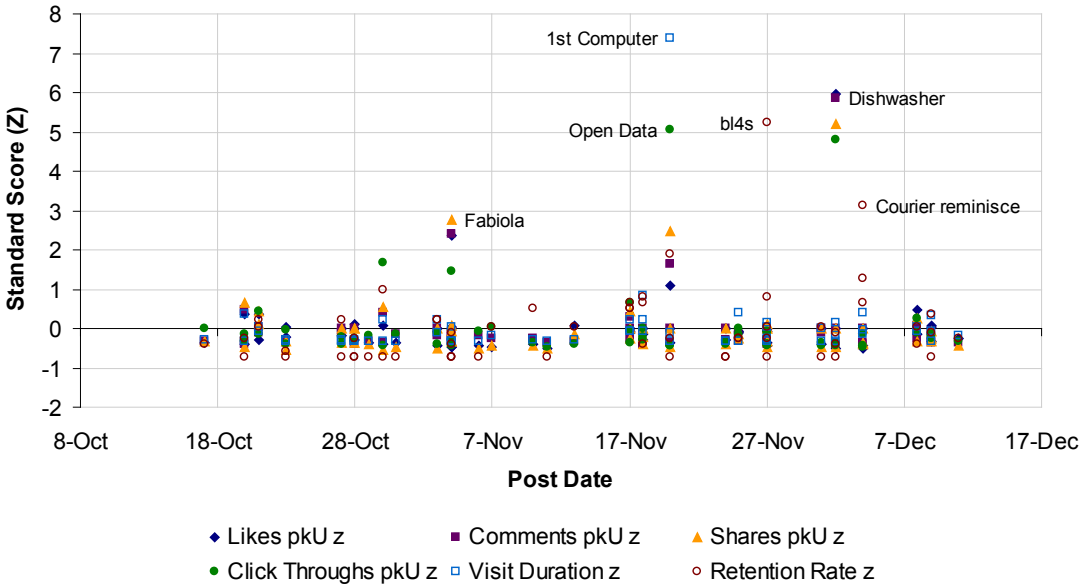

Figure 2. User engagement with scientific content on CERN's *Facebook* page, normalized by audience size, October-December 2014.

High Engagement Across Platforms is Significantly Associated with Item Topic

Of the 35 "high engagement" items found in the study, 16 items each represented a different topic that received high engagement in just one platform (hereafter: "unique" high-engagement items). The other 19 items represented instances of just 6 topics that received high engagement across multiple platforms (hereafter: "recurring" high-engagement topics/items). For example, the "Open Data" topic received high engagement scores not only on *Facebook* but also on *Google+*, *Twitter* English and *Twitter* French, making it a recurring high-engagement topic. These data indicate an association between high engagement and item topic (Table 2).

Table 2. Distribution of "unique" and "recurring" high-engagement topics on CERN's social media platforms

	% of High Engagement Items	# of High Engagement Items	Comments
"Unique" High Engagement Items	46%	16	Items representing one topic each
"Recurring" High Engagement Items	54%	19	These items represent repeated instances of just **6** topics on different platforms (of the 48 topics in the sample)
Total	**100**	**35**	

Some characteristics of the high-engagement topics are that they may have referred to (1) news items receiving attention from traditional media (e.g., the "Fabiola" topic), or (2) an awe-inspiring image (e.g., "CMS", "Dishwasher" and "Pipes") (Table 3).

Table 3. Recurring high engagement topics

	Recurring High Engagement Topic Code	Type	Image Caption	Recurred as High Engagement Item on…
1.	1st Computer	Throwback Thursday	"The Ferranti Mercury, CERN's 1st 'central' computer"	*Facebook*, *Twitter* English
2.	CMS	Wow	"The LHC's Compact Muon Solenoid (CMS) detector"	*Instagram*, *Twitter* English, *Twitter* French
3.	Dishwasher	Wow	"That's right, a CERN dishwasher for circuit boards"	*Facebook*, *Google+*, *Instagram*, *Twitter* English, *Twitter* French
4.	Fabiola	News	"CERN Council selects Italian physicist, Dr Fabiola Gianotti, as CERN's next Director-General"	*Facebook*, *Twitter* English, *Twitter* French
5.	Open Data	News	"CERN launches Open Data Portal to make public the data of LHC experiments"	*Facebook*, *Google+*, *Twitter* English, *Twitter* French
6.	Pipes	Guess What It Is	"CERN's cooling & ventilation systems get refreshed"	*Google+*, *Twitter* French

Research Limitations

The main methodological limitation stems from the architecture of the platforms. The items posted were not necessarily seen by all CERN's subscribers. The "organic reach" is determined by the technical settings of the platforms, and may be affected by many different variables, including whether an item was posted on the platform the day before (for a study including some analysis of "posting efficiency", see Fauville et al., 2015). Also, the items do not represent a randomly distributed, year-round sample. "Throwback Thursday" items, for example, were posted only on Thursdays. These temporal characteristics of the sample add further possible confounding factors to the study.

Discussion

How does the public engage with science communication items on different platforms of social media? To some extent, engagement is similar irrespective of platform, but in some respects engagement is different. Across platforms, user engagement with scientific items on social media tends to fluctuate, due to frequent "high engagement" items. Often (but not always) the same "high engagement" topics attract interactions across platforms. Awe-inspiring imagery is especially prone to high engagement (similar to findings found in Berger & Milkman, 2011). However, an analysis of engagement across platforms reveals an "*Instagram* effect": On average, smaller audiences are more engaged audiences. Perhaps in new accounts, "early adopters" might tend to be more engaged users, especially on novel platforms such as *Instagram*. Some "high engagement" topics may be specific to certain platforms because of the unique characteristics of the audiences on different platforms (e.g., the opening of a film in French-speaking Switzerland and in France was of particular interest to followers on *Twitter*

French). Scientific items on social media that tend to attract large numbers of user interactions include some awe-inspiring imagery as well as news items that were newsworthy enough to receive attention from traditional media.

To our knowledge, this study provides the first quantitative description of public engagement with science on social media, across several platforms. It may serve for benchmarking social media analytics for science communication activities in the future. In turn, it may inform the design of science communication campaigns that serve audiences' informational needs and interests, and may contribute to audience members' lifelong learning of science.

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