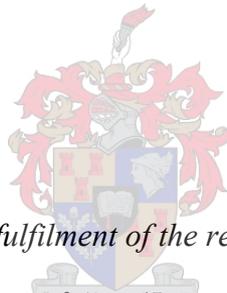


Science communication and the nature of the social media audience: Breaking and spreading of science news on Twitter in the South African context

by

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Dedication

This thesis is dedicated to my wife, Lésa, who excels in her loving support of all of my endeavours, to my parents, Renier and Stienie van Rooyen, whose wisdom, faith and patience shaped me, and to God, in whom I place my trust.

Declaration

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Abstract

Twitter has been shown to be a powerful medium for the breaking and spreading of news and science news. In this study the TAGS v6.0 software and the Gephi graph visualisation platform are used to visually analyse how, and by whom, various science news stories were actually spread on Twitter in real-time, in order to determine who are the most prominent disseminators of science news globally as well as in the South African context. This is measured in terms of total number of retweets per Twitter account. The conclusion is made that the Twitter audience tends to retweet mainly from sources that they know and trust to be true and accurate. This has implications for how science communicators ought to go about understanding the nature of the social media audience. The study shows that globally major scientists and scientific institutions use public trust on Twitter to great effect to successfully communicate science, but that science communication role players in South Africa have so far failed to realise Twitter's potential. Recommendations are made for how South African scientists, science institutions and science journalists ought to best exploit the platform to enhance the effective communication of sound, evidence-based science.

Keywords: audiences, audience participation, breaking news, data visualisation, Facebook, fragmentation, Gephi, journalism, media, news, retweets, science communication, science journalism, scientists, segmentation, social media, TAGS v6.0, tweets, Twitter, Twitter analysis, viral

Opsomming

Daar is al bewys dat Twitter 'n kragtige medium is om nuus, en wetenskapnuus, te breek en te versprei. In hierdie studie word die TAGS v6.0-sagteware en die Gephi grafiese visualiseringsplatform gebruik om visueel uit te beeld hoe, en deur wie, verskeie wetenskapnuusstories intyds op Twitter versprei het, om sodoende vas te stel wie die mees prominente verspreiders van wetenskapnuus is op globale vlak, sowel as in die Suid-Afrikaanse konteks. Dit word gemeet aan die maatstaf van die grootste aantal 'retweets' per profiel. Die gevolgtrekking word gemaak dat die Twitter-gehoor hoofsaaklik twiets versprei (retweet) afkomstig van bronne wat hulle ken en vertrou om waar en akkuraat te wees. Dit het gevolge vir hoe wetenskapkommunikeerders te werk behoort te gaan om die aard van die sosiale media-gehoor te verstaan. Die studie wys dat gesaghebbende wetenskaplikes en wetenskaplike instansies op internasionale vlak die publiek se vertroue baie effektief op Twitter benut om wetenskap te kommunikeer, maar dat wetenskapkommunikasie-rolspelers in Suid-Afrika tot dusver gefaal het om Twitter se potensiaal te benut. Aanbevelings word gemaak oor hoe Suid-Afrikaanse wetenskaplikes, wetenskaplike instansies en wetenskapjoernaliste te werk moet gaan om die platform bes moontlik te benut vir die verbeterde effektiewe kommunikasie van behoorlike, bewys-gestaafde wetenskap.

Chapter 1 - Introduction

Facebook is eating the world.

This was the headline of an article written by Bell (2016) in March 2016 for the *Columbia Journalism Review*. In the context of the article Bell is not referring to the social media network Facebook per se, but to social media in general and the profound effect it has had on how people live and communicate. Specifically, she refers to how social media has changed the nature of the media landscape and news consumption, and how it is “swallowing” journalism. In her own words, Bell (2016) states:

“Our news ecosystem has changed more dramatically in the past five years than perhaps at any time in the past five hundred... Social media hasn’t just swallowed journalism, it has swallowed everything. It has swallowed political campaigns, banking systems, personal histories, the leisure industry, retail, even government and security. The phone in our pocket is our portal to the world. I think in many ways this heralds enormously exciting opportunities for education, information, and connection, but it brings with it a host of contingent existential risks. Journalism is a small subsidiary activity of the main business of social platforms, but one of central interest to citizens.”

According to Bell (2016) two dramatic and significant things have happened to the news ecosystem that have not received the attention it deserves. Bell (2016) says:

“First, news publishers have lost control over distribution. Social media and platform companies took over what publishers couldn’t have built even if they wanted to. Now the news is filtered through algorithms and platforms which are opaque and unpredictable. The news business is embracing this trend, and digital native entrants like BuzzFeed, Vox, and Fusion have built their presence on the premise that they are working within this system, not against it. Second, the inevitable outcome of this is the increase in power of social media companies. The largest of the platform and social media companies, Google,

Apple, Facebook, Amazon, and even second order companies such as Twitter, Snapchat and emerging messaging app companies, have become extremely powerful in terms of controlling who publishes what to whom, and how that publication is monetized.”

Although Bell (2016) refers to Twitter being a second order company compared to giants like Google, Apple and Facebook, it is widely accepted that when it comes to breaking news, Twitter is a leading social platform due to its emphasis on succinct immediacy.

1.1 Brevity and breaking news

In an article for *ABC News* entitled “Is Twitter the news outlet for the 21st century?”, Coyle (2016) says Twitter has provided a “jolt of democratisation to journalism”. He cites several examples (Coyle, 2016) of news events that were first broken and extensively covered and discussed on Twitter, such as the 2008 Mumbai terrorist attacks, the US Airways flight that ended up in New York’s Hudson river in 2009 and Iranian protesters using Twitter to assemble marches against the government over a perceived unjust 2009 election. Coyle (2016) states:

“Twitter's constantly updating record of up-to-the-minute reaction has in some instances threatened to usurp media coverage of breaking news... Many users have become accustomed to clicking on Twitter when news breaks. There, they can find a sea of reaction, commentary and links to actual articles.”

The article (Coyle, 2016) also cites Ross Dawson, author and communications strategy analyst, saying:

“I like to refer to Marshall McLuhan's description of media as 'an extension of our senses.' Now, Twitter is extending our senses to tens of millions of people who are often right on the scene where things are happening.”

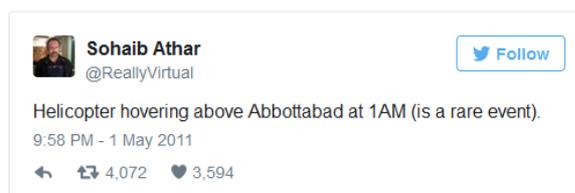
Ingram (2012) echoed the above sentiments in an article for the emerging technology thought leader GigaOm, entitled “If you think Twitter doesn’t break news, you’re living in a dream world”. Ingram (2012) says:

“...the ‘democratization of distribution’ provided by the web and social media means news can come from anywhere, at any time, and from a wide variety of sources. In many cases, those sources will be individuals who are actually involved in the news — whether they are dissidents in Syria video-taping the revolution there and uploading it to YouTube, or Rupert Murdoch posting his thoughts to Twitter.”

Good examples of global news events that were broken and extensively covered and engaged with on Twitter is listed in an article by Turner (2013) for Mashable.com wherein she states that Twitter has “revolutionised global news delivery and consumption”, and that Twitter “often breaks news before the media can report it”.

She goes on to list nine examples of Twitter breaking news stories that can be seen as representations of the power of citizen journalism through this social platform (Turner, 2013).

These include the British monarchy’s announcement in 2010 on Twitter of Prince William’s engagement to Kate Middleton, the 2008 earthquake in China which sent figurative shockwaves across the Twittersphere before agencies like the United States Geological Survey (USGS) could comment, the news of the singer Whitney Houston’s death which broke on Twitter in 2012 before the media could report on it, news about the Boston marathon terrorist bombings in 2013 which originated from those tweeting from the event, and when in 2011 news about the US Navy SEAL raid on Osama Bin Laden’s compound in Abbottabad, Pakistan, was leaked thanks to a simple tweet (below) by a local citizen (Turner, 2013).



In a study by the American Press Institute (Rosenstiel *et al.*, 2015), in which over 3000 Twitter news users were asked about their Twitter-habits, it was found that “...the immediacy of using the [Twitter] network to track news in real-time, as noted above, is one of the primary reasons that people say they use Twitter” (Rosenstiel *et al.*, 2015).

Some of the findings of that study were that 80% of Twitter users who had followed a breaking news story in the preceding month, said they clicked on a story as events were moving in real-time (Rosenstiel *et al.*, 2015) and 81% of Twitter-users could recall engaging with a specific news story on Twitter in the last week, while 30% could recall doing so in the last day (Rosenstiel *et al.*, 2015).

Of the Twitter-users who had followed a breaking news story in the preceding month, over half (55%) said they had retweeted a story (Rosenstiel *et al.*, 2015). Considering the fact that every retweet exposes a news story to a whole new audience (the followers of the person who retweeted) and that each of those members could potentially also retweet the story and so on, it is easy to see how news on Twitter can spread virally almost instantaneously.

1.2 Science in 140 characters

Twitter then, is a powerful tool for breaking news, but it also has limitations – the most obvious being the fact that Twitter only allows a maximum of 140 characters per tweet. This can make it difficult to convey complex issues understandably – including science.

According to Titcomb (2016) the 140-character limitation was a decision made by Twitter-founder Jack Dorsey and colleagues to allow tweets to fit into single text messages. Twitter launched in 2006 before the era of smartphones and messaging apps (Titcomb, 2016), which meant mobile phone messages were still sent almost exclusively by text messages limited to 160 characters. Says Titcomb (2016):

“Before the smartphone era, tweets were designed to be sent by text, which were limited to 160 characters (the extra 20 was set aside for usernames). In the 10 years since, we’ve all bought smartphones, and text messages have been replaced by apps. Twitter itself has also changed – adding photos, hashtags, polls, faves (now hearts) and more, but the 140-character cap has remained the same, a defining feature (if not the defining feature) of the social network that set it apart from the likes of Facebook.”

In January 2016 Dorsey announced that Twitter was considering doing away with the 140-character limitation, with rumours indicating that the limit would be extended to 10 000 characters (Koh, 2016). There was an immediate backlash from Twitter-users. Says Koh (2016):

“Twitter’s loud and devoted user base was quick to bemoan that such a change — expected to be announced by the end of March — would spoil the brevity and speed of the real-time service. The character limit that forces users to pen snappy tweets could give way to the longer essays found on Facebook, for example. It could transform Twitter into more of a public blogging platform rather than one that is succinct and well-suited to quips and breaking news headlines.”

Such was the backlash that in March 2016 Dorsey announced (Abutaleb, 2016) that Twitter would keep the 140-character limit, saying it is a “good constraint” that allows for “of-the-moment brevity” (Abutaleb, 2016). According to Titcomb (2016), the constraint is what sets Twitter apart as a social platform well suited for breaking news:

“A huge part of Twitter’s appeal, they [Twitter devotees] say, is that tweets are short (if not always sweet). The cap allows users to keep up with the dozens of tweets a minute that pop up on their feeds, and it forces the public figures, pundits and comedians to keep things concise.”

This, however, presents a logical problem when trying to convey complex issues or information. Compressing complicated political analyses or nuanced controversies (like the Edward Snowden issue) understandably and accurately into a 140-character tweet for instance, is not always easy.

To get around this, some users are opting to take screenshots of longer blocks of text and then to rather tweet the photo (Titcomb, 2016). This is however not a complete solution. A user scrolling through their timeline only sees a small part of the photo and has to click on the tweet to see the entire image, which means the tweet text itself still has to entice a user to click on it. When it comes to Twitter, brevity really is the soul of wit.

When it comes to communicating science news however, brevity can be a problem. For science communicators, be they scientists, science journalists, educators or institutions, trying to convey difficult, complex or technical scientific information (such as nanotechnology or quantum mechanics) to the public is hard enough without being forced to cram the information into 140-character tweets.

Nevertheless, studies have shown that it is indeed beneficial for scientists and scientific institutions to have an online social media presence (Bik & Goldstein, 2013), that Twitter can foster better public engagement with science (Jarreau, 2016) and that communicating science on Twitter “works” (Novak, 2015), partly by relaying science to a more diverse audience. Bombaci *et al.*, (2015:216) notes:

“Scientists are increasingly using Twitter as a tool for communicating science. Twitter can promote scholarly discussion, disseminate research rapidly, and extend and diversify the scope of audiences reached. However, scientists also caution that if Twitter does not accurately convey science

due to the inherent brevity of this media, misinformation could cascade quickly through social media.”

For science, Twitter can be a double-edged sword. A good example of how Twitter can play a simultaneously positive and negative role in the dissemination of science-related information in a breaking news context, and on a global scale, is what happened during the 2014 West Africa Ebola virus outbreak.

1.3 When tweets get infected

Over the course of the West Africa Ebola outbreak, seemingly equal amounts of media coverage were devoted to the positive role (Risen, 2014; Murdock, 2014) that social media were playing in aiding the fight against the pandemic and the negative role (Luckerson, 2014; Blair, 2014) that social media were playing by allowing for the rapid, rampant spread of misinformation about the disease. Says Blair (2014):

“On one hand, social media are a crucial mode of communication, as they were in the case of Israeli rocket strikes or Arab Spring protests. Information about outbreaks and treatments can reach remote areas within milliseconds, warning would-be victims of potential and ongoing outbreaks in real-time. However, social media are as unregulated as they are democratizing. The Ebola outbreak has unveiled a darker side of social media – the voracious spread of misinformation. Rumored preventatives and cures rapidly gain traction online as desperate West-Africans search for any method to counteract the thus-far untreatable disease. Eating raw onion, eating koala-nut, or drinking coffee have all surfaced as solutions. In Nigeria, two people died from drinking salt water – making misinformation in that country half as deadly as the disease itself. The rumored cure has hospitalized dozens more. The ill-informed noise on social media has made it difficult for legitimate sources, such as the Center for Disease Control (CDC) or the World Health Organization (WHO) to make their voices heard.”

As Luckerson (2014) puts it, information, both accurate and not, spreads faster thanks to social media. On Twitter in fact, information spreads much like a virus itself, according to Luckerson (2014):

“Trying to stem the spread of bad information online actually shares many similarities with containing a real-world virus. Infected Internet users, who may have picked up bogus info from an inaccurate media report, another person on social media or word-of-mouth, proceed to ‘infect’ others with each false tweet or Facebook post.”

The same viral nature of social media also aided health care workers during the Ebola-outbreak however, especially in Nigeria. Says Murdock (2014):

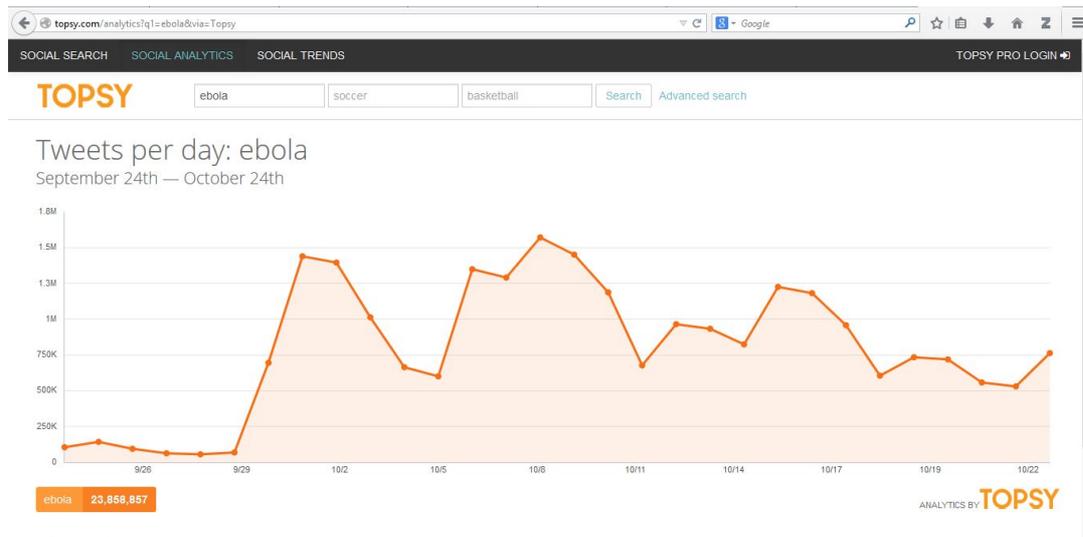
“The Nigerian government says communication is its first line of defense against Ebola. With no known cure and new fears about a potentially infected corpse found at a mortuary, health officials are Facebooking, Tweeting and writing radio jingles in an effort to reach everyone in Africa's most populous country. Their main message is ‘Wash your hands.’ ... Health officials are also posting information about how the disease spreads and numbers to call for questions or to report illness on their Facebook page, that are being Tweeted by other agencies, like the Nigerian Police.”

The role of social media in the West Africa outbreak was perhaps more noticeable in Nigeria, a more developed country than Liberia, Sierra-Leone and Guinea, but predictably it was when the first US citizen became infected that Twitter’s might as a platform to break and instantly and virally spread news of a scientific nature became most apparent.

Following the first diagnosis of an Ebola case in the United States on 30 September 2014, mentions of the virus on Twitter leapt from about 100 per minute to more than 6 000 per minute and between 16 September and 6 October a massive 10.5 million tweets mentioning the word “Ebola” were recorded (Luckerson, 2014b).

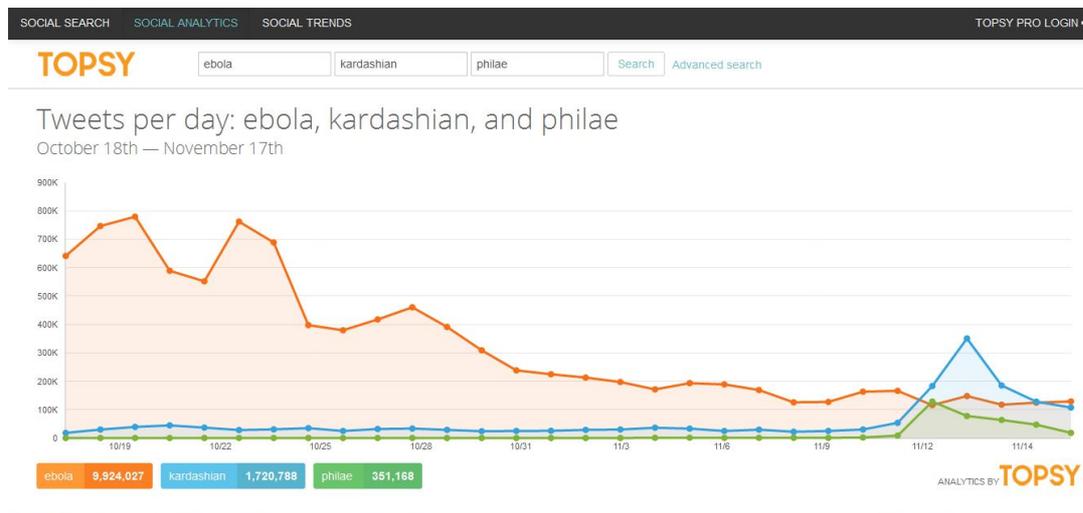
The upsurge of Ebola tweets directly after the CDC confirmed the first Ebola-case in the US (in patient Thomas Eric Duncan) could clearly be seen in graphs produced through the online Twitter analytics service Topsy, which has since closed down after being bought by Apple (Russell, 2015). The Topsy graph below (Fig.1) shows tweets containing the word “Ebola” that were sent between 24 September 2014 and 24 October 2014, revealing a clear, dramatic spike on 30 September (coinciding with the first positive diagnosis in the US).

Figure 1: Tweets per day containing “ebola”, 24 September to 24 October 2014



Twitter’s ability to spark global conversation around a breaking science news story like the Ebola outbreak becomes even clearer when comparing the Ebola-tweets with other notable breaking news events at the time. The graph below (Fig.2) is a comparison of the total number of tweets containing the words “Ebola”, “Kardashian” and “Philae” that were sent between 18 October and 17 November 2014.

Figure 2: Tweets per day containing “ebola”, “kardashian” and “philae”, 18 October to 17 November 2014



The spike in “Philae” tweets on 12 November happened when the Philae spacecraft landed on comet 67P/Churyumov-Gerasimenko – marking the first time an earth-launched craft had touched down on a comet.

The “Kardashian” spike on 11 November was when the magazine *Paper* unveiled their controversial winter 2014 cover photo featuring the naked derriere of celebrity Kim Kardashian – a global publicity stunt conceived to “break the internet” (Paper staff, 2014).

What becomes most apparent is that even an historic science story like the Philae-landing or a carefully conceived publicity stunt involving one of the world’s most popular celebrities (Kim Kardashian has over 43 million followers on Twitter, making her the 9th most followed person on the social platform at the time of writing according to socialbakers.com) is dwarfed by the amount of Twitter-conversation that took place at the height of the US Ebola-scare when citizens feared they might contract the disease.

The Ebola outbreak clearly showed that Twitter can play a significant role in the dissemination of science-related news and information, both accurate and inaccurate, especially if people believe the information can impact their lives. It also serves to demonstrate Twitter’s potential for good science communication through the viral tweeting and retweeting of sound science.

The need for good science communication is especially great in Africa’s developing countries, according to Ogodu (2012):

“Africa still suffers from myriad developmental challenges ranging from poverty, disease and ignorance. The need for dissemination of science and its tools for change for the continent cannot be gainsaid.”

For evidence of South Africa’s remaining need for better science communication one needs to look no further than a speech given by the MEC for Basic Education in KwaZulu-Natal, Ms. Nelisiwe Peggy Nkonyeni, in January 2015, in which she describes her ideal vision for the education system as one that would include phrenology and graphology to “channel the children accordingly” (Spaull, 2015).

The fields of graphology and phrenology are generally considered pseudo-science, according to Spaull (2015), since they “have no scientific evidence base whatsoever, and have been debunked for over 100 years already”. That such utterances can be made by an MEC responsible for basic education is worrying.

An incident of even greater concern occurred during the #FeesMustFall student protests (campaigning for free education), when on 13 October 2016 conversations started trending on Twitter around the hashtag #ScienceMustFall, after a video surfaced on YouTube of a public debate wherein a student leader of the #FeesMustFall group called for the “scrapping of Western science” (MyBroadband staff, 2016). The student in question claimed that science “is a product of Western modernity, and the whole thing should be scratched off”, and said: “We have to restart science from an African perspective, from our perspective, of how we experienced science” (MyBroadband staff, 2016).

The fact that a student who has advanced to a tertiary level education can be so ill advised as to believe that science can be experienced from various perspectives (as opposed to being true regardless of perspective or personal bias as a prerequisite to being called science in the first place) is indeed alarming.

The question then necessarily arises of how South African science communicators can best take advantage of the potential of Twitter in order to maximise the healthy viral spread of accurate and informative, impactful or helpful science content.

1.4 Studying viral (and stagnant) science on Twitter

To know how sound and evidence-based science should be tweeted for maximum effect, we need to first determine how science is currently communicated on Twitter as well as who is doing the tweeting.

The purpose of this study is to determine what can be learned from a data-visual analysis of how several big recent international and local news stories broke and were initially spread on Twitter, and by whom, compared with how international and local *science* news stories initially spread through tweeting and retweeting, in real-time.

This is undertaken to pinpoint which agents (Twitter-users such as scientific institutions, science journalists, scientists, science enthusiasts etc.) are most often responsible for breaking and spreading science news on Twitter and how they go about doing so, as well as which type of science news tweets often get the most traction (in terms of retweets and mentions).

Furthermore, we need to understand how social media audiences differ from how media audiences have traditionally been viewed. For this purpose, a literature review of existing audience theory will help to shed light on the nature and characteristics of social media audiences and how science communicators should view and interact with such an audience.

Although substantial research exists on the value, role and importance of Twitter as a platform for breaking and spreading news, very little academic research exists on how news actually breaks and spreads on Twitter in real-time. Even less research is available for how science news gets disseminated on the platform.

Bruns (2012), for instance, made use of network visualisation to map out Twitter conversations around a specific hashtag (#) topic, with the aim of highlighting the shifting roles played by individual participants, as well as the response of the overall hashtag community to new participants or new information over the course of a hashtag conversation. The focus however, was not on breaking news. Uren & Dadzie (2015) made use of a novel high-dimensional visualisation and analysis method to study the framing of science messages on Twitter. The study is however based on three very specific science topics, which makes generalisation difficult. Wu & Shen (2015) suggested the use of a news popularity prediction model to be able to predict the final number of retweets that a specific news tweet will enjoy.

These studies and others that are discussed in more detail in the literature review in Chapter 2, does provide valuable information but do not address how science news is actually being disseminated on Twitter.

One study that does provide a data-visual network analysis of the spread of news on Twitter is that done by Ram & Bhattacharya (2012) who examined the lifespan of retweeted news articles that were tweeted by various major news agencies over a time period. This was done to help news agencies gauge their performance on Twitter by examining how far and wide their news articles get read.

Although a very insightful study, it is large in scale (looking at the total lifespan of news tweets), it takes a news agency-centred view, is concerned with specific tweets (those sent by news agencies) and its focus is not on science news.

This study, in contrast, is a smaller-scale, data-visual network analysis focusing only on the first 3 000 or less tweets that were sent out in the hours or minutes directly after a specific breaking news event was first tweeted about in real-time. The study's small-scale nature has the explicit purpose of making data-visual analysis more useful (less cluttered) and serves to better allow for the identification of individual agents that were responsible for the initial breaking and/or spreading of news around an event or announcement.

The study is also story-centred, focusing on either a breaking news event of importance (such as an earthquake or terrorist attack or political scandal etc.) or a scientific discovery or embargoed announcement. Being story-centred, the study has no bias toward traditional spreaders of news such as news agencies or journalists. It specifically aims to identify the true agents responsible for breaking and spreading news – be they news agencies, science journalists, terrorists or teenagers.

For this data-visual network analysis, the exact methodology of which is set out in the third chapter, various examples of four types of news stories were identified over several months - namely local and international news events and local and international science news events.

The initial tweets around such events, identified by signature terms specific to that event (ie. "Osama bin Laden AND raid"), were captured in real-time as quickly after each event as was possible, using the TAGS v6.0 Twitter archiving spreadsheet template developed by Martin Hawksey (tags.hawksey.info).

TAGS was used because it is a cloud-based Google Sheets template that can be saved on the Google Drive cloud storage platform, which allowed for the quick and easy capture of tweet archives whenever and wherever the author became aware of a breaking news event. In other words, it enabled the capture of tweets on a multitude of available devices without the need to first reinstall software onto a specific device. This was crucial in order to capture tweet archives quickly enough after breaking news events occurred.

These tweet archives, treated as raw data, were then exported into the open-source Gephi (gephi.org) network visualisation platform to create visualisations where nodes (Twitter-users who

tweeted about signature terms) are weighted according to the amount of retweets they received so that the most retweeted nodes appeared bigger, allowing for the easy visual identification of the main agents involved in the breaking and spreading of information around studied news events.

Key data for each event, such as the original tweet and its author (if available), the total number of tweets captured, the number of key agents identified, the nature of these agents and the timeframe of the tweets captured (against the timeframe of the news event itself), were also recorded.

The resulting graph visualisations and data allow for valuable observations about which agents are often responsible for initially disseminating science news on Twitter, about how science is often tweeted, about what types of science news and tweets get the most traction and about the patterns that emerge, in data-visual terms, when science news goes viral on Twitter.

These observations in turn allow for conclusions to be made about how science communicators, both internationally and in South Africa, should go about tweeting science to allow for the healthy spread of accurate and helpful scientific information on Twitter, and about how social media have fundamentally changed the nature of media audiences.

First however, a thorough examination is needed of the existing relevant research and what it reveals about breaking news and science communication on Twitter and about social media in relation to audience theory.

Chapter 2 – Literature review

The share of people for whom Twitter and Facebook have become an important source of news continues to rise (Barthel *et al.*, 2015) and the rise comes primarily from more current users encountering news on Twitter and Facebook rather than simply the increase in the overall user base (Barthel *et al.*, 2015).

This is according to a study by the Pew Research Center based on a nationally representative online survey conducted in 2015 involving 2 035 adults over the age of 18 years living in the United States (Barthel *et al.*, 2015). The study revealed that clear majorities of Twitter (63%) and Facebook users (63%) see these platforms as a source of news about events and issues outside the realm of friends and family, which showed a substantial increase from two years earlier, in 2013, when 52% of Twitter users and 47% of Facebook users felt the same (Barthel *et al.*, 2015).

What the study also revealed is that for many users Twitter is indeed seen as a breaking news service. Say Barthel *et al.* (2015):

“Although both social networks have the same portion of users getting news on these sites, there are significant differences in their potential news distribution strengths. The proportion of users who say they follow breaking news on Twitter, for example, is nearly twice as high as those who say they do so on Facebook (59% vs. 31%) – lending support, perhaps, to the view that Twitter’s great strength is providing as-it-happens coverage and commentary on live events.”

2.1 On Twitter, news, science and audiences

One in ten US adults, across all demographic groups, said they get news on Twitter, and Twitter users reported seeing a higher rate of topics, representing a wider variety of news, than was reported among Facebook users (Barthel *et al.*, 2015). Crucially, younger users place greater importance on Twitter as an important source of news, with 49% of 18 to 34 year olds who reported that Twitter is either their most important or an important source of news, compared with 31% of those older than 35 years having said the same (Barthel *et al.*, 2015).

In its Digital News Report 2016 (Newman, 2016), the Reuters Institute reported similar findings, stating that across the entire survey sample (spanning across 25 countries) half of respondents (51%) said they use social media as a source of news each week. Around one in ten (12%) said it has become their main source of news and more than a quarter of 18 to 24 year-olds say social media (28%) are now their main source of news – more than television (24%) for the first time

(Newman, 2016). Says Newman (2016) in the report:

“But the biggest change in digital media has been the growth of news accessed via social media sites like Facebook, Twitter, Instagram, and Snapchat. In the United States, to take one example, the percentage of people saying they use social media as a source of news has risen to 46% of our sample – almost doubling since 2013...But this is not just about *access* to news via social media, our data suggest that an increasing proportion are coming to depend on it for direct consumption. News has become a more important part of the Facebook mix over the last year. Algorithms have prioritised breaking news, news-related videos, live streams, and other visual content, while publishers have been stepping up their efforts to publish native formats.”

Both Facebook and Twitter are stepping up efforts to become the dominant social media news source significantly. Taking into account the fact that Twitter has embraced the slogan “What’s happening” on their home page (twitter.com); the company’s purchase and assimilation (into Twitter’s newsfeed functionality) in early 2015 of the live video-streaming app Periscope (Barthel *et al.*, 2015); and the fact that what used to be Twitter’s secretive “Project Lightning” (Honan, 2015) has been launched as Twitter Moments (not yet available in South Africa), a real-time curated news service tailored to the individual, it becomes clear that Twitter wants to position itself as the leading social media platform when it comes to breaking news.

Features like Moments, aimed at instantly providing “the very best of what’s happening on Twitter” (support.twitter.com) at any given time in terms of curated news, sport and entertainment story highlights from around the world, will most likely further cement Twitter’s value and importance in real-time news dissemination.

News editors and journalists, as well as science journalists and science communicators wishing to successfully convey sound, evidence-based science news to the social media-savvy masses, will therefore do well to position themselves to be able to take advantage of Twitter’s potential. Already 56% of Twitter users report regularly seeing tweets about science and technology (Barthel *et al.*, 2015).

In South Africa too, Twitter’s user base has continued to rise, boasting 7.4 million active users at the end of 2015 compared with 6.6 million in 2014, 5.5 million in 2013 and 2.4 million in 2012 (World Wide Worx staff, 2016). This trend is set to continue as according to the organisation We Are Social’s annual Digital Report (Shezi, 2016), the number of South Africans actively accessing the internet grew by 1.9 million from 24.9 million in January 2015 to 26.8 million in

January 2016. On average, these 26.8 million Internet users now also spend close to three hours per day on social media alone (Shezi, 2016).

The report showed a growth of 10% in active social media users in South Africa from January 2015 to January 2016 (Shezi, 2016). Furthermore, it is noteworthy that 92% of South Africans say they primarily use their mobile phones to go online, while 60% say they use a smart phone (Shezi, 2016). Twitter, with its succinct, on-the-go approach to social media messaging, lends itself to mobile use on cellular and smart phones through its mobile Twitter app.

The above makes it clear that scientists, science communicators and science journalists will benefit from knowing how science news breaks and spreads on Twitter and more importantly, how science should best be disseminated using the platform.

A literature review dealing with how science communication intersects with social media and how social media has changed the nature of media audiences, needs to take into account relevant existing research on the breaking and spreading of news on Twitter, on science communication through Twitter and on the history of audience theory in relation to social media.

2.2 Breaking news on Twitter

The study briefly mentioned in chapter 1 by Ram & Bhattacharya (2012), that examined the Twitter activity of 12 major news agencies using the Gephi network visualisation platform also used for this study, showed varying levels of success for Twitter as a news sharing tool depending on the news agency in question, but served to highlight that how news is tweeted, matters, because “different propagation mechanisms result in different lifespans for news articles” (Ram & Bhattacharya, 2012: 966).

A colleague of Sudha Ram and Devipsita Bhattacharya also hailing from the University of Arizona, Alexis Blue, provides an insightful summation of the results of this study (Blue, 2012).

Over six months the study examined the Twitter activity of news agencies that included *The New York Times*, Reuters, *The Washington Post*, BBC, *Forbes*, Mashable, Wired and Bloomberg, all of whom regularly share news on Twitter, and tracked what happened to a news article after it was tweeted (Blue, 2012). It looked at how many people retweeted the article and how many times it was subsequently retweeted from those accounts and so forth in order to evaluate the volume and extent of spread of a news article on Twitter, as well as its overall lifespan (Blue, 2012).

The data was then rendered visually as images using Gephi, creating network visualisations that appeared like fireworks (see Figure 3 below) with central nodes representing tweets and cascade outward streams representing retweets.

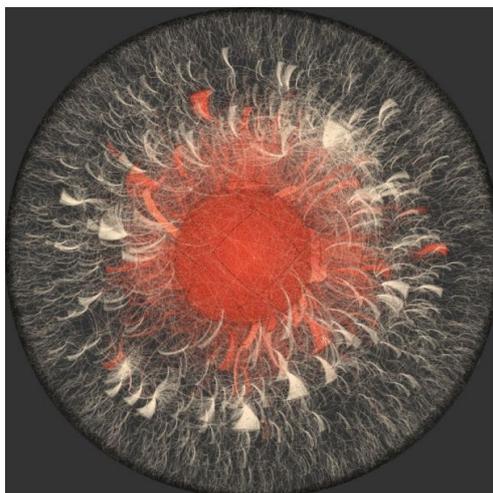
This analysis, which chiefly made use of graph theory and network analysis, showed that the BBC had the maximum reach in terms of affected users and levels of retweets, as well as the highest chance of survival for its articles, through continuous retweets, for more than three days (Blue, 2012).

The BBC’s effectiveness on Twitter could partially be explained by the fact that it makes use

of several Twitter profiles, including @BBCNews, @BBCBreaking and @BBCWorld (Blue, 2012). *The New York Times* and Mashable had the second highest levels of reach, which is notable because Mashable.com has a strong focus on technology news.

Overall the study reveals that news articles retweeted on Twitter dissipate on average between 10 and 72 hours after an article is tweeted (Blue, 2012). Ram & Bhattacharya (2012:971) view their results as a point of departure for further planned research that is needed to understand how news is disseminated on Twitter.

Figure 3: The Twitter activity network for *The New York Times* showed a high number of users participating in long chains of tweeting and retweeting (Blue, 2012)



The study by Ram & Bhattacharya (2012) is an ambitious and thorough effort that provides valuable insight into the lifespan and diffusion patterns of news articles on Twitter. Because of its large scale, involving tens of thousands of retweets from the initial tweet by the relevant news agency to the final death-throes of the news article in the Twittersphere, fairly complex network analysis techniques were required and the visualisations generated (as seen in Figure 3) were equally complex and extremely dense. Without further analysis and breakdown, these visualisations do not, on their own, provide immediate insight.

In contrast this study, being confined to only the first 3 000 tweets (maximum) that were generated as close as possible in time to a news event, resulted in far simpler visualisations with the aim of enabling anyone, at a glance, to immediately see who were the main agents of dissemination after a news event was tweeted. This made it easy, to an extent, to see who are in real terms often the disseminators of science news, locally and internationally, and which types of tweets were the most successful (in terms of retweets).

Furthermore, the focus for this study is not on specific news articles tweeted by specific news agencies, but rather on news events and stories captured through the identification of the most appropriate search terms in each case. This in effect casts a wider net and allows for a more organic,

but more direct way of identifying which agents, news agencies or no, were first responsible for the dissemination of a breaking news story on Twitter, as and when it occurred. The study by Ram & Bhattacharya (2012) also did not focus specifically on the dissemination of science news.

Building on their previous work Ram & Bhattacharya (2015) conducted further research suggesting various network analysis and graph theory metrics that can be used to analyse the performance and effectiveness of news agencies on Twitter.

That study resulted in several general insights, one of which is that both followers and nonfollowers of news agencies play an important role in news article propagation (Ram & Bhattacharya, 2015).

This is important because it illustrates the viral nature of news dissemination on Twitter. When a news agency tweets a news article, it might be retweeted by a follower of that agency and retweeted again by a follower of that follower, who might not be a follower of the news agency itself, and so on and so forth. To focus only on tweets sent out by news agencies (or journalists or science institutions), or on their direct follower base, would only give a very limited view on how news is spread on Twitter. To examine a captured set of tweets around a specific new hashtag or event close to the time when the story or event is first tweeted, can arguably paint a more complete picture.

The study concluded that news agencies ought to employ multiple measures to enhance effectiveness on Twitter (in particular that brand influence plays a significant role), and that news propagation on Twitter is incomparable to traditional models of propagation such as disease spread (Ram & Bhattacharya, 2015:11-22):

“...it appears that the overall performance of a news agency can be attributed to many different reasons, including its brand influence, its capability to create interesting content (tweet and article text), and its ability to engage both followers and nonfollowers. Our proposed framework and methodology underscores the importance of using multiple measures for a comprehensive performance evaluation of a news agency relative to its competitors... Our study also shows that news article propagation is quite different from traditional propagation models that focus either on disease spread or diffusion of innovations. In disease propagation, the time at which the first person becomes infected plays a significant role in determining the rate of spread and the lifespan of the infection. However, in our study, we did not find any link between response time and rate of spread or lifespan.”

Response time refers to the time between a tweet being posted and it being retweeted for the first time (Ram & Bhattacharya, 2015). What the above means is that a tweet can go viral directly after it has been tweeted, or hours or days later, or not at all, depending on a myriad of opaque and unpredictable factors. Nevertheless, for this study it made sense to capture a set of tweets as close to the first tweet (of a given news event or story) as possible in order to have the best chance of identifying main agents of dissemination while a topic is *hot*, or in Twitter terms, *trending*.

Wu & Shen (2015) emphasised the importance of popular, traditional news agencies, finding that Twitter supernodes (i.e. news media accounts such as @Reuters with millions of followers) act as some of the most important news sources on Twitter. Furthermore retweeting by followers and nonfollowers, according to Wu & Shen (2015: 702), is the most important propagation mechanism on Twitter.

This fact was first underscored by Kwak *et al.* (2010), who found that:

“...any retweeted tweet is to reach an average of 1,000 users no matter what the number of followers is of the original tweet. Once retweeted, a tweet gets retweeted almost instantly on next hops, signifying fast diffusion of information after the 1st retweet.”

By studying the retweet propagation characteristics from news media supernodes, Wu & Shen (2015) were able to build a news popularity prediction model that can predict the final number of retweets of a news tweet quickly. Wu & Shen (2015) also found that there is a correlation between the average interaction frequency between the news source and the retweeters and news popularity, as well as between retweet popularity and the negative sentiment of news. Even on Twitter then, bad news travels faster.

Bruns (2012) explored the use of the Gephi graph visualisation platform as part of a methodology to extract Twitter activity data around specific hashtag conversations (i.e. #ObamaCare) and came to the conclusion that such dynamic network visualisations enables one to highlight the shifting roles played by individual Twitter users over time, as well as the response of the overall hashtag community (people tweeting about the same topic) to new stimuli – such as the entry of new participants or the availability of new information. Bruns (2012) further stated that dynamic visualisation software like Gephi (and conversely also TAGS v6.0 used here) has many more possibilities for visualising dynamic Twitter data, which allows for significant additional opportunities for further research.

Vis (2013) highlighted the use of Twitter as an effective reporting tool for journalists covering breaking news events, by way of a detailed analysis of the Twitter-use of journalists Paul Lewis (*The Guardian*) and Ravi Somaiya (*The New York Times*) during the 2011 UK summer riots. It identified a

need to better understand such online journalistic practices and showed that valuable insights can be gleaned from a relatively small Twitter data set connected to a real-time event, without the need to rely on extensive computational intervention (Vis, 2013:45-46).

Finally, studies have shown that while Twitter enables any user to become a citizen journalist capable of breaking and spreading news on a global scale, traditional news media still play a very prominent role in news dissemination on the platform. Murthy (2011:786) says Twitter's power is in the fact that profound tweets appear side by side with banal ones on a second by second basis, which affords citizen journalists the possibility to break profound news to a global public.

At the same time however, Murthy (2011:786) demonstrated that the public is interested in the stories themselves rather than the original source tweets or the individual tweeter responsible for breaking the story. This suggests that tweeting citizen journalists are "ephemeral, vanishing after their 15 minutes in the limelight...unpaid and unknown" (Murthy, 2011:786) once the story has been picked up by the tweeting news media.

Similarly, Hu *et al.* (2012) conducted an in-depth analysis of how the news of Osama Bin Laden's death was first broken and spread on Twitter and concluded that Twitter had convinced a large number of its audience that Bin Laden had indeed been killed, before mainstream media confirmed the news. Hu *et al.* (2012) also demonstrated that three groups of opinion leaders played a key role in the spreading of news on Twitter, namely individuals affiliated with media, the mass media itself and celebrities with huge Twitter-followings who stimulated conversation. The conclusion from these two studies is that Twitter has great potential as a news medium and an enabler of citizen journalists, but that the traditional news media, tweeting journalists and news agencies still play a prominent role on the medium.

The studies mentioned above, and others, have provided good insights into the role that Twitter plays in the breaking and spreading of news, but they do not address the implications of Twitter for science communication in particular.

2.3 Science communication and Twitter

A myriad of studies, including Nelkin (1995), Hartz & Chappell (1997), The Wellcome Trust (2000), Knip (2002) and Shukla & Bauer (2007), have demonstrated that there is a clear need for the better communication of science by scientists and science journalists in order to enhance the public understanding of science.

Surveys conducted among scientists, news editors, journalists and the public by Pouris (1991, 1993, 2001) and Claassen (2011) have further shown that the situation in South Africa is of particular concern, revealing a low public science literacy and a high level of ignorance with regards to scientifically proven knowledge such as evolution, contrasting with a gullibility and even affinity for pseudoscience such as astrology and homeopathy.

Claassen's study (Claassen, 2011) revealed that more than 50% of South African scientists and journalists questioned believe that the South African public is gullible concerning pseudoscientific claims. Claassen (2011) demonstrates that the South African public struggles to discern between science and pseudoscience and between text book science and frontier science, that the South African media should give serious attention to raising the standards of science reporting by establishing dedicated science desks and allocating more editorial space to science content, and that scientists themselves ought to be better trained to communicate science with the media and the public. Says Claassen (2011):

“Furthermore, scientists should be far more willing to communicate with the public and the media, whereas scientific associations should emphasise the importance of their members communicating their findings through the media.”

This, however, is not just a local problem, but a global one. Even in this digital age, very few academics and scientists do a great deal to share their often important and relevant findings with the general public, with research (Heleta, 2016) showing that of the 1.5 million peer-reviewed articles published annually (more or less), many are ignored even within scientific communities. Data suggests 82% of articles published in humanities journals are not even cited once (Heleta, 2016).

Many potentially world altering ideas are therefore not getting into the public domain and according to Heleta (2016) the three main reasons are: A narrow idea of what academics should or should not do, a lack of incentives from universities or governments, and a lack of training in the art of explaining complex concepts to a lay audience.

In a November 2010 survey among 1 248 neuroscientists to determine how they use old and new media (such as blogs and social media), Allgaier *et al.* (2013) found that these scientists continue to rely heavily on traditional journalistic outlets such as newspapers, magazines, radio, and television rather than social media, and have been slow on the uptake on the usefulness of social channels to relay research findings.

As already stated above however, several studies have shown that scientists and science journalists can greatly benefit through better use of social media and Twitter.

Bombaci *et al.* (2015) examined live tweeting as a means of communicating conservation science at the 2013 International Congress for Conservation Biology (ICCB) and found that Twitter can be used to effectively communicate speakers' findings to diverse audiences beyond conference halls, and can promote scholarly discussion, disseminate research rapidly, and extend and diversify the scope of audiences reached.

Smith (2015) explored how scientists use Twitter for science communication and concluded that given Twitter's unique characteristics, the effect of science tweeting “does appear to offer the potential to break down barriers between scientists and non-scientists”.

Bik & Goldstein (2013) similarly states:

“In the age of the internet, social media tools offer a powerful way for scientists to boost their professional profile and act as a public voice for science. Although the type of online conversations and shared content can vary widely, scientists are increasingly using social media as a way to share journal articles, advertise their thoughts and scientific opinions, post updates from conferences and meetings, and circulate information about professional opportunities and upcoming events.”

According to Bik & Goldstein (2013) the advantages for scientists using social media include the fact that online tools like Twitter and Facebook can improve research efficiency (for instance by keeping up to date on relevant research developments elsewhere), the fact that online visibility can help track and improve scientific metrics (by increasing citations), that social media enhances professional networking and that social media can significantly broaden the impact of research. Vinas (2011) raises the same points and also posits that Twitter removes the gatekeepers (i.e. journalists and the news media) and lets scientists communicate their science directly to the public. This is also true for science journalists who want to speak directly to their audience instead of through news articles.

Liang *et al.* (2014) compared the scientific impact of highly cited nanoscientists, as measured by their h-index (citations metric), with the way they chose to engage with the public through science blogs, public lectures, journalistic interviews and Twitter. Findings suggested no relationship between scientific impact and blogging or public lectures, but found that interactions with reporters and being mentioned on Twitter can contribute to a scholar's scientific impact (Liang *et al.*, 2014). Most importantly, being mentioned on Twitter was further shown by Liang *et al.* (2014) to amplify the effect of interactions between the scholar, journalists and the public on the scholar's scientific impact.

Clearly then, scientists and science journalists familiarising themselves with Twitter in order to effectively convey the importance and applications of new discoveries, knowledge or technologies can play a big role in advancing the potential impact of scientific endeavours.

Several science communication experts already offer courses for scientists on how to use social media, and the website tweetyourscience.com provides lists of scientists for other scientists to follow on Twitter and provides “Twitter 101” online training courses and updated research on science communication through Twitter.

Using data from an online survey among 3 500 researchers and scientists from 95 countries conducted by the Nature Publishing Group, Collins (2014) reveals that only 14% of scientists said they have heard of Twitter and use it regularly compared with 71% who said they have heard of Twitter but do not use it regularly and 15% who said they have not heard of Twitter.

Also of interest is the so-called Kardashian-index (K-index) first proposed by genomicist Neil Hall in 2014. Hall sparked controversy (You, 2014) by proposing a K-index to compare a scientist's number of Twitter followers with their citation count. Scientists with a high K-index score, named after the reality TV star Kim Kardashian, one of the most popular celebrities on the social media platform, should "get off Twitter" and write more papers, suggested Hall (You, 2014). Subsequently the journal *Science* compiled a list (You, 2014) of the 50 most followed scientists on Twitter and calculated their K-indexes by drawing on citation data from Google Scholar. Topping the list was the popular astrophysicist Neil deGrasse Tyson, the physicist and TV-personality Brian Cox and the evolutionary biologist Richard Dawkins.

The list reveals that a majority of science Twitter stars spend much of their time on science communication. Having been queried by You (2014) it seems many of them see Twitter popularity as a means to amplify their efforts in public outreach. The list also highlighted the poor representation of female scientists on Twitter, with only four women making the list (You, 2014). Notably, the list showed that Twitter stardom does not necessarily imply that a scientist is lazy in producing research, with many on the list who have thousands of citations (You, 2014).

The *Mail & Guardian* recently compiled a list (M&G staff, 2016) of 15 of "Africa's most brilliant young scientists". It might be interesting to track the Twitter habits of these younger, African science stars and to monitor their own K-indexes over a couple of years.

The emergence of Sci-Hub, the world's first pirate site for downloading scientific papers without having to first get behind a paywall (Bohannon, 2016), can also be seen as a motivator for scientists and science communicators to become more active online and more interactive and aware on Twitter. With more and more scientific papers becoming readily available for anyone online, it becomes important for scientists to monitor how their research is cited, used and possibly misinterpreted without their knowledge.

Scant research is available on how science news spreads on social networks. Uren & Dadzie (2015) did however assess high-dimensional data visualisation as an approach to observing dynamic changes in the ways people tweet about science topics. Applying their mixed methods approach to three specific science discussions on Twitter (namely the Mars Curiosity landing, Phosphorus and Permafrost) Uren & Dadzie (2015) concluded that data visualisations of Twitter metrics or network analysis are effective methods for observing dynamic changes in communication, and science communication, on Twitter.

Very little research exists on how breaking science news actually spreads on Twitter in real-time and what that could teach scientists and science communicators on how better to make use of the

platform to more successfully convey science. Even less research exists on how science news is communicated in a South African context.

To understand how social media and Twitter have changed audience dynamics and the implications of these dynamics for science communication, one needs to also take a brief look at the history of mass media audience theory.

2.4 Twitter and the evolving mass media audience

Without going into much detail, the idea of a mass media audience first became popular with the advent of broadcasting in the first half of the previous century (McQuail, 2005:389). This mass audience was initially regarded as a single “large, heterogeneous and widely dispersed” collective consisting of largely passive members who “did not and could not know each other” (McQuail, 2005: 389).

Over time the idea that the mass media audience as a passive, homogenous whole was abandoned as media owners realised that audience demographics matter (for marketing and growth), that audience member preferences cannot be ignored and that audiences can be described by the varying levels of activity and selectivity of its members (McQuail, 2005:414). Various theoretical viewpoints evolved in an effort to explain the relationship between the media and its audience.

Du Plooy (2009:25) summarises the clear evolution of theoretical assumptions about audiences from a simple concept in the 1930s of *linear sequences* focusing on a clear, one-directional message from media to audience, to *stimulus-response theory* (also known as *hypodermic needle* or *magic bullet* theory) highlighting the cause-and-effect nature of media messages with a view that the media are capable of direct influence on a mass audience, and later to *information theory* that acknowledged the fact that there could be “interference” in various forms that might distort the media’s intended message (Du Plooy, 2009:25).

In the 1940s a popular theory emerged in the *two-step flow model*, which acknowledged that audiences “are not passive victims of external stimuli” but consume media in a social context in two steps, from media to opinion leaders and then to the social group (Du Plooy, 2009:25).

This was taken further in the 1950s with the so-called *uses and gratifications* approach which emphasised the “gratifications sought and obtained by audiences” (Du Plooy, 2009:26), which acknowledged for the first time the fact that the individual’s media needs differ, and that they matter.

In the 1970s attention shifted to *agenda-setting theory*, highlighting the media’s power to set the cultural and political agenda, and the fact that the emphasis the media place on issues determines the importance that audiences attach to those issues (Littlejohn & Foss, 2009:31). More recently (1980s and 1990s) attention shifted to various forms of what is termed *cultivation theory*, which is concerned with the long term effect that the media have on shaping the audience’s view of how they see the world, of their cultural beliefs and values and therefore how they view society and each other (Du Plooy, 2009:27).

The above is a condensed summary of a multitude of models and theories that have emerged, with the simple purpose of illustrating that, where the mass media audience was once seen as a passive, largely homogenous collective of individuals with no connections to each other, audience theorists gradually came to accept that audience members are not passive at all, that they have specific media needs, that audience needs and views influence the media as well and that, increasingly, new technologies and in particular social media have allowed audiences to become more and more active, engaging and interactive with the media.

Another important development in media studies has been the increasing fragmentation and segmentation of the media audience.

Media fragmentation, according to Napoli (2003:136), refers to the extent to which media audiences are more widely distributed across an increasing variety of content options, facilitated by new media technologies and the “increasing number of media options and their increasing capacity for carrying content that appeals to narrow audience segments” (Napoli, 2003:136).

The related concept of audience segmentation is the process by which the production and distribution of media content is targeted to reach specific types of people (based on age, gender, lifestyle, ethnicity etc.) with messages tailored specifically for these differing audience segments (Turow, 2011:160).

Over the last century and especially since the advent of the internet, cellular technology and social media, there has been a gradual splintering of the cohesive mass media audience, to such an extent that audience members now have a venerable kaleidoscope of media outlets (TV, radio, print, Internet, Facebook, Twitter, Apps etc.) and content options available to them – all of which is now accessible from anywhere using a smart phone or tablet. The media have to work a lot harder to keep the audience’s attention, or they will simply move elsewhere with a single click.

With its focus on individual users each with tailored profiles and preferences and personal networks it is easy to see how social media have added substantially to audience fragmentation and segmentation (with media companies investing lots into their new Facebook and Twitter audiences).

What is most pertinent to our discussion is what social media and especially Twitter has done for audience participation.

Social media have added an unprecedented level of audience activity, selectivity, interaction and empowerment to the media-audience-dynamic. Social platforms have made possible a previously unthinkable level of engagement between individual audience members and each other, between audience members and journalists, between audience members and traditional news media and even between the audience and the very subjects of news, including celebrities, politicians, athletes, kings and queens and even the Pope (@Pontifex).

This has caused a massive shake-up of the news media industry. Rutenberg (2016) states that in a culture where audience members can instantly navigate to new content and where the news media have to compete with viral videos of “grumpy cats or exploding watermelons” (Rutenberg,

2016), big changes are coming very fast in how major news institutions are presenting their journalism, what that journalism includes and how decisions are made about what to include; the goal being to draw big, addicted audiences (Rutenberg, 2016). News organisations, according to Rutenberg (2016), are all scrambling to “find their own watermelons”.

Survival increasingly means finding ways to give readers what they really want, how they want it, when they want it (Rutenberg, 2016). This new era of manic audience participation does also afford opportunities. Says Rutenberg (2016):

“It’s about convincing already-inundated audiences that they want what you’re producing, and they want it so badly that they will pay for it through subscriptions. That’s essential as advertising revenue drops to levels that will not support robust news gathering. Hooking people on your news product is a lot harder than, say, hooking them on heroin or even coffee. But news organizations have ways they never had before to figure it out. Through real-time analytics, reporters and editors know how many people are reading their work and through which devices and sites, how long those readers are sticking with it, and what they’re ignoring... This is the biggest and least talked about development in traditional print media as it converts to digital: It now has ratings, just as television does. The findings from these ratings have been fairly consistent. Videos, podcasts, short items of interest that can be read easily on smartphones, and almost anything with the words ‘Donald Trump’ rate well.”

As has been stated, Twitter lends itself perfectly to short news items and is therefore important to the evolving news media, but it is also easy to see that the “Donald Trump” reference does not bode well for science news that is usually far less laughable or easy to sell than Trump, or exploding watermelons.

In order to compete, news (and science news) has to increasingly be packaged in succinct, attractive and more entertaining ways. As Laurie (2010) says, news has become a cultural currency:

“We’re no longer lazy consumers of passive messages. Instead we’re active participants. We now get news through the network we’ve created, and the news we pass to one another says something about us. It tells others what we’re interested in and what’s important to us. We used to call this gossip — and to a

certain extent it still is — but unless you were a journalist at a local daily, the amplification that's now possible through the likes of Twitter, Digg or StumbledUpon hasn't been experienced before.”

This level of audience participation has made Twitter fertile ground for research that can shed light on how news is spread and how users want their news, and their science news, to be presented.

Deller (2011) argues that Twitter provides a significant development in our understanding of audiences and their relationship to the media and concludes that Twitter users directly engage with the news and in some cases, creates the news. Harrington *et al.* (2013) looked at how Twitter is used alongside television as a traditional form of media and conclude that Twitter has become an important backchannel and “virtual lounge room” (Harrington *et al.*, 2013:405) that connects active audience members and through which social activity is sustained and made more widely visible.

Marwick (2011:114) highlights the fact that social media collapse multiple audiences into single contexts and says this many-to-many communication model often forces individuals (and journalists, news agencies, scientists) to conceptualise and navigate “imagined audiences” to gain an understanding of who they are tweeting to. Says Marwick (2011:129-130):

“Audience members take turns creating and producing content, and in this ‘many-to-many’ model the network constantly centers on who is talking, responding, or replying. Social media environments become a place where person-to-person conversations take place around user-generated content amidst potentially large audiences. The networked audience contains many different social relationships to be navigated, so users acknowledge concurrent multiple audiences. Just as writers fictionalize the audience within the text in their *audience addressed*, Twitter users speak directly to their imagined audience.”

A study by Rudat *et al.* (2014:138) suggests that although users adapt their communication on Twitter according to their followers’ interests (their imagined audience), there is evidence to show that users still prefer messages with high informational value over messages with low informational value and often decide to retweet messages they deem as informative. This at least bodes well for science communication to Twitter audiences.

The message from these studies and others, is that Twitter has brought unprecedented audience participation, selection and complex social and contextual dynamics to the news arena.

Where once the mass media audience was a passive, homogenous collective it has not only fragmented but has, in large part thanks to social media, shattered; Every single audience member is now able to actively pick and choose any kind of media diet and each has his or her own little audience and the power to become a global voice in an instant.

At the heart of the social media revolution seems to be this fact: That while social networks like Facebook and Twitter might be viewed as the pinnacle of audience fragmentation and segmentation, it also allows for any user to instantly become part of a global conversation around a breaking news event that at once connects again all the shattered pieces. Examples include the #OccupyWallStreet protests of 2011 against economic inequality or the #ArabSpring democratic uprisings of the same year. The power is now, more than ever before, in the hands of the hyper-connected social media-savvy audience. Any Twitter user can at once be an audience member, a citizen journalist, a science communicator or the latest lone whistleblower to spark a global outcry.

Arguably, Twitter has become a new type of mass media audience, a kind of intricate, interconnected social news net, albeit one that is driven not by media moguls or governments, but by the audience itself.

This modern mass media audience is a social one that is at once splintered into millions of extremely diverse audiences with very unique content preferences and yet also an intricately connected mesh of individuals able to spontaneously unite to speak suddenly and loudly with a single voice that the media, and the world, cannot ignore.

Says Alejandro (2010:42):

“We are in the middle of some kind of industrial revolution in the media. At the centre of this revolution is the rise of social media... For a long time, the conversation between mainstream media and the audience has been one-way even during the early days of the internet. That was Web 1.0. Then Google, Facebook, Twitter, YouTube came and all of a sudden the audience can communicate back and give feedback. That’s where we are now, in the Web 2.0 phase. In the next ten years we may witness another transition, this time to Web 3.0 or what techies call the semantic web whereby businesses including news organizations can capitalize on the conversation because new technology will allow them to better understand and quantify the audience in a multiplatform environment... While these web innovations may be disruptive (for now) as most innovations are, this upheaval is a much needed one – a cathartic change from which a better news

media industry will emerge and new or hybrid forms of journalism will surface.”

What this means for science communication represents both a challenge and a massive opportunity.

Social media provide the means to bring cutting edge science out of the lab and drop it squarely at the feet of those who might benefit most from it. Two examples of how this is being done is the Facebook-driven IFLScience (short for “I Fucking Love Science”) that started out as a Facebook page of a young science enthusiast and is now a major source of aggregate science news sourced globally and repackaged to be both informative, eye-catching and entertaining; And the local Scibraai.co.za not-for-profit science communication website that has active social followings on both Facebook and Twitter and aims to champion local research efforts and South Africa’s often unseen science heroes.

On the other hand science, like all news, also has to compete with those exploding watermelons and funny cat videos. Furthermore, the power of social media to misinform is especially troubling when it comes to science and the instantly viral nature of Twitter communication.

A data-visual network analysis study of how science news actually breaks and spreads on Twitter in real-time, and by whom, will go a long way to shed light on how international and specifically South African scientists, science journalists, educators and science junkies can best make use of the significant potential that Twitter affords.

Chapter 3 - Methodology and approach

In this chapter the software and content analysis methodology used in this study to capture, plot and analyse Twitter data sets around news events, is explained.

3.1 News event capturing using TAGS v6.0

The TAGS v6.0 software tool (Tags, 2016) developed by Martin Hawksey (mashe.hawksey.info) is a free Twitter archiving spreadsheet template that makes use of Google's cloud-based Google Sheet software to interact with Twitter's API (Application Program Interface). An API is the set of rules and protocols that dictate how specific software applications should interact. TAGS v6.0 essentially allows the user to create a custom spreadsheet database of a collection of tweets centering around a specific search term or event hashtag, in accordance with the allowances and limitations of Twitter's API.

Hawksey (2016) explained the limitations imposed by Twitter's API as follows:

“TAGS uses their [Twitter's] API which can only get data from the last 7-10 days and only the last 18 000 tweets. In terms of selecting data from the last 7-10 days again you are limited to a day window rather than time. The solution is to get a day's worth then trim out what you don't need. The problem you can encounter with this approach is if the tweets you are interested in were at the beginning of the day you can only get the last 18 000 tweets from that day. In terms of what TAGS collects, it includes the original tweets [which includes the designated search term and criteria] plus retweets.”

For this study the limitations set out by Twitter's API (limiting searchable access to only the last 7-10 days or 18 000 tweets) is luckily of no concern seeing as the focus is only on the first 3 000 or less tweets around a news event, captured as close to that event as possible to determine the primary news disseminators of that event or story.

There have been several iterations of the TAGS software, with the first version appearing in June 2010 and the current, sixth version having been published in September 2014. A major advantage of TAGS v6.0 is that it makes it quick and easy to create a copy of the 'clean' master sheet (with no search terms yet added), complete with the necessary license and permissions needed to interact with Twitter's API, and then to enter new search criteria and capture a new datasheet which is then automatically saved as a separate document on the user's Google Drive cloud account. The

databases of tweets can then be viewed, exported and analysed at any later time.

Figure 4 (below) is an example of a TAGS v6.0 spreadsheet where the search term “SpaceX AND Mars AND 2018” have been entered in order to capture a dataset of tweets (up to 3 000) sent out shortly after the SpaceX company announced their plan to commence missions to Mars in 2018. Figure 5 below shows a sample of the resulting archive of tweets that were captured.

For this study it was decided to limit the capturing of tweets to 3 000 or less, for two reasons: First, the study has the explicit purpose of trying to identify the actual primary disseminators, on Twitter, of news connected to a specific event or story. As such, even just 50 or less tweets sent out after an event or announcement will provide valuable insight and more than 3 000 tweets might not be viewed as primary anymore and could result in too much clutter or noise.

The second reason for the hard limit of 3 000 tweets is the fact that trial-and-error has shown that the TAGSExplorer function, which allows for a simple, instant visualisation of the captured network, weighted according to retweets and mentions, requires significant computational power. Analysing networks of more than 3 000 tweets simply becomes too slow (and is prone to crashes) if one does not have instant access to a high-powered PC. This would undermine the key advantage stated above of being able to quickly and easily capture and analyse news networks, even only with access to a laptop or tablet.

Figure 6 below is an example showing the TAGSExplorer visual network display of the data captured in Figure 5, clearly showing that tweets from the @SpaceX account were in this case by far the most mentioned and retweeted, concerning the announcement in question.

Figure 4: Example of a TAGS v6.0 spreadsheet template with the search term “SpaceX AND Mars AND 2018” entered

The screenshot shows a Google Spreadsheet template for TAGS v6.0. The title bar reads "SpaceX AND Mars AND 2018 (3000 - 17:15 SA time)(minutes after IFLScience FB post, 24 hours after Sp...". The spreadsheet content includes instructions on how to use the tool, such as making a copy, enabling the custom menu, and entering search terms. The search term "SpaceX AND Mars AND 2018" is entered in cell B9. The spreadsheet also includes advanced settings like "Period" set to "default".

the Gephi open-source software platform for enhanced network visualisation.

3.2 Visual network analysis using Gephi

Gephi (2016) is a powerful open graph visualisation platform widely used to create useful and understandable visual representations of complex graphs and networks.

For this study the dataset of tweets captured for each individual news event or announcement (tied to a specific event hashtag or search term) was in each case converted into the required CSV file format and exported into Gephi as a new unprocessed graph, to be ready for analysis.

According to Guibourg (2015) a network graph basically consists of *nodes* (in the case of Twitter networks, the nodes are the Twitter user accounts) and the connections between them, which are called *edges* (in this case the edges are retweets).

When the TAGS v6.0 datasets were exported into Gephi, the option to create a directed graph (as opposed to an undirected graph) was chosen. This would vary depending on the type of network being analysed but for Twitter, which has asymmetrical follow relationships, a directed graph makes more sense; For Facebook, where a friendship can only go both ways, undirected would be better (Guibourg, 2015).

Gephi has several layout templates that can be employed to start making sense of the raw imported graph data. For this study the template “Force Atlas 2” was used, which employs an algorithm to group collections of nodes (Twitter users) based on their relationships to each other, i.e. their edges (retweet connections) and to space out the graph so as to be more easily readable in a visual sense.

Nodes were then coloured based on their groupings (by using Gephi’s modularity algorithm) and *centrality* was used to make the nodes’ sizes reflect their importance. In other words, the more retweets that a user received, the bigger that user’s node appeared in the graph visualisation.

Centrality identifies the most important nodes in a graph based on different parameters (Guibourg, 2015). In this case, nodes were weighted according to what is known as *in-degree centrality*, which provides a layout based on the number of ties (retweet connections) directed to each node. Out-degree centrality, which refers to the ties that a node directs outward to its edges, would in this case not be appropriate as individual Twitter users have no control or often even knowledge about who retweets their tweets.

The resulting graph layouts provided visual representations revealing, at a glance, the main Twitter users (the biggest nodes on the graph, weighted according to their total number of received retweets) who were involved in the breaking and spreading of news surrounding a particular event, announcement or story.

Along with these viral news graphs revealing the main agents of news dissemination for particular events, the archived TAGS v6.0 datasets provided further key data about each event. This included the first tweet captured for each news event (mostly for contextual purposes as the first

captured tweet is usually arbitrary unless known that it was the very first tweet on the topic), the search term that was used in each case (which is subjective), the total number of tweets captured, the time at which the event or announcement occurred (if available) as well as the actual time of data capture (to provide a timeframe between event and capturing), and the content of the most retweeted tweets in each case (to shed light on which types of tweet content could be deemed as more successful).

To capture this data one first has to be aware when a breaking news event occurs or when a scientific announcement is first tweeted about, which can obviously be difficult. The first step is to follow, on Twitter, as many credible local and international news agencies, journalists, news media, scientific institutions, science communicators, scientists, science journalists, emergency services and law enforcement agencies, alert accounts (such as weather or earthquake alerts), prominent politicians and whichever account was deemed trustworthy and has the potential to be a source of breaking news.

Because social media is such an intricate, interconnected phenomenon with a lot of constant cross-pollination happening for instance between Twitter, YouTube, Facebook and Instagram, the same following strategy as for Twitter was employed for these other social networks. The idea being that if breaking news were to be mentioned on another social network one could quickly check if it has been tweeted about and, if in time, capture a dataset of those tweets.

In this study, using TAGS v6.0, many Twitter datasets were captured for a great variety of news stories of which 30 captured events were chosen for detailed analysis and visualisation using Gephi. The 30 events chosen – 5 local and 5 international breaking news stories and 10 local and 10 international *science* news events – were those events that were deemed as the most successful captures, yielding the most useful data. Local and international breaking news stories were first analysed to establish baseline trends against which science news stories could be compared.

Judging which captured events were the most successful is subjective and open to interpretation but the criteria makes logical sense: The captured dataset of tweets around an event was deemed as successful and ready for analysis if the TAGS v6.0 search query yielded less than the set maximum of 3 000 tweets; the implication being that all tweets containing the chosen search term, were indeed captured.

Secondly, if the maximum number of 3 000 tweets were captured for a given search term, meaning that the capture may have missed the first batch of related tweets (which is often inevitable given the speed at which news spreads on Twitter), it was still deemed a success if the capture was done close enough in real-time to the actual event that occurred. For instance, when Nasa launches a new spacecraft there can often be tens of thousands of new tweets relating to the launch within minutes or seconds of the launch occurring. In such cases, a dataset of 3 000 tweets about the launch, captured shortly enough after the launch happened may not include the first couple of hundred or even thousands of tweets but will still yield valuable insight into who the primary news disseminators were who tweeted about the launch (especially as most people tweeting directly about an event will most

likely post a series of tweets over the course of the event).

From the literature review that was done it seemed this method, of the combined use of TAGS v6.0 and Gephi to capture and analyse tweets around breaking news events, in real-time, in order to illuminate trends and to identify the actual primary disseminators of science news on Twitter and how these agents go about tweeting science, has not been employed in a study before.

The study therefore had the secondary purpose of assessing the usefulness of this particular methodology as a viable means to conduct research on Twitter and on the spread of news on Twitter. As with any research endeavor, this methodology does of course also have its share of limitations that need mentioning.

3.3 Limitations of the approach

The most obvious limitation of the approach used here is that it is subjective, involving several choices (which events to capture and analyse, what search terms to use, which profiles to follow etc.) that would yield different results depending on who performs it.

This also inevitably implies a sense of personal bias. The events that are indeed captured will depend on which news stories or announcements are deemed as interesting, relevant or newsworthy in the eyes of the person or persons conducting the study. Capturing a variety of event datasets, covering a diverse array of news stories, can be seen as a rectifying measure but it cannot fully erase the personal bias or subjective nature inherent in such a study.

Another, less obvious limitation, is that of waking hours. News happens all around the globe in all time-zones and news can break at any given moment, yet the person or persons conducting a study such as this will only be able to capture tweets around events while they are awake, aware, and within reach of technology able to do the capturing. While sleeping, or being away from a computer with internet access, no capturing can be done. Where many events are captured over the course of several months, such as in this study, the waking hours effect eventually disappears to an extent but it bears mentioning. This is also where TAGS v6.0 provides a distinct advantage because it is cloud-based and can be easily accessed from any computer or tablet with internet access.

An important limitation to take note of is the fact that breaking news does not always read as breaking news on Twitter. For instance, the tweet mentioned in Chapter 1 that broke the news of the raid on Osama bin Laden's compound simply stated that it was a rare event to have a helicopter hovering over Abbottabad at 01:00 AM. It included no mention of Osama Bin Laden, about a raid, or even about the fact that it was a military helicopter, and did not include any obvious hashtags such as #BinLadenKilled or #OsamaDead etc.

In other words, capturing tweets around a search term such as "Osama AND Dead OR Killed" would in this case not have included the tweet that actually broke the story. On Twitter anyone can be the source of breaking news but the fact of the matter is that one cannot follow everyone on Twitter and cannot always anticipate where news might come from. Nevertheless, if the proposed approach

cannot always capture the initial originators of breaking news on Twitter (connected to an obvious search term), then it will at least provide insight into who was tweeting first once the event *became* news.

Finally, another limitation is that capturing tweets containing a specific search term often includes tweets that amount to general conversation and do not necessarily relate to the event in question. Capturing tweets with the search term “EgyptAir” directly after an EgyptAir flight disaster (EgyptAir flight 804 from Paris to Cairo crashed into the Mediterranean sea on 19 May 2016) might coincidentally include a tweet such as “Flying EgyptAir to Dubai for some shopping today!”, which does not relate to news of an aircraft crash.

By and large it was found that this limitation did not significantly skew results, seeing as tweets pertaining directly to the news events in question invariably far outweighed tweets with casual reference to the search terms used. Where search terms produced conflicting or confusing results, different iterations of the term (for instance “Airport AND Bombing AND Istanbul” rather than “Terror AND Attack AND Istanbul”, in the case of the 28 June 2016 terror attack at the Ataturk airport in Istanbul, Turkey) were used to get a satisfactory result.

Although the above limitations are all worth mentioning, the methodology has significant potential for further research pertaining to the analysis of breaking news on Twitter. In this study it produced valuable insights into how news and specifically science news is actually spread on Twitter, and by whom. In the next chapter the data that was captured and analysed using this methodology, is presented.

Chapter 4 – Data analysis

In this chapter the method to analyse the captured data is set out and put to practice, presenting visualisations and key data around captured breaking news and breaking science news events to find the relevant tweets that were retweeted most, and who tweeted them.

For each of the 30 stories that were visualised below using Gephi, a link is provided where the interactive raw data captured with TAGS v6.0 can be viewed online (to be seen in clearer detail by zooming in and out of the graphs).

When the linked page has loaded, scroll to the bottom and click on “TAGSExplorer”. The resulting popup display is of the captured dataset of tweets for the chosen search term, represented as unorganised nodes and edges. Click on the “retweets” option on the bottom right of the page to organise the nodes and edges according to retweets. A new graph visualisation will appear that will closely resemble the more detailed visualisation as it has been rendered in Gephi (and displayed here) in each case. In TAGSExplorer, simply click on any node to see a summation of the corresponding tweet data that was captured.

As explained in the previous chapter, the tweets of the most retweeted news disseminators in each story are also quoted in order to take note of any trends or patterns that may appear regarding the content of the most retweeted tweets. For the purposes here, URL links in these tweets, for instance to full news stories, were not included in tweet quotes seeing as it is only the tweet content itself (that which caused a person to retweet) that is of interest. Where necessary, URLs were replaced with “[link]” for clarity.

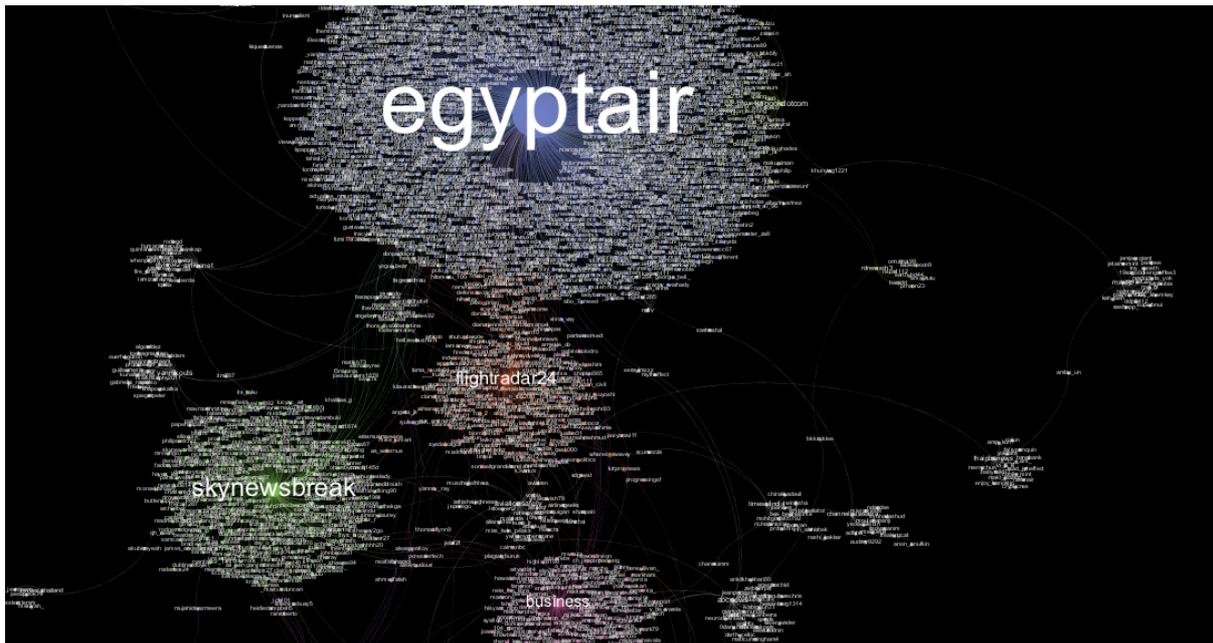
Also important to note is the fact that the tweet that is quoted for each of the most dominant nodes (Twitter accounts) may not be the only tweet sent by that particular account during the captured time period, but is in each case a tweet chosen that seemed to have resulted in significant retweeting.

The “first captured tweet” is also not necessarily the first tweet relating to a topic that was sent out, or that broke the news story on Twitter, but is the first tweet in the captured dataset for the purpose of context.

4.1 International news stories

The below five data visualisations are of tweets and retweets captured and analysed using the TAGSv6.0 software and Gephi. Data capturing in each case took place shortly after international breaking news events occurred. Event times and times of data capture always refer to South African time (GMT+2).

4.1.1 Flight MS181



Event/story: The hijacking of EgyptAir Flight MS181 on the way from Alexandria to Cairo by an Egyptian man.

Time of event: 29 March 2016 08:36 (EgyptAir confirms hijacking)

Time of data capture: 29 March 2016 08:58

Search term used: MS181

Tweets captured: 2 970

First captured tweet: @malamadremx – “RT @Pajaropolitico: Corrección: @EgyptAir informa que el vuelo #MS181 lleva 81 pasajeros, no 55, como había informado inicialmente.”

Most retweeted account: @EgyptAir (1203 retweets)

“Our flight MS181 is officially hijacked. we’ll publish an official statement now. #Egyptair”

Main other identified agents of news dissemination:

- @SkyNewsBreak (346 retweets): “Update - AP: Cypriot official says #EgyptAir flight #MS181 hijackers have allowed women and children to leave with some now disembarking”
- @Flightradar24 (196 retweets): “We are following reports that #MS181 has been hijacked. The aircraft has landed in Larnaca.”
- @Business (170 retweets): “Person with explosive belt force pilot to divert, #EgyptAir confirms after flight #MS181 hijacked”

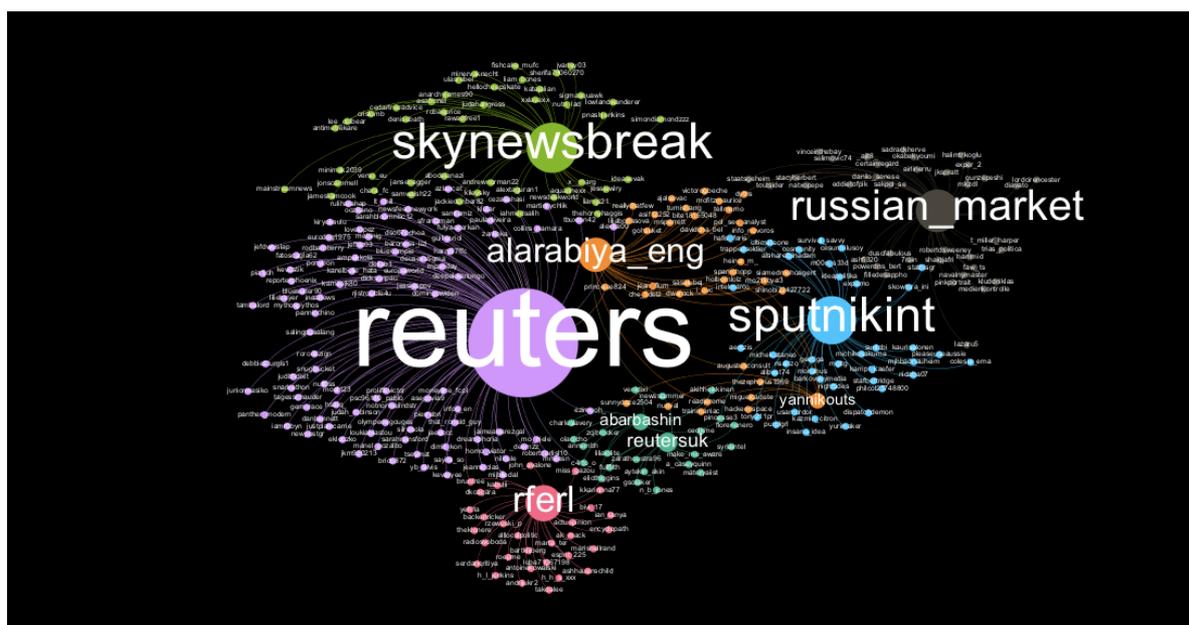
Observations: The EgyptAir airline was by far the most retweeted account, followed by Sky News.

Flightradar24.com is a website dedicated to live tracking of global scheduled commercial flights.

@Business is the official account for the Bloomberg business news agency.

Web link: <https://docs.google.com/spreadsheets/d/1P-i-VwJzfwPBB6nP6ZthNymu9kYLJAOZI0K1HbrIZSM/pubhtml>

4.1.2 Stavropol bombers



Event/story: Four suicide bombers set off a series of explosions outside a police station in the Stavropol region of Russia. The bombers were all killed and no one else was hurt.

Time of event: 11 April 2016, exact time unknown – first tweets sent at 10:15

Time of data capture: 11 April 2016 10:30

Search term used: Stavropol AND bombers

Tweets captured: 403

First captured tweet: @russian_market (38 retweets) – “3 suicide bombers attack police office in Stavropol region, Russia.”

Most retweeted account: @Reuters (109 retweets)

“Three suicide bombers carry out explosions in Russia's Stavropol region - Interfax”

Main other identified agents of news dissemination:

- @SkyNewsBreak (46 retweets): “Reuters: Interfax agency reports three suicide bombers have carried out attack in Russia's Stavropol region”
- @SputnikInt (44 retweets): “BREAKING Three suicide bombers blow themselves up near the Police Department in Russia”
- @REFRL (31 retweets): “BREAKING: Interfax reports 3 suicide bombers have blown themselves up in a village in #Russia's Stavropol region.”
- @AlArabiya_Eng (29 retweets): “BREAKING: #Russia's #Stavropol region hit by suicide bombers”

Observations: Reuters was the most retweeted. Sky News quoted Reuters. Reuters, Sky News and Radio Free Europe/Radio Liberty (REFRL) all quoted the Russian Interfax news agency, but tweets from Interfax itself did not feature at all. Sputnik is another Russian news agency. Al Arabiya is a leading news channel in the Arab world. The @russian_market account, one of the first to tweet, seems to be from an individual based in Zurich.

Web link: https://docs.google.com/spreadsheets/d/1gDN9ROmECPJ6W-bOFqoXWfAdl_c6hdAn75gxgrUsSLw/pubhtml

4.1.3 ‘Drone’ hits plane at Heathrow



Event/story: Reports surface that a British Airways passenger plane collided with a drone prior to safely landing at Heathrow airport in London. Initially thought to be the first air crash incident involving a drone. Subsequent investigations were unable to determine what the aircraft had hit.

Time of event: 17 April 2016 13:50 (plane hit)

Time of data capture: 17 April 2016 20:10

Search term used: drone AND plane AND Heathrow

Tweets captured: 2 693

First captured tweet: @SkyNews (152 retweets) – “Drone Strikes Plane At Heathrow Airport [link]”

Most retweeted account: @BBCBreaking (580 retweets)

“Drone believed to have hit a plane before it landed safely at Heathrow, UK police say.”

Main other identified agents of news dissemination:

- @SkyNewsBreak (329 retweets): “Pilot on flight into #Heathrow airport from Geneva has reported to Metropolitan Police a drone struck the aircraft”
- @BBCNews (117 retweets): “Drone hit plane approaching Heathrow”

Observations: As could be expected, BBC News and Sky News received the most retweets (being British news agencies). Noteworthy is the fact that both agencies significantly broaden their reach by tweeting from different accounts, namely @BBCNews and @BBCBreaking, and @SkyNewsBreak and @SkyNews.

Web link: https://docs.google.com/spreadsheets/d/1suIAN4tb9iWSfj7N4x2qlx5tKumsi_utJ9pKfnU30wo/pubhtml

4.1.6 Trends in international stories

What immediately becomes apparent is the prominence of well-known, traditional news agencies such as BBC News, Sky News, Reuters, AP, AFP and other news outlets or news agencies.

BBC, in particular, seems to have a very strong Twitter presence across several Twitter profiles, as does Sky News.

Relevant organisations, such as the EgyptAir airline, the FlightRadar24 tracking service and a seismological service (@newearthquake) also played a significant role.

In some cases individuals were also prominent in terms of retweets achieved, but they were journalists tied to news agencies and a political figure (India's foreign affairs minister).

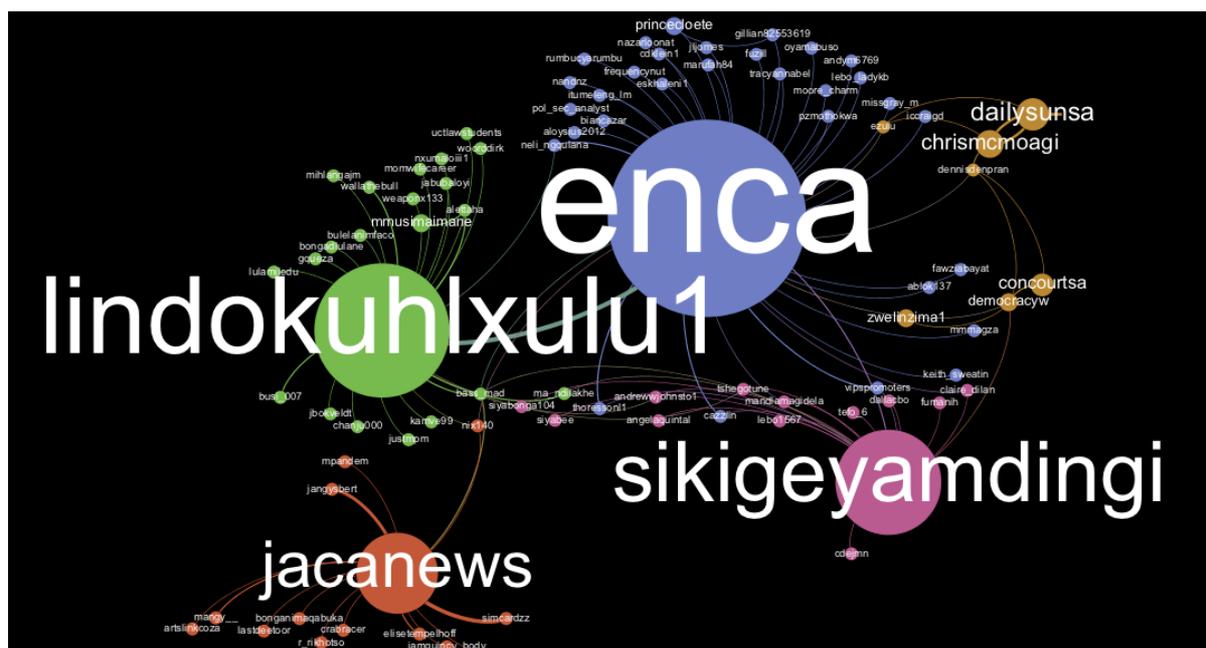
These five examples suggest that trusted traditional news agencies, trusted organisations relevant to particular events and prominent individuals (as opposed to random audience members and citizen journalists) seem to often be responsible for the dissemination of news on Twitter.

4.2 Local news stories

Below follows data visualisations for five local South African news stories where Twitter data was captured and analysed using TAGS v6.0 shortly after the events occurred.

As with the international stories in the previous section, these examples serve to establish baseline trends for non-science news stories as a point of comparison when local and international science stories are similarly dealt with later in the chapter.

4.2.1 #CivilProtest



Event/story: A group of civil society organisations collectively protested outside the Constitutional Court building, briefing media on why they were demanding that President Jacob Zuma must step down.

Time of event: 6 April 2016 15:00 (scheduled time of media briefing)

Time of data capture: 6 April 2016 15:10

Search term used: #civilprotest

Tweets captured: 177

First captured tweet: @eyob_asfaw – “#Civilprotest ...had achieved what #terrorisme had manifestly failed to deliver al Qaeda was z biggest loser via [link]”

Most retweeted account: @eNCA (51 retweets)

“WATCH LIVE: Civil society launches 'Zuma step down' campaign. From 3pm. #CivilProtest [link]”

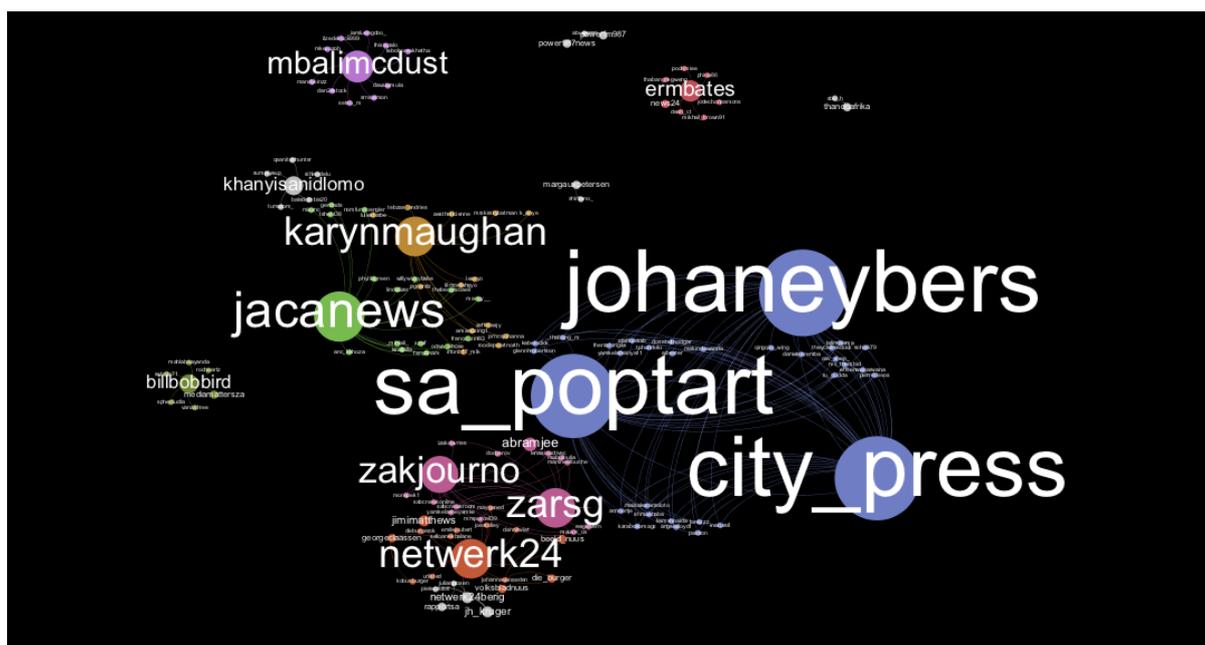
Main other identified agents of news dissemination:

- @LindokuhlXulu1 (36 retweets): “Some of the faces behind the #CivilProtest [link]”
- @JacaNews (26 retweets): “#civilprotest Rev Thla says the country is in a constitutional crisis, President Zuma has become a liability.STM”
- @SikigeyaMdingi (20 retweets): “South Africa is in a constituional crisis.The ConCourt has spoken.Robben Island prisoners have spoken. Jacob Zuma must resign. #CivilProtest”

Observations: An eNews Channel Africa (eNCA) reporter, Sikigeya Mdingi, and an eNCA intern and journalism student, Lindokuhl Xulu, was retweeted about as much as Jacaranda News, while the official eNCA account was also the most retweeted.

Web link: https://docs.google.com/spreadsheets/d/1fqH4CKt6zeFkbKFY_zADw0XMKJqfmmgYQMxeON6g2j8/pubhtml

4.2.2 Jimi Matthews resigns



Event/story: After a series of controversial management decisions by SABC head Hlaudi Motsoeneng, the SABC's head of news, Jimi Matthews, publicly resigns with immediate effect.

Time of event: 27 June 2016 08:40 (Jimi tweets his resignation)

Time of data capture: 27 June 2016 09:31

Search term used: Jimi AND Matthews AND resigned OR bedank

Tweets captured: 155

First captured tweet: @Netwerk24Berig – “#SABC: Jimi Matthews, waarnemende groefhoof van die SAUK, het Maandagoggend bedank. @JH_Kruger”

Most retweeted account: @sa_poptart (32 retweets)

“SABC news boss Jimi Matthews has resigned, reports @JohanEybers”

Main other identified agents of news dissemination:

@CityPress (32 retweets): “RT @sa_poptart: SABC news boss Jimi Matthews has resigned, reports @JohanEybers”

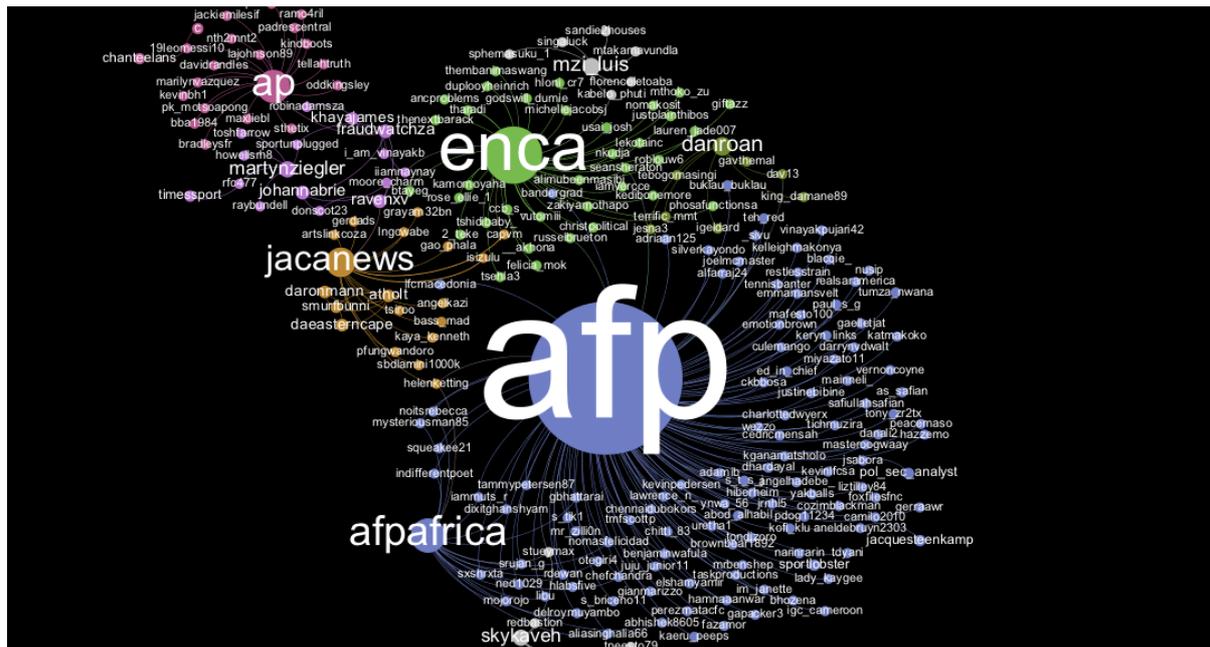
@JohanEybers (31 retweets): Own tweet not captured, retweets consisted of mentions of @JohanEybers as the first reporting source.

@JacaNews (17 retweets): “#SABC head of news Jimi Matthews has resigned with immediate effect.”

Observations: Retweets of the account @sa_poptart, belonging to City Press journalist Charl Blignaut, and retweet mentions of Rapport journalist Johan Eybers, cited as one of the first sources, rivaled retweets by City Press itself. Two more journalists, Karyn Maughan from eNCA, and Izak du Plessis from Radio RSG, also enjoyed a good number of retweets.

Web link: https://docs.google.com/spreadsheets/d/16GFB9335NyLNgyYWdzj110Sf8ht83-zDO0_P97kXI4-Y/pubhtml

4.2.3 Fifa accuses SA



Event/story: Fifa accuses South Africa of paying a \$10 million bribe for the 2010 Soccer World Cup.

Time of event: 16 March 2016 13:06 (AFP breaking news tweet)

Time of data capture: 16 March 2016 13:42

Search term used: FIFA AND bribe

Tweets captured: 368

First captured tweet: @ddsportsindia – “#BREAKING :: #FIFA says South Africa paid \$10 million bribe for 2010 Football World Cup: Reports [link]”

Most retweeted account: @AFP (119 retweets)

“#BREAKING Football: FIFA says South Africa paid \$10 million bribe for 2010 World Cup”

Main other identified agents of news dissemination:

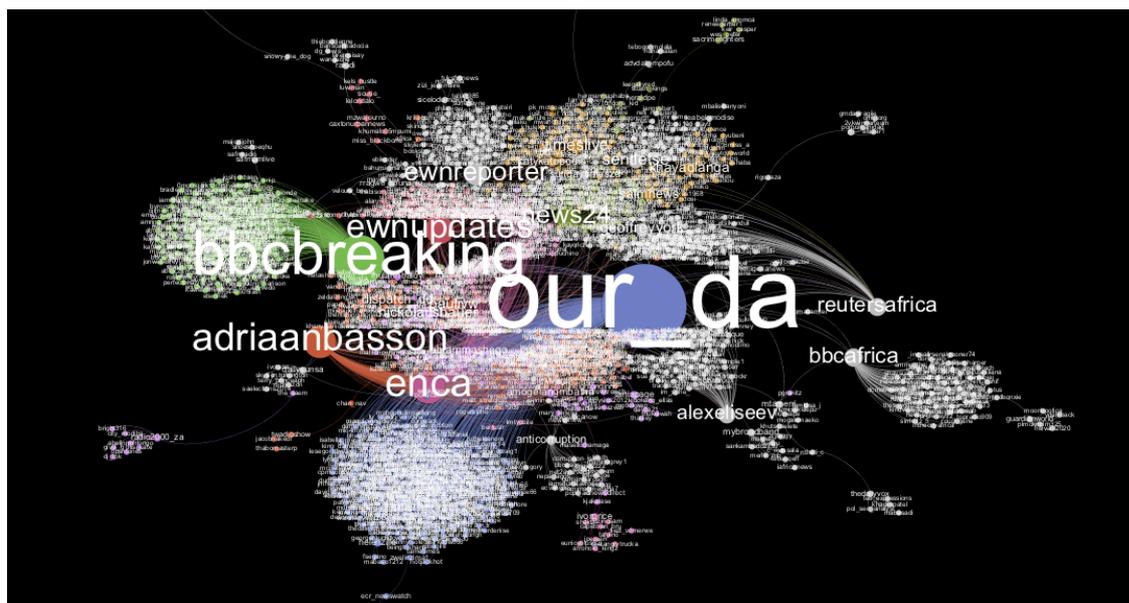
- @eNCA (40 retweets): “BREAKING NEWS: FIFA - SA paid \$10 million bribe >>[link]”
- @AFPAfrica (20 retweets): “#BREAKING: FIFA says South Africa paid \$10 million bribe for 2010 World Cup @AFP”
- @AP (19 retweets): “FIFA admits votes were bought in past World Cups hosting contests, seeks 'tens of millions' in seized bribe money: [link]”
- @JacaNews (18 retweets): “#FIFA openly accuses SA of paying a \$10 million bribe to secure votes for the #WC2010 as part of wide-ranging admission to US authorities.”

Observations: AFP was the most retweeted, owing probably to it having broken the news first.

Locally eNCA was most widely retweeted, using a very concise tweet. AP (international) and Jacaranda News (local) was also prominent.

Web link: <https://docs.google.com/spreadsheets/d/1vZj9mq-cI5uc4G-yGif7Q2LbkoHE9UqNpyR2SXCRwY/pubhtml>

4.2.4 Zuma charges reinstated



Event/story: High court grants leave to appeal to review a 2009 court decision to drop corruption charges against President Jacob Zuma, effectively reinstating the charges.

Time of event: 29 April 2016 11:45 (judge's ruling)

Time of data capture: 29 April 2016 12:47

Search term used: Zuma AND corruption AND charges

Tweets captured: 2 969

First captured tweet: @Our_DA - "RETWEET if you think Zuma should account for his 783 CHARGES of racketeering, corruption, fraud etc. #SpyTapes"

Most retweeted account: @Our_DA (386 retweets)

"RETWEET if you think Zuma should account for his 783 CHARGES of racketeering, corruption, fraud etc. #SpyTapes"

Main other identified agents of news dissemination:

- @BBCBreaking (220 retweets): "South Africa court approves review of 2009 decision to drop hundreds of corruption charges against President Zuma [link]"
- @eNCA (147 retweets): "DA wins court bid for review of Zuma corruption charges #spytapes"
- @AdriaanBasson (143 retweets): "The decision to withdraw corruption charges against Zuma has been set aside. SA has a president who is a corruption accused today. #spytapes"
- @ewnupdates (112 retweets): "BREAKING NEWS: President Zuma must face corruption charges [link] #spytapes"

Observations: The Democratic Alliance was the most retweeted, which makes sense as they are the main opposition party to Zuma's ANC. A lot of the retweets was garnered however from a campaign started before the court ruling, asking people to retweet if they want Zuma to account for charges. Adriaan Basson, editor for Netwerk24, the eNCA news channel, and BBC News was also widely retweeted.

Web link: https://docs.google.com/spreadsheets/d/1eha_NfrGScDF3YgcIQYXV_ZoXLYjpGSTTtv-kgA0Kls/pubhtml

4.2.5 #TshwaneUnrest



Event/story: Minister Nosiviwe Mapisa-Nqakula briefs the media after an interministerial justice cluster meeting on required action after a series of violent protests erupted in and around Tshwane, linked to anger over the ANC's announcement of Thoko Didiza as their mayoral candidate.

Time of event: 21 June 2016 16:15 (briefing starts)

Time of data capture: 21 June 2016 16:29

Search term used: #TshwaneUnrest AND Mapisa-Nqakula

Tweets captured: 313

First captured tweet: @GCISMedia – “#TshwaneUnrest Min Mapisa-Nqakula to lead a JCPS media briefing at 16h00 on the Tshwane matter”

Most retweeted account: @BarryBateman (30 retweets)

“#TshwaneUnrest Mapisa-Nqakula: the destruction and chaos is highly unacceptable and should not be allowed to continue. BB”

Main other identified agents of news dissemination:

- @ThulasSims (28 retweets): “Mapisa Nqakula; 'Destruction of property & chaos is highly unacceptable and should not be allowed to continue' #TshwaneUnrest”
- @ewnreporter (24 retweets): “#TshwaneUnrest Mapisa-Nqakula says SANDF will not be deployed at this stage - first exhaust all other security measures. BB”
- @GovernmentZA (16 retweets): “Minister Mapisa-Nqakula The law enforcement agencies are currently hard at work to ensure that calm returns to all areas...”
- @JacaNews (15 retweets): “Mapisa-Nqakula: Govt calls for calm and for people to continue with their normal businesses-govt is responding adequately.SM”

Observations: Barry Bateman, journalist for Eyewitness News (EWN), provided live tweeting of the event and was the most retweeted, followed by eNCA journalist Thulasizwe Simelane, who also live-tweeted the briefing. EWN's own account mirrored Bateman's tweets and was also widely retweeted. Three government accounts received a fair number of retweets for publicising the briefing.

Web link: <https://docs.google.com/spreadsheets/d/1CZj7-T1y5rAHnFt2VrgYhSKD-WFiJmOloM3QB2TW3eQ/pubhtml>

4.2.6 Trends in local stories

In the five local stories that were analysed, the role of journalists are highlighted.

In several cases tweeting journalists (such as Barry Bateman, Adriaan Basson, Charl Blignaut, Karyn Maughan etc.) were retweeted even more than the official accounts of the news agencies or outlets that these journalists represent. This indicates firstly the power that Twitter affords the individual, but also implies that the association with a known, trusted news organisation provides prominence to individual tweeting journalists.

People seem to be inclined to retweet news content associated with trusted traditional news agencies, be it print, television or radio, as well as recognised journalists associated (and thus also trusted) with these media.

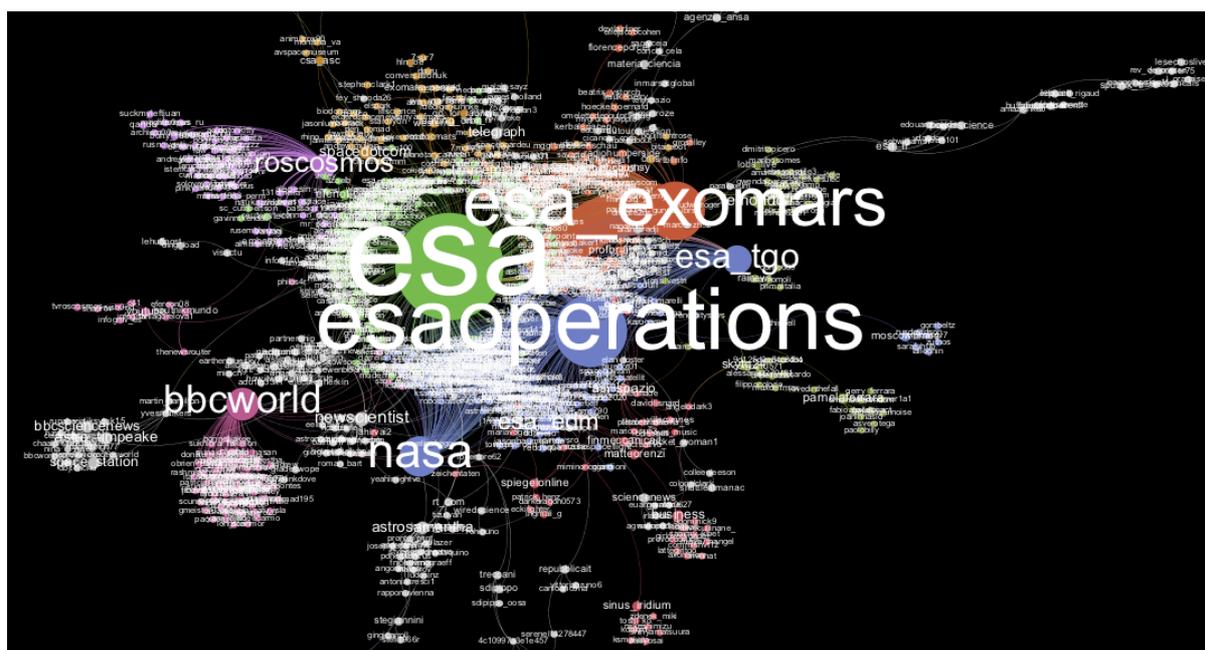
Whatever the case may be, in South Africa it seems journalists play an important role in news dissemination on Twitter.

Next we will look at whether these trends hold true for the spreading of science news, both internationally and then locally.

4.3 International science news stories

As has already been demonstrated in previous chapters, Twitter can function as a powerful means of communicating science if used correctly. How science news is actually spread on Twitter, and by whom, is investigated below, first with ten examples of international science news stories for which Twitter data was captured and analysed, and then (in section 4.4) with ten more examples of science news from within the South African context that was tweeted about, captured, analysed and visualised.

4.3.1 ExoMars launch



Event/story: Launch of the ExoMars spacecraft, a joint mission by the European Space Agency (ESA) and the Russian Federal Space Agency (Roscosmos), that aims to travel to Mars in search of signs of life.

Time of event: 14 March 2016 11:31 (launch time)

Time of data capture: 14 March 2016 13:13

Search term used: ExoMars

Tweets captured: 2 751

First captured tweet: @Nedermanz – “RT @ESA_nl: Met deze raket wordt #ExoMars straks naar de ruimte gebracht. [link]”

Most retweeted account: @ESA (373 retweets)
“Meanwhile, enjoy that #ExoMars lift off again [link]”

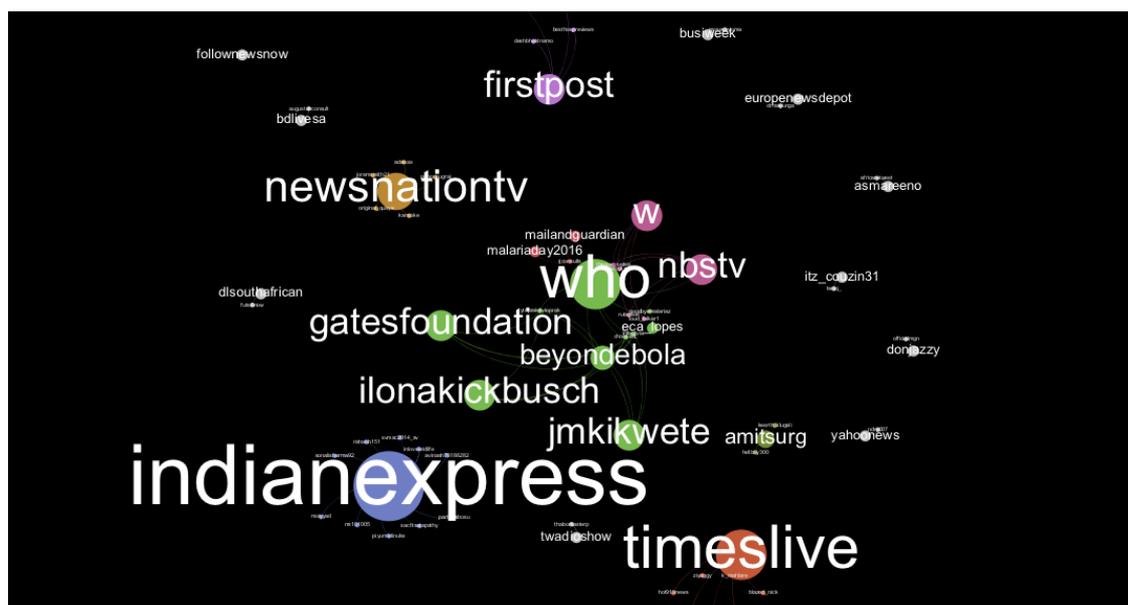
Main other identified agents of news dissemination:

- @ESA_ExoMars (314 retweets): “We’re back! Find out more about #ExoMars in our dedicated talks on mission science & ops. Qs? Use #askESA. Watch: [link]”
- @esaoperations (259 retweets): “ExoMars 2016 journey to Mars: this animation shows #ExoMars 's 7month journey to the Red Planet [link]”
- @Nasa (116 retweets): “@ESA's #ExoMars launched at 5:31am ET! For updates, follow @ESAOperations or visit: [link]”
- @BBCWorld (83 retweets): “#ExoMars is on its way to the Red Planet. [link]”
- @Roscosmos (77 retweets): “Для тех кто еще раз хочет насладиться захватывающими кадрами пуска: [link]! #ПротонМ #ExoMars”

Observations: Three different Twitter accounts related to the ESA, all of which also referred to each other and made use of the same hashtag (#ExoMars), received the vast bulk of retweets, followed by BBC World, Nasa and Roscosmos.

Web link: https://docs.google.com/spreadsheets/d/1m_Qa59Dl8YuQ6A8FFc7xLtUAUsjwpFGd0gtCI27B3wo/pubhtml

4.3.2 Malaria-free Africa



Event/story: A World Health Organisation (WHO) report suggests six African nations could be Malaria-free by 2020.

Time of event: 25 April 2016 06:58 (eNCA publishes embargoed release)

Time of data capture: 25 April 2016 12:00

Search term used: Africa AND Malaria AND WHO AND free

Tweets captured: 132

First captured tweet: @Itz_cousin31 – “What an effort! I'm hoping for a day that #Africa would also be recorded #Malaria free. Not impossible but hard [link]”

Most retweeted account: @IndianExpress (11 retweets)

“Twenty one countries, including six from Africa, could be free of malaria by 2020: WHO | [link]”

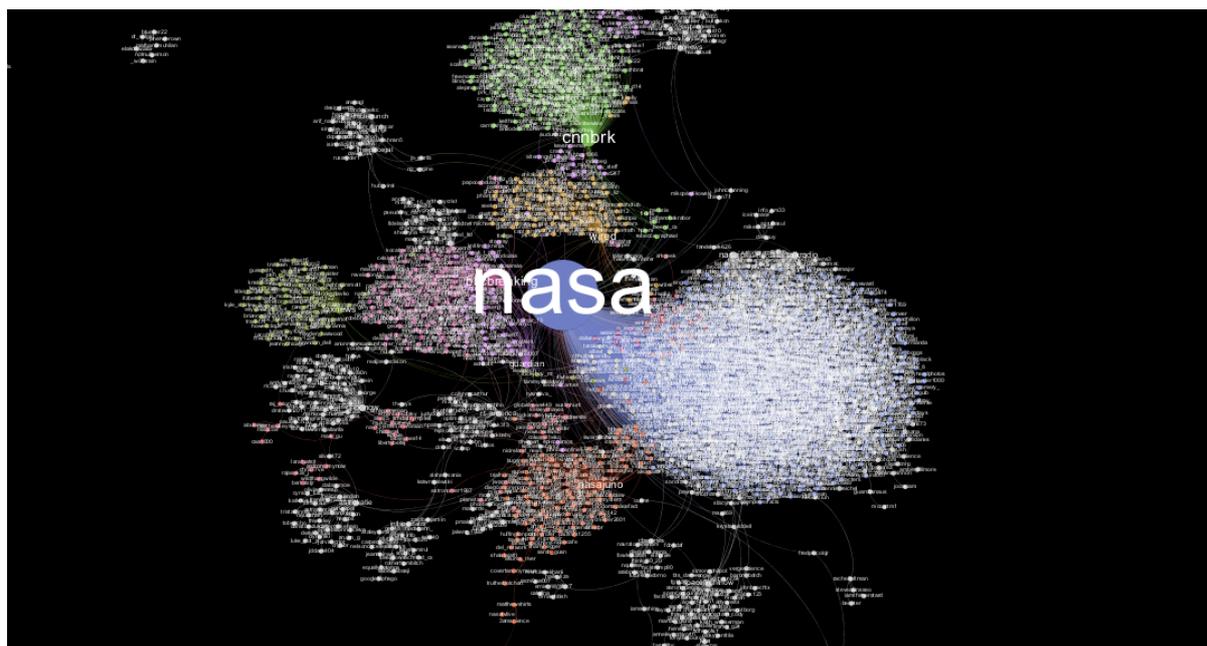
Main other identified agents of news dissemination:

- @TimesLive (7 retweets): “Six African nations could be malaria-free by 2020: WHO [link]”
- @BeyondEbola (7 retweets): “Europe is now #malaria FREE - @WHO. We must keep the fight in #Africa @jmkikwete @gatesfoundation @IlonaKickbush”
- @NewsNationTV (5 retweets): “#WorldMalariaDay: These six countries of Africa could be free of the disease by 2020 says WHO report [link]”
- @Firstpost (4 retweets): “Six African countries could be malaria-free by 2020: WHO on World Malaria Day [link]”

Observations: Three Indian news services (Indian Express, News Nation TV and Firstpost) count among the most retweeted accounts. Beyond Ebola is a Washington-based NGO committed to global health security. Overall the story did not receive a lot of tweets or retweets, and only one account among the most retweeted is from within Africa, which is Times Live. The WHO (and other green-coloured accounts surrounding @BeyondEbola) shows up prominently on the graph not because of its tweets that were retweeted, but because it was frequently mentioned in the retweets of others.

Web link: <https://docs.google.com/spreadsheets/d/1PvYJCQevcr6NbAxdAQf9tslU7dBbcbcnJmuUUUV9kVW4Q/pubhtml>

4.3.3 Juno orbits Jupiter



Event/story: After a five year journey from Earth, Nasa’s Juno spacecraft enters orbit around Jupiter.

Time of event: 5 July 2016 05:54 (orbit confirmed)

Time of data capture: 5 July 2016 06:04

Search term used: Juno AND orbit AND Jupiter

Tweets captured: 2 943

First captured tweet: @AndreWCoy – “CONGRATS to the whole team @NASA as Juno is now officially in Jupiter's orbit!!! [link]”

Most retweeted account: (Nasa 1 318 retweets)

“Success! Engine burn complete. #Juno is now orbiting #Jupiter, poised to unlock the planet's secrets. [link]”

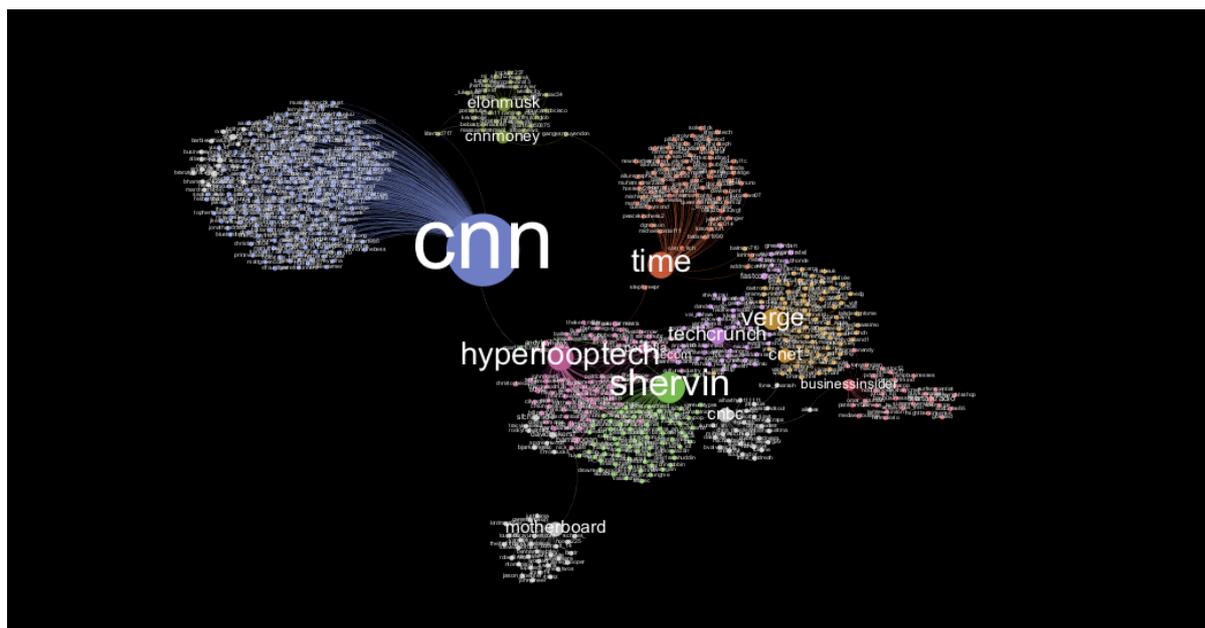
Main other identified agents of news dissemination:

- @BBCBreaking (121 retweets): “The US space agency's Juno probe puts itself in orbit around Jupiter, ready to undertake a survey of the planet [link]”
- @Guardian (56 retweets): “#BREAKING: Nasa's Juno spacecraft has successfully entered orbit of Jupiter, the solar system's largest planet [link]”
- @RT_America (33 retweets): “Burn complete, orbit obtained’: #Juno mission ready to unlock #Jupiter’s secrets (LIVE) [link]”
- @Twitter (33 retweets): “After an epic five-year journey through space, follow along with @Nasa as #Juno enters Jupiter's orbit. [link]”
- @buzzfeednews (13 retweets): “NASA’s Juno Spacecraft Has Entered Orbit Around Jupiter [link]”

Observations: The official account for Nasa was by far the most retweeted, dwarfing other accounts, possibly because Nasa is a very well-known, well-respected organisation known to tweet often about its various missions. The hashtags #Juno and #Jupiter was very popular and BBC News and CNN both received substantial retweets through their “breaking news” accounts.

Web link: https://docs.google.com/spreadsheets/d/1D60_pKOWO0EuW1QX316P-J4zGYiR6zR96i_hGiscUu8/pubhtml

4.3.5 Hyperloop One



Event/story: Elon Musk reveals the name, partners and plans of Hyperloop One, the company aiming to build his futuristic concept Hyperloop public transportation system.
Time of event: 11 May 2016 02:00 (Live-tweeting begins for Hyperloop One announcement)
Time of data capture: 11 May 2016 05:15

Search term used: Hyperloop AND One

Tweets captured: 2 922

First captured tweet: @iBookChick – “Here Comes Hyperloop One: Startup Raises \$80 Million: The promise: Traveling at 750 miles per hour, 30 minute... [link]”

Most retweeted account: @CNN (198 retweets)

“Elon Musk’s Hyperloop vision races toward first public test [link]”

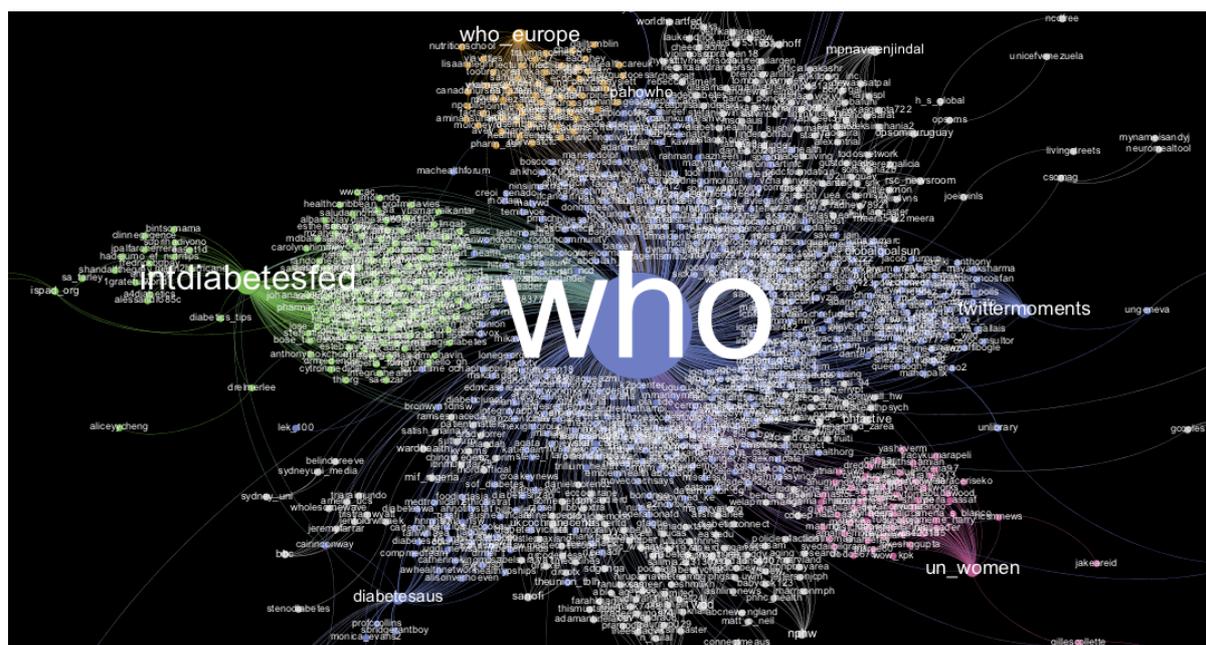
Main other identified agents of news dissemination:

- @HyperloopTech (93 retweets): “That’s why we’re changing our name to... Hyperloop One...” #hyperloop #HyperloopOne [link]”
- @Shervin (83 retweets): “Hyperloop Technologies becomes Hyperloop One, pulls in \$80 million and announces global partners [link]”
- @TIME (65 retweets): “The race to build the Hyperloop just got real [link]”
- @Verge (48 retweets): “The Hyperloop is about to have its first public test, and the stakes couldn’t be higher [link]”
- @TechCrunch (35 retweets): “Hyperloop Technologies becomes Hyperloop One, pulls in \$80 million and announces global partners [link]”

Observations: CNN was the most retweeted, followed by the official Hyperloop account and the Twitter account of Shervin Pishevar, co-founder of Hyperloop One. Both these Hyperloop-related accounts had more retweets than TIME, as well as science and technology-centric The Verge and TechCrunch news services.

Web link: https://docs.google.com/spreadsheets/d/1nr9VdqGGahuurh0DegVE8m_Cwoyng283raQ54Aq3Bo/pubhtml

4.3.6 World Diabetes report



Event/story: The World Health Organisation (WHO) releases its first ever global diabetes report on World Health Day.

Time of event: 7 April 2016 19:58 (WHO tweets link to report)

Time of data capture: 7 April 2016 22:15

Search term used: WHO AND global AND diabetes AND report

Tweets captured: 1 490

First captured tweet: @IntDiabetesFed – “7 April is #WorldHealthDay: Beat #diabetes and its consequences. @WHO Global report on diabetes to be released soon [link]”

Most retweeted account: @WHO (976 retweets)

“WHO first ever global report on #diabetes [link] #WorldHealthDay”

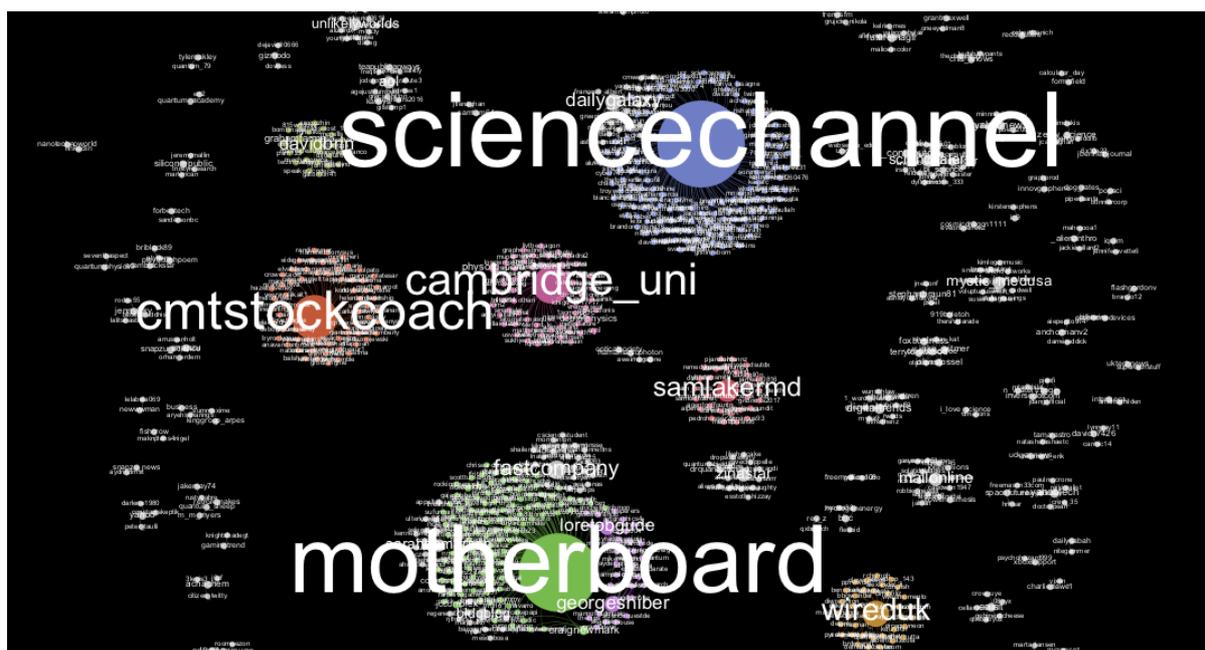
Main other identified agents of news dissemination:

- @IntDiabetesFed (174 retweets): “7 April is #WorldHealthDay: Beat #diabetes and its consequences. @WHO Global report on diabetes to be released soon [link]”
- @AJPlus (75 retweets): “Diabetes now affects every one in 11 adults, says WHO's first-ever global report. [link]” (off-screen)
- @WHO_Europe (74 retweets): “On #WorldHealthDay @WHO launches first-ever Global #diabetes report. Read it here: [link]”
- @TwitterMoments (60 retweets): “The @WHO has released its first global report on diabetes in anticipation of tomorrow's #WorldHealthDay [link]”
- @UN_Women (59 retweets): “According to most recent global data, women estimated to be more overweight or obese than men: [link] @WHO #WorldHealthDay”

Observations: The WHO was the most retweeted and completely dominated the conversation as it was mentioned in most retweets as well. It was followed by the International Diabetes Federation, the AJ Plus news service “for the connected generation”, WHO Europe, Twitter’s own Moments account (which tracks Twitter’s biggest stories) and the United Nations’ Women’s organisation.

Web link: https://docs.google.com/spreadsheets/d/1HExo-X3ce-0EJpPHYN7Q4z_yNXUCpjkd9oiDmqDoLKA/pubhtml

4.3.7 Quantum matter



Event/story: Scientists announce the discovery of a new quantum state of matter called quantum spin liquid.

Time of event: 4 April 2016 (exact time of announcement unknown)

Time of data capture: 6 April 2016 22:20

Search term used: Quantum AND matter

Tweets captured: 1 543

First captured tweet: @energy_psych – “Beautiful article on consciousness, mind and matter. [link]”

Most retweeted account: @ScienceChannel (135 retweets)

“Scientists have just discovered a new state of matter - it's called quantum spin liquid! [link]”

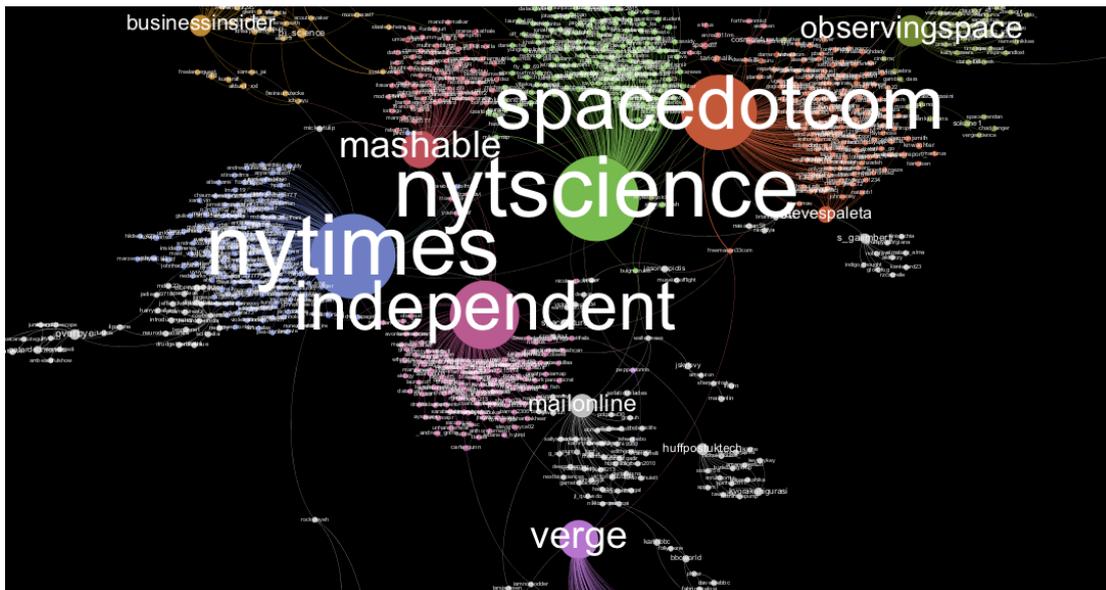
Main other identified agents of news dissemination:

- @motherboard (121 retweets): “A newly discovered state of matter could be a breakthrough for quantum computing [link]”
- @CMTStockCoach (65 retweets): “Scientists just discovered a new state of matter [link]”
- @Cambridge_Uni (52 retweets): “New quantum state of matter detected in a 2D material, in which electrons break apart: [link]”
- @WiredUK (34 retweets): “Scientists just discovered a new state of matter [link]”
- @SamLakeRMD (28 retweets): ““No matter which side #QuantumBreak is showing, it's always going to be a spectacular one.” 8.5/10 [link]”

Observations: Science Channel (a TV science channel) received the most retweets, followed by Vice’s Motherboard tech news site, Christian Tharp, a stock market coach with 20 000 followers, Cambridge University, and tech news site Wired UK. Retweets for Sam Lake, the creative director for Remedy Games, is unrelated and was captured by coincidence due to discussions around a game called Quantum Break.

Web link: <https://docs.google.com/spreadsheets/d/1FFXGcos0MVSgMkypcZZoVhzdGcQ--xHVggmTKRazFW8/pubhtml>

4.3.8 Project Starshot



Event/story: Renowned theoretical physicist Stephen Hawking, in partnership with Facebook-founder Mark Zuckerberg and Russian billionaire Yuri Milner, announce plans to send a laser-propelled robotic spacecraft to Alpha Centauri, called Project Starshot.

Time of event: 12 April 2016 18:00 (announcement)

Time of data capture: 12 April 2016 21:49

Search term used: Starshot AND Stephen AND Hawking

Tweets captured: 2 970

First captured tweet: @WIRheum – “Shooting #robots across the galaxy with #lasers. Seriously? Damn that's cool. A Visionary Project [link]”

Most retweeted account: @NYTScience (192 retweets)

“Stephen Hawking at the #starshot announcement: “We can launch a mission to Alpha Centauri within a generation.””

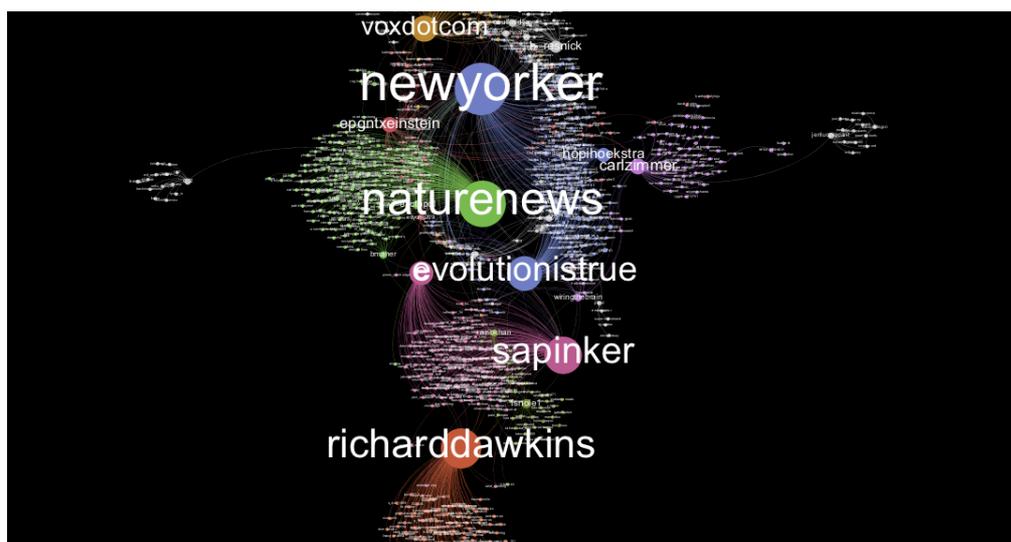
Main other identified agents of news dissemination:

- @NYTimes (175 retweets): “Half a lifetime from now, they hope we'll see images from our solar system's neighbor [link]”
- @SPACEdotcom (168 retweets): “Stephen Hawking: 'Transcending Our Limits' With Breakthrough Starshot | Video [link]”
- @Independent (141 retweets): “The most ambitious alien finding project in history has been launched by Stephen Hawking [link]”
- @Verge (73 retweets): “Stephen Hawking and a Russian billionaire want to send a tiny spacecraft to Alpha Centauri [link]”
- @Mashable (70 retweets): “This star is nearly 5 light-years away. Stephen Hawking is sending a spacecraft there. [link]”
- @ObservingSpace (57 retweets): “Stephen Hawking wants to send nanosatellites to Alpha Centauri; reach it in 20 yrs [link]”

Observations: Two accounts for *The New York Times* together received the most retweets, followed by space news site Space.com and the UK newspaper *The Independent*. Less, but significant retweets are noted for tech and digital news site Mashable, ObservingSpace.com and The Verge (tech news).

Web link: https://docs.google.com/spreadsheets/d/1B2mtPiXvagTkA997rkUf_soO3-br2bE64RjnHJgHWX4/pubhtml

4.3.9 Epigenetics controversy



Event/story: Scientists attack a feature article written by Siddhartha Mukherjee for *The New Yorker*, on epigenetics, saying it inaccurately describes how genes are regulated.

Time of event: 10 May 2016 09:35 (Nature News tweets that *The New Yorker* has 'stepped on a landmine')

Time of data capture: 10 May 2016 11:35

Search term used: New AND Yorker AND epigenetics

Tweets captured: 1 549

First captured tweet: @Gregorscience – “Fantastic New Yorker article about the rise of epigenetics: Same but Different [link]”

Most retweeted account: @NatureNews (196 retweets)

“The Emperor of all Twitterstorms? The New Yorker steps on a landmine named epigenetics. [link]”

Main other identified agents of news dissemination:

- @RichardDawkins (166 retweets): “It’s high time the 15 minutes of undeserved fame for “epigenetics” came to an overdue end. [link]”
- @sapinker (158 retweets): “The New Yorker screws up big time with science: researchers criticize new piece on epigenetics [link]”
- @Evolutionistrue (144 retweets): “The New Yorker screws up big time with science: researchers criticize the Mukherjee piece on epigenetics [link]”
- @Voxdotcom (106 retweets): “Why scientists are infuriated with a New Yorker article on epigenetics [link]”

Observations: The first tweet captured (on 2 May) actually praises the article in question. *The New Yorker*’s account is shown as dominant in retweets (232 retweet connections captured) but this is due to being mentioned in other retweets rather than being retweeted itself. The actual most retweeted account was that of Nature News, followed by popular evolutionary scientist Richard Dawkins (1.49 million followers), Jerry Coyne, an evolutionary biologist at the University of Chicago (@evolutionistrue, 30 000 followers), Steven Pinker, a cognitive scientist at Harvard University (255 000 followers), and the online news service Vox.com.

Web link: <https://docs.google.com/spreadsheets/d/15I7TITQ51aU2g0fqDV4X3elh1XAzMzt8LJXWXXkZTf1k/pubhtml>

4.3.10 Kepler announcement



Event/story: Nasa hosts live announcement to reveal that the Kepler space telescope had doubled its count of identified and verified exoplanets to 2 325.

Time of event: 10 May 2016 19:05 (live announcement)

Time of data capture: 10 May 2016 19:15

Search term used: Nasa AND planets

Tweets captured: 740

First captured tweet: @TechFunGadgets – “NASA’s Kepler mission finds the most Earth-like planets ... - #tech #technews #technology [link]”

Most retweeted account: @NASAKepler (237 retweets)

“Kepler announces a planet boon- 1,284 new planets! This brings the Kepler count to 2,325. [link]”

Main other identified agents of news dissemination:

- @BreakingNews (127 retweets): “NASA announces 1,284 new planets found by Kepler mission, bringing Kepler count to 2,325 - NASA Kepler [link]”
- @PZF (38 retweets): “BREAKING: NASA announces 1,284 new planets found by Kepler mission, bringing Kepler count to 2,325 - NASA Kepler [link]”
- @Nasa (32 retweets): “1,284 new planets found by @NASAKepler mission, bringing Kepler count to 2,325 [link]”

Observations: Interestingly, the Nasa Kepler account received a lot more retweets than the official Nasa account. Two popular breaking news services on Twitter (BreakingNews and PZF) also received a good number of retweets.

Web link: <https://docs.google.com/spreadsheets/d/1NneXu-TiB6s6zf4orttEpFU3YRkm6GgtjKv8bSK2HDA/pubhtml>

4.3.11 Trends in international science stories

The prominence of well-known, trusted scientific organisations such as Nasa, Cambridge University, the ESA and the WHO is very apparent, as is the prominence of science-specific (or at least science and technology inclined) news outlets such as The New York Times Science, Motherboard, Wired, The Verge, TechCrunch, the Science Channel and Mashable.

The role of individual scientists as news disseminators is also highlighted, with scientists such as Richard Dawkins, Jerry Coyne, Steven Pinker, Josh Neufeld and Anna Vanclova, who have each amassed sizable followings, being shown to be responsible for significant distribution of news content in some of the given examples.

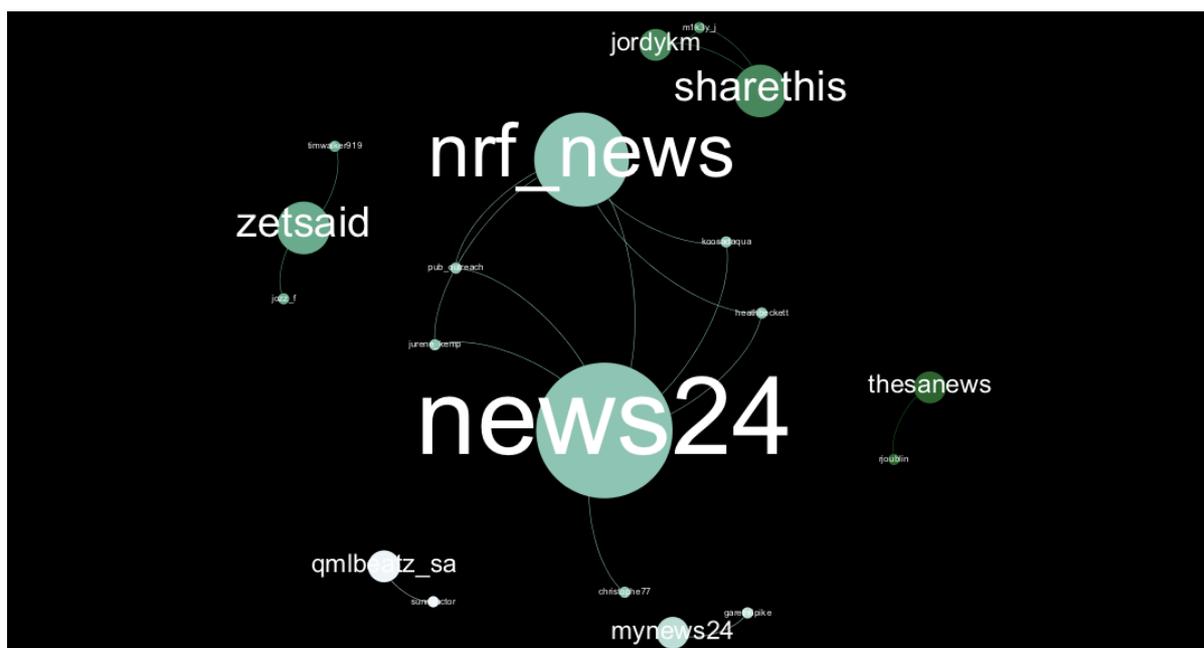
Also worth noting is that in many instances large numbers of tweets were captured within the first hours or even minutes of breaking international science news stories, which clearly shows that there is a large appetite for cutting edge science and technology news in the so-called Twittersphere. Next we take a look at whether these trends hold true for South African science news on Twitter.

4.4 Local science stories

As in the previous three sections, below are data visualisations of tweet data sets that were rendered in Gephi after being captured and analysed with TAGSv6.0, for 10 science news stories with a clear link to South Africa.

The goal was to determine which types of accounts (belonging to which institutions or individuals) are most often responsible for the dissemination of South African science news on Twitter, and what kind of traction South African science stories get when exposed to the global Twitter audience.

4.4.1 N2 Fossil find



Event/story: A treasure trove of fossils is discovered by accident during roadworks on the N2 near Grahamstown in the Eastern Cape.

Time of event: 1 June 2016 08:00 (News24 and other outlets report on the find)

Time of data capture: 1 June 2016 11:00

Search term used: Fossils AND Grahamstown

Tweets captured: 23

First captured tweet: @OFMNews9497 – “Fossils dating back millions of years found near Grahamstown [link]”

Most retweeted account: @NRF_News (5 retweets)

“Treasure trove of fossils unearthed by roadworks near Grahamstown [link] #palaeontology via @News24”

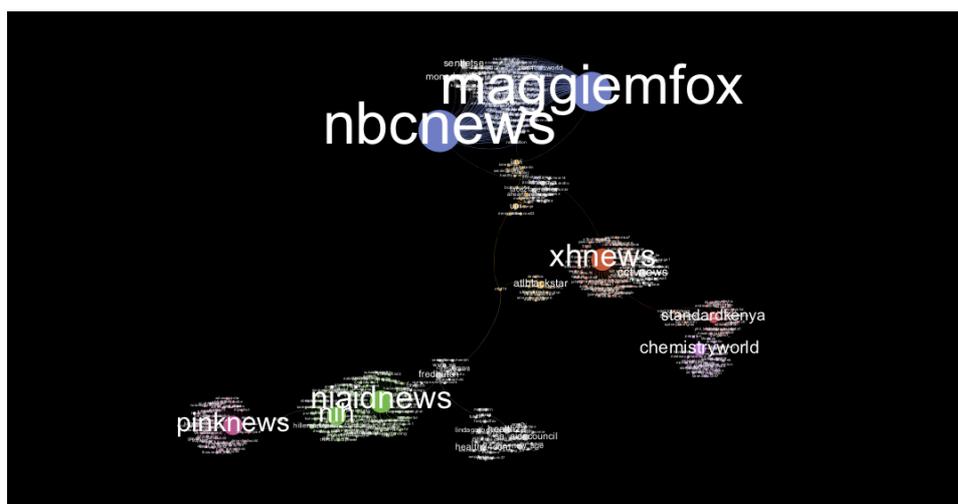
Main other identified agents of news dissemination:

- @Zetsaid (2 retweets): “Devonian era fossils found near Grahamstown during roadworks - very cool: [link]”

Observations: The story received very little traction on Twitter, even though it is fairly unusual and has more potential news value than ‘normal’ fossil finds. The National Research Foundation (NRF) and News24 can be said to share the most retweets because even though News24 did not tweet itself, its report was linked in the tweet by the NRF. Anzet du Plessis, a science communication specialist with around 2 000 followers, was the only other account that can be said to have helped spread the story. TheSouthAfrican.com and a geomorphologist with 124 followers (@JordyKM) had single mentions in the tweets of others but no retweets. The OFM radio station, with 4000 followers, broke the news on Twitter and posted two separate tweets, but was not retweeted.

Web link: <https://docs.google.com/spreadsheets/d/1hOdALEBrHcnwsjRv3STR7pxbpUq9GFX8461vSvQgbY/pubhtml>

4.4.3 HIV vaccine



Event/story: Announcement of a large trial for a promising experimental HIV vaccine to be launched in South Africa.

Time of event: 17 May 2016 (exact time of announcement unknown)

Time of data capture: 26 May 2016 16:00

Search term used: HIV AND vaccine AND South AND Africa

Tweets captured: 1 345

First captured tweet: @docjuli – “South Africa: HIV vaccine – closer than ever: We are not there yet, but experts are optimistic about a jab to... [link]”

Most retweeted account: @NBCNews (112 retweets)

“New HIV vaccine will be tested in South Africa, @maggiefox reports”

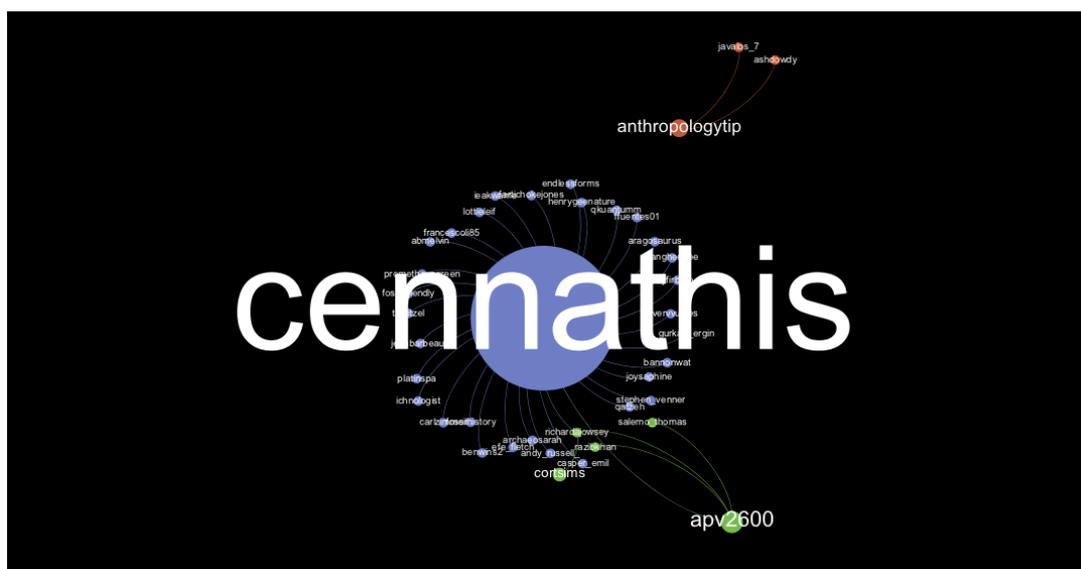
Main other identified agents of news dissemination:

- @MaggieMFox (102 retweets): “South Africa to test new HIV vaccine [link]”
- @NIAIDNews (57 retweets): “NEWS: NIH-funded #HIV vaccine trial to launch in South Africa to test safety, efficacy [link]”
- @XHNews (54 retweets): “Large-scale HIV vaccine trial to begin in South Africa: U.S. agency [link]”
- @NIH (46 retweets): “News: Large-scale HIV vaccine trial to launch in South Africa [link]”
- @PinkNews (45 retweets): “Experimental HIV vaccine to be tested in large-scale public trial in South Africa [link]”
- @ChemistryWorld (27 retweets): “US National Institutes of Health to launch large HIV vaccine trial in South Africa [link]”

Observations: A week after the story broke only 1 345 tweets were recorded. Despite the story being locally based, the most retweeted accounts were those of US news agency NBC and their senior health writer Maggie Fox (15 000 followers), followed by the US National Institute of Allergy and Infectious Diseases (NIAID), the Chinese Xinhua news agency, the US National Institutes of Health (NIH), the LGBT+ (lesbian, gay, bisexual and trans) digital media publisher PinkNews and the chemistry magazine Chemistry World. In contrast, Kenya’s The Standard Digital received only 23 and South Africa’s Health24.com only 11 retweets.

Web link: https://docs.google.com/spreadsheets/d/16wWHF1sboIQe_JlxNI-FCK-zy5kvIAW4JkUAtlY5qs/pubhtml

4.4.4 *Homo naledi* dated



Event/story: Researchers announce that Bayesian statistical analysis dates the *Homo naledi* hominin fossils (found in South Africa’s Cradle of Humankind) to 912 000 years old, much younger than the initial estimated age of 2 million years. The study could have implications for the human fossil record.

Time of event: 14 June 2016 00:52 (first tweet)

Time of data capture: 14 June 2016 08:50

Search term used: Homo AND naledi AND age since:2016-06-12

Tweets captured: 46

First captured tweet: @APV2600 – “The evolutionary relationships and age of *Homo naledi*: An assessment using dated Bayesian phylogenetic methods’ [link]”

Most retweeted account: @Cennathis (33 retweets)

“Bayesian Analysis dates *Homo naledi* to 912,000 years of age. [link]”

Main other identified agents of news dissemination:

- @APV2600 (4 retweets): “The evolutionary relationships and age of *Homo naledi*: An assessment using dated Bayesian phylogenetic methods’ [link]”
- @AnthropologyTip (2 retweets): “The evolutionary relationships and age of *Homo naledi* [link]”

Observations: A time barrier was added to the search term in order to exclude vast amounts of tweets containing speculations over *Homo naledi*’s age before the study in question was published. The most retweeted by far was Charles Clarke (415 followers), a London-based palaeoanthropologist who runs the Cennathis.com blog. Adam van Arsdale, a biological anthropologist from Wellesley College in the US (1 700 followers) and the Twitter-based anthropology news service @AnthropologyTip (10 000 followers) received scant retweets. Given the fact that the discovery of *Homo naledi* was one of the biggest South African science stories in the past decade, it is peculiar that the story – the first evidence based dating study – received so little traction. Mainstream South African news outlets like Eyewitness News only picked up on the story on 8 July, three weeks later.

Web link: https://docs.google.com/spreadsheets/d/1Bmtw4PaEH0bUDmiCJmZsmlteytnbjzPKXLes_Ut60Pk/pubhtml

4.4.5 Hydrogen forklift



Event/story: The Impala Platinum mining company, together with the Department of Science and Technology (DST) and the University of the Western Cape, unveil Africa’s first hydrogen fuel cell-powered forklift and refueling station for use in Implats mines.

Time of event: 31 March 2016 07:15 (Implats tweet)

Time of data capture: 1 April 2016 09:05

Search term used: Implats AND hydrogen

Tweets captured: 78

First captured tweet: @Implats – “#Implats, Department of Science & Technology & University of the Western Cape, launched its hydrogen fuel cell forklift & refuelling station”

Most retweeted account: @MiningWeekly (6 retweets)

“Implats boosts fuel cell outlook at impressive launch - Watch full video: [link]”

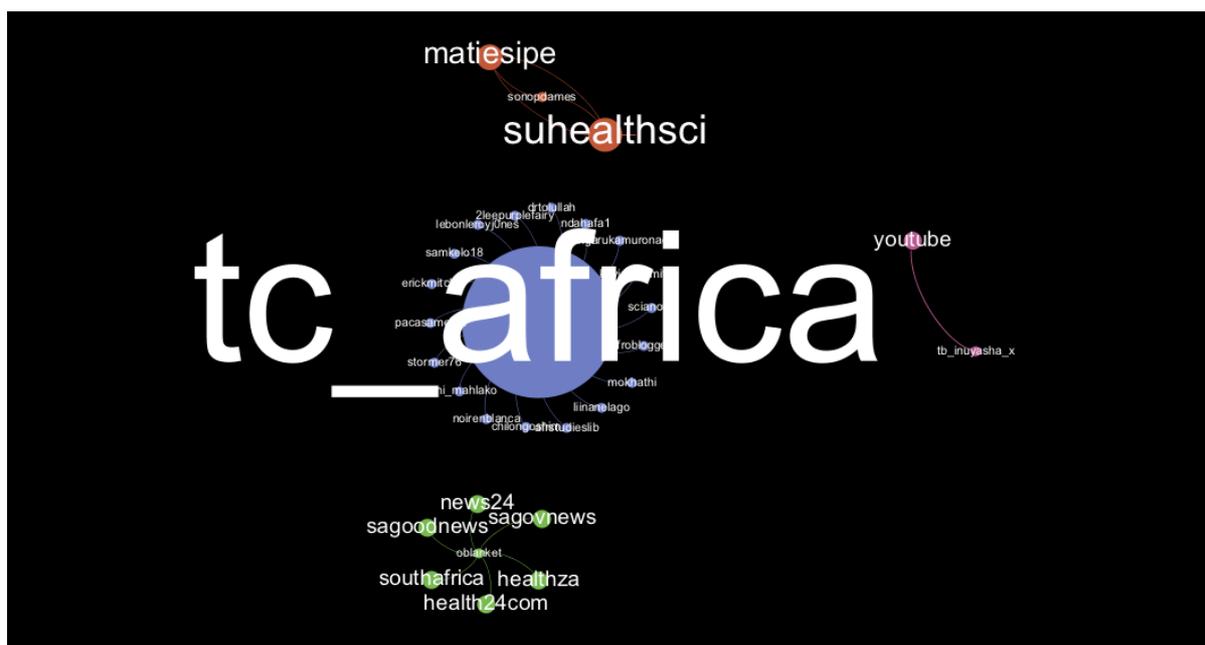
Main other identified agents of news dissemination:

- @MartinCreamer1 (6 retweets): “Implats boosts fuel cell outlook at impressive launch [link]”
- @Mineweb (5 retweets): “Implats demonstrates hydrogen fuel cell technology is contender as a major source of renewable energy going forward: [link]”
- @UWOnline (4 retweets): “Africa’s first #hydrogen #fuelcell forklift and refuelling station at Impala Refineries in Springs @dstgovza [link]”
- @HydroKevin (4 retweets): “Impala Platinum Unveils Hydrogen Fueling Station with #Fuelcell Forklift in South Africa [link]”
- @Moneyweb (3 retweets): “Implats leads local hydrogen fuel cell charge [link] via @Mineweb”

Observations: The *Mining Weekly* magazine, together with Martin Creamer (600 followers), the publishing editor of Creamer Media, who publishes *Mining Weekly*, together had the most retweets. The Moneyweb business news service and its mining counterpart Mineweb also featured, as did the University of the Western Cape (@UWOnline), Implats itself and a certain “Hydro Kevin” (2 700 followers) who seems to be a hydrogen car enthusiast from California. Overall, in more than 24 hours the story did not gain a lot of traction on Twitter. The Department of Science and Technology received mentions only.

Web link: <https://docs.google.com/spreadsheets/d/1XdM44hwAASvgfkqoJCYmbVenLOpFAQaBjCQH1iCyPal/pubhtml>

4.4.6 Quick TB test



Event/story: South African scientists from the University of Stellenbosch develop a new, cheaper test for tuberculosis (TB) that delivers results very quickly.

Time of event: 12 May 2016 07:00 (The Conversation Africa breaks story with tweet)

Time of data capture: 13 May 2016 08:17

Search term used: quick AND TB AND test

Tweets captured: 31

First captured tweet: @TC_Africa – “African scientists have developed and patented a test for TB that delivers quick results and is much cheaper [link]”

Most retweeted account: @TC_Africa (18 retweets)

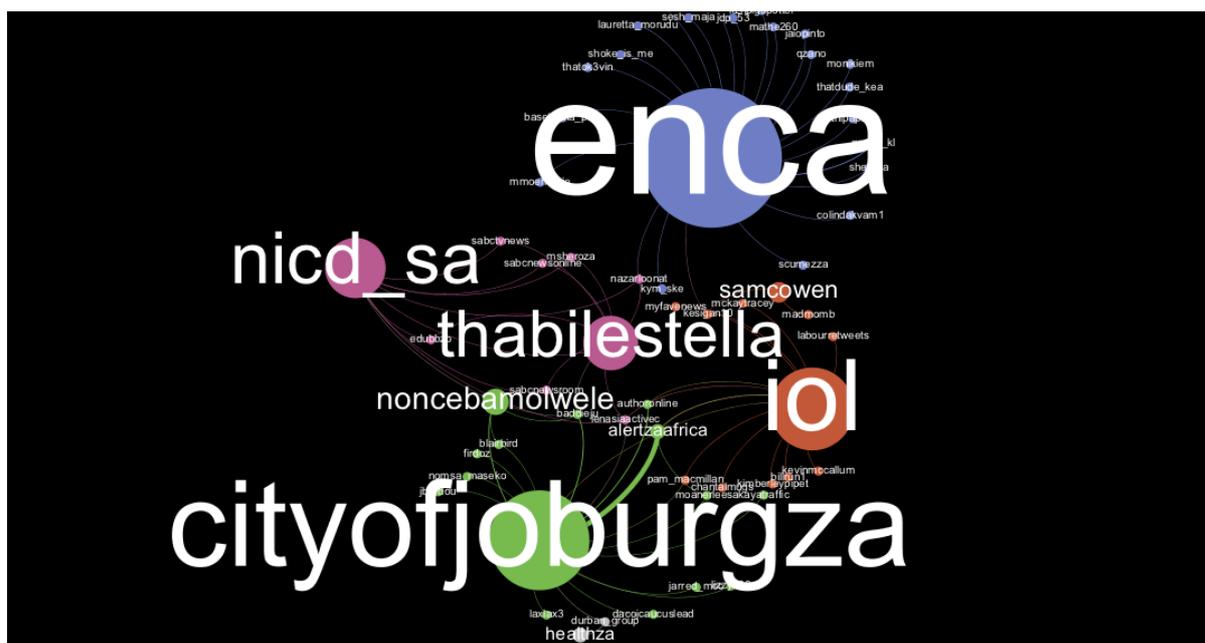
Main other identified agents of news dissemination:

- @OBlanket (6 retweets): “#WeCare: New quick TB test developed in @SouthAfrica @Health24com [link] @News24 @SAGovnewz @sagoodnewz @HealthZA”
- @MatiesIPE (4 retweets): “Well done colleagues @SUhealthsci with new quick test for TB [link]”

Observations: In more than 24 hours, the story received very little spread (only 31 tweets), despite the fact that TB prevalence is still a major problem in South Africa. The Conversation Africa (@TC_Africa), an independent online news service primarily run by academics, who broke the story on Twitter, received the most retweets, followed by Operation Blanket, an NGO committed to supporting the terminally ill, and the University of Stellenbosch’s Interprofessional Education & Practice (IPEP) centre at the Faculty of Medicine and Health Sciences. The University’s health faculty (@SUhealthsci) received mentions only.

Web link: <https://docs.google.com/spreadsheets/d/1RLnb4jifQzhfs-lfTynEqTas31Sg98nfwI4NHQm1WvHU/pubhtml>

4.4.7 Pikitup and the Plague



Event/story: The City of Johannesburg expresses worry about the health and environmental impact of the ongoing strike at waste management entity Pikitup, after a rodent tested positive for the dormant Plague.

Time of event: 1 April 2016 17:00 (first tweets by City of Johannesburg)

Time of data capture: 5 April 2016 08:17

Search term used: plague AND Pikitup

Tweets captured: 116

First captured tweet: @CityofJoburgZA – “So we might have a plague situation, not an outbreak #Pikitup^TK”

Most retweeted account: @CityofJoburgZA (31 retweets)

“We cannot confirm if the #Pikitup situation is the cause of the plague.^TK”

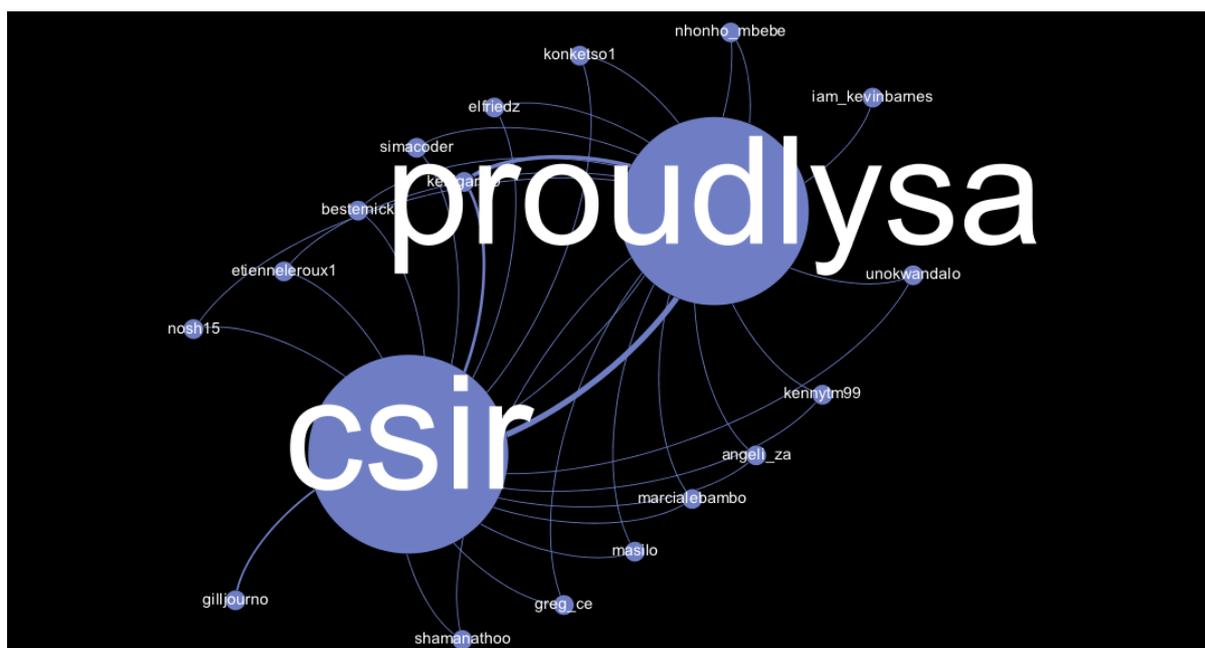
Main other identified agents of news dissemination:

- @eNCA (24 retweets): “eNCA | Rat tests positive for plague, but Pikitup refuses to collect [link]”
- @IOL (14 retweets): “Pikitup strike worries Joburg after Plague scare [link]”
- @AlertZaAfrica (11 retweets): “Retweeted City of Joburg (@CityofJoburgZA):#Pikitup, outbreak or plague...? ^TK [link]”
- @ThabileStella (9 retweets): “The National Institute for Communicable Diseases @nicd_sa says there is no outbreak of plague in Gauteng due to Pikitup strike #sabcnews”

Observations: One would think a potential outbreak of the Plague during a waste management strike would result in more than 116 tweets over almost five days. The primary retweeted account was that of the City of Johannesburg, followed by the eNCA news channel, Independent Online news, a South African crime and incident reporting Twitter service (@AlertZaAfrica), and Thabile Mbhele, an SABC news anchor. The National Institute for Communicable Diseases (NICD) received some mentions.

Web link: <https://docs.google.com/spreadsheets/d/13-mgun77qxr9f6SLzjOZ6xtnrFhuZCji2E0v0U3izDo/pubhtml>

4.4.8 Skin lab



Event/story: The CSIR’s Center for Tissue Engineering launches South Africa’s first “skin lab” and skin banking programme for skin, bone, cornea and heart valve transplants.

Time of event: 14 April 2016 18:00 (launch event at CSIR)

Time of data capture: 14 April 2016 21:12

Search term used: CSIR AND skin

Tweets captured: 27

First captured tweet: @ProudlySA – “Center for Tissue Engineering's Skin Banking Programme is launched at @CSIR this afternoon - a first for SA! #TUT [link]”

Most retweeted account: @ProudlySA (25 retweets)

“Official launch of the skin banking program - we tour the research lab at the CSIR campus @CSIR”

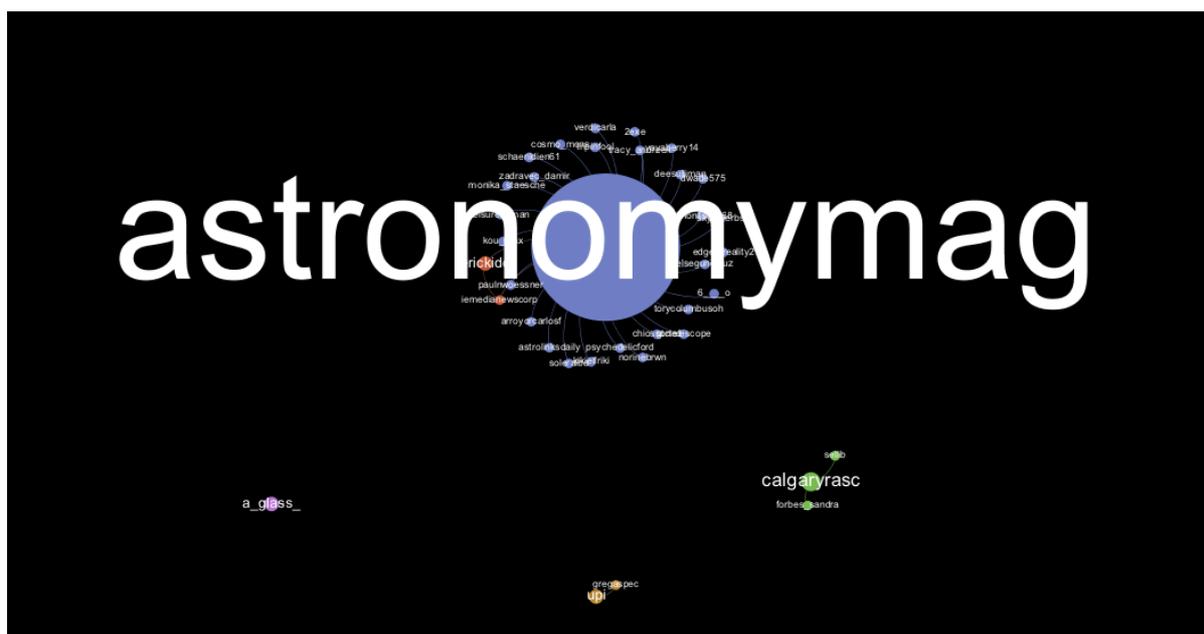
Main other identified agents of news dissemination:

- @CSIR (25 retweets): No own tweets recorded, only mentions.
- @gilljournno (2 retweets): “Apart from organs & skin, one can also donate corneas, bone and heart valves #CentreforTissueEngineering @CSIR”

Observations: It would seem that only the Proudly South African organisation, that attended the launch, tweeted about the event. No media tweets were recorded. Individuals merely mentioned the CSIR and retweeted the @ProudlySA tweets, except for “Gill Journno” (1 800 followers), PR manager for Proudly South African, who tweeted as herself as well. It is somewhat troubling that the @CSIR itself did not bother to tweet about the launch event at all.

Web link: <https://docs.google.com/spreadsheets/d/1iFL1coKhHHdt8WZ4d64gUBtsItswfpTtIUSZCnTrfVU/pubhtml>

4.4.9 Black holes aligned



Event/story: Deep radio imaging by researchers at the University of Cape Town (UCT) and the University of the Western Cape (UWC) revealed that supermassive black holes seem to all be mysteriously aligned and are all spinning out radio jets in the same direction.

Time of event: 11 April 2016 21:21 (first tweet)

Time of data capture: 13 April 16:40

Search term used: black AND holes AND align

Tweets captured: 78

First captured tweet: @SciBraai – “Ever wanted to know how black holes align in space? [link]”

Most retweeted account: @AstronomyMag (30 retweets)

“Black holes mysteriously align [link]”

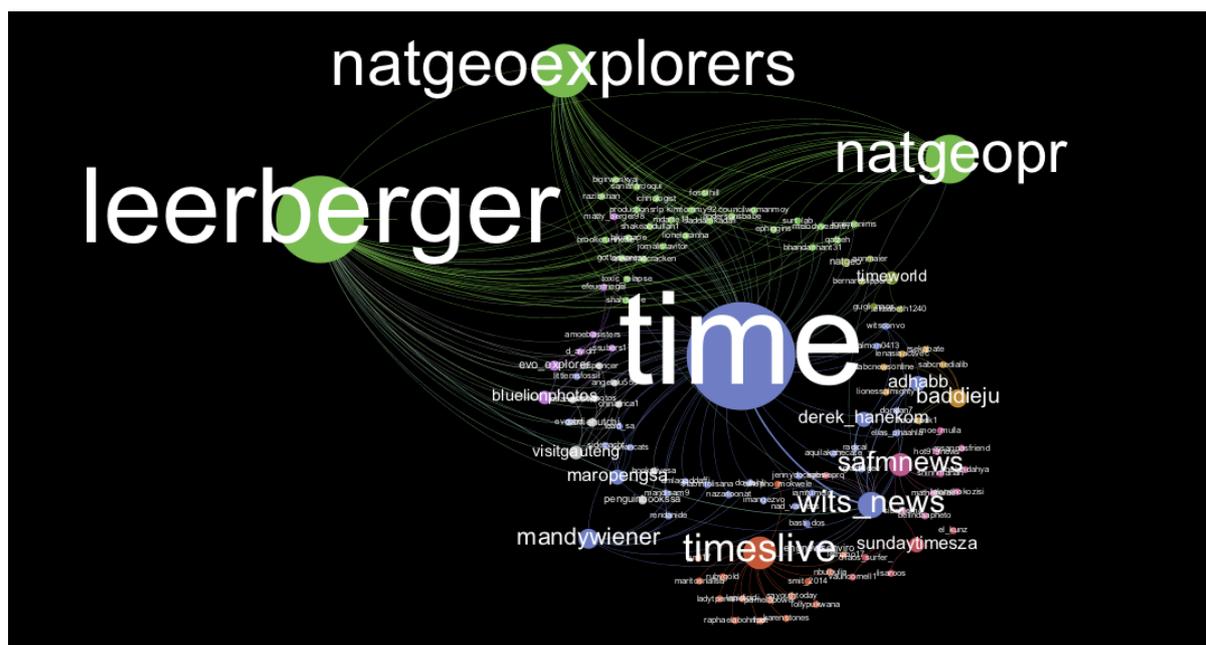
Main other identified agents of news dissemination:

- @CalgaryRASC (2 retweets): “Supermassive #blackholes hint at large-scale structural organisation of parts of the #Universe”

Observations: No tweets or retweets were recorded for the two South African universities involved, or from the scientists involved, or local media (except for two tweets by local science news service Scibraai, which was not retweeted). Astronomy Magazine was largely responsible for the story getting any traction on Twitter, and the Calgary Centre of the Royal Astronomical Society of Canada (RASC) was the only astronomical institution to tweet about the findings.

Web link: <https://docs.google.com/spreadsheets/d/1mui6edmrDVCwpBqmSAT1XPTUpS9U7bc8jeMavdYktjU/pubhtml>

4.4.10 TIME commends Lee Berger



Event/story: Prof Lee Berger from the University of the Witwatersrand (Wits), who was responsible for the discovery of several hominin fossil finds in the Cradle of Humankind, including the *Homo sediba* and *Homo naledi* fossils, is named by TIME magazine as one of the 100 most influential people on earth.

Time of event: 21 April 2016 13:01 (TIME tweet)

Time of data capture: 22 April 08:20

Search term used: Lee AND Berger AND influential AND time

Tweets captured: 149

First captured tweet: @Wits_News: "Lee Berger is on @TIME's list of the world's most influential people #TIME100 [link] @Derek_Hanekom @AdHabb"

Most retweeted account: @TIME (70 retweets)

"RT @NatGeoPR: Congrats to @NatGeoExplorers @LeeRBerger, named one of @TIME's most influential people [link] #TIME100"

Main other identified agents of news dissemination:

- @LeeRBerger (55 retweets): "RT @NatGeoPR: Congrats to @NatGeoExplorers @LeeRBerger, named one of @TIME's most influential people [link] #TIME100"
- @Wits_News (31 retweets): "Wits paleoanthropologist Lee Berger among Time's 100 most influential people in world - Times LIVE"
- @NatGeoPR (29 retweets): "Congrats to @NatGeoExplorers @LeeRBerger, named one of @TIME's most influential people [link] #TIME100"
- @natgeoexplorers (29 retweets): "RT @NatGeoPR: Congrats to @NatGeoExplorers @LeeRBerger, named one of @TIME's most influential people [link] #TIME100"
- @TimesLIVE (16 retweets): "Wits paleoanthropologist Lee Berger among Time's 100 most influential people in world [link]"
- @MandyWiener (9 retweets): "Wow! Professor Lee Berger has been named to @TIME magazine's 100 most influential people in the WORLD!"

Observations: The most retweeted account was that of *TIME* magazine, but the tweet in question was itself a retweet of the National Geographic PR account which was also retweeted by Lee Berger himself and the National Geographic Explorers account. Wits News credited a tweet by Times Live –

whose own original tweet received a fair number of retweets. Mandy Wiener is a well-known local journalist and author. With such big names involved (TIME, National Geographic, Prof Lee Berger), one might have expected more tweets in almost 20 hours.

Web link: <https://docs.google.com/spreadsheets/d/1mqYAk-ZBQNdYSoDNI1zvNFnMeRe4IpD1wwNWRpT4v04/pubhtml>

4.4.11 Trends in local science stories

Overall, local science news stories with a South African link seem to gain far, far less traction than international science news stories. In many of the cases studied, it was possible to capture all tweets surrounding a news story, even days after the story broke – simply because so few tweets were posted about the event.

Also, in many cases it was international news agencies or scientific institutions that tweeted about South African scientific news, rather than South African news media, scientists or science communicators. One contributing factor must be the fact that, according to Claassen (2011), the South African media has very few dedicated science journalists and that science news and science stories is not given nearly enough editorial space. But this is obviously not the only problem. Often the South African scientific institutions involved in a new scientific announcement or development did not bother to tweet at all, even though they have Twitter accounts presumably for exactly such occasions.

The results clearly show that there is much room for improvement when it comes to effective science communication on Twitter for South Africa's scientists, science communicators, journalists and news media. In the following chapter, the implications of these results are discussed.

Chapter 5 – Discussion of trends and implications

The graphs that were created for datavisual analysis from the Twitter stories that were captured for this study successfully demonstrated that the chosen methodology works – and that it can easily be used for further related research.

The TAGSv6.0 software proved easy to use, flexible, and effective as a means of capturing datasets of tweets shortly after breaking news events occur. It provided all of the information, such as tweet contents, number of tweets captured, times of capture, account details and other parameters needed for the study. The TAGSExplorer function was extremely useful in order to immediately arrange a captured dataset according to the number of retweets each account received, and to identify those accounts that were most retweeted. It proved easy to convert the TAGSv6.0 data into the required CSV format and to import it as a graph into Gephi.

Gephi itself proved to be a powerful graph visualisation tool that allowed for the creation of appealing network visuals that easily identified the most retweeted accounts (weighted and sized according to retweets). In each of the data analysis subsections (international and local news, and international and local science news) clear trends quickly emerged, suggesting the methodology was useful and successful.

The captured data prove that Twitter is a powerful tool for the almost instantaneous breaking and spreading of news. In some cases (such as Flight M181 in 4.1.1) thousands of tweets were captured within minutes of an event occurring.

It bears remembering that these captured tweets and retweets only account for tweets that contained the chosen search terms, and does not provide a number for the real audience that was exposed to these stories. It is reasonable to assume that for every tweet directly mentioning the story, or every retweet, hundreds or thousands more Twitter users must have seen and read those tweets and simply decided not to respond or retweet themselves. Many would have read the tweets and quite possibly found them interesting and may have talked about them with friends or family, and may even have discussed them on other social networks like Facebook, WhatsApp or Instagram, even though they remained silent on Twitter. The point being that the tweets captured in this study merely represent the active audience that each story enjoyed. The passive, silent audience was most likely much larger still.

Some general findings and Twitter habits that were exposed by the analysis done in the previous chapter include:

- It is very difficult to pinpoint the first tweet that was responsible for the breaking of a news story. Whoever first tweets about an event does not necessarily make use of the search terms

or hashtags that later define a story, and it is therefore almost impossible to determine whether the first captured tweets corresponding to a search term was in fact the first tweet relating to that event. Nonetheless, even without knowing which Twitter user broke a story, the captured data invariably proved valuable in understanding the spread of news on Twitter.

- Tweets of the most retweeted accounts were often very succinct and to the point, and almost always contained a hyperlink to a news story or press release for further information.
- Concerning the “5 W’s and the H” (What? Who? Why? Where?, When? and How?) of traditional news journalism, tweets that were widely retweeted often contained only the basics of What, Who, When and Where, and almost never touched on Why or How – presumably because these questions often require more space to answer than Twitter allows and is therefore usually kept for news articles or news releases themselves (often linked to a tweet).
- In all the cases studied, the most retweeted accounts were invariably those of well-known or prominent news media, organisations, journalists or scientists. Random Twitter users or so-called citizen journalists almost did not feature at all.

This last point brings us to what is likely the most important finding of this study – the issue of trust as a currency on Twitter.

5.1 Trust as a social media currency

In the studied news stories the most retweeted accounts were invariably those of individuals or organisations that have to a large extent earned the public trust (and consequently also a substantial Twitter following). Some examples:

- Established, trusted news agencies (BBC News, Associated Press, Reuters, The New York Times, Sky News, TIME, National Geographic, eNews, Eyewitness News)
- Official public service organisations or well-known companies (EgyptAir, SpaceX, City of Joburg, Proudly South African)
- Trusted scientific or academic institutions (Nasa, Wits, UCT, WHO, CSIR, ESA, Roscosmos, NICD, USGS)
- Popular, trusted science and technology news outlets (*Astronomy Magazine*, Nature News, ScienceAlert, Wired, Mashable, TechCrunch, Space.com)
- Popular, trusted journalists (Barry Bateman, Mandy Wiener, Adriaan Basson)
- Trusted scientists (Richard Dawkins, Lee Berger, Josh Neufeld)

From the assembled data it seems Twitter users, following breaking news events, vastly prefer retweeting tweets from accounts (sources) that they trust to be accurate and truthful.

This has important implications because it affords some degree of predictability in retweet behaviour. It implies a strong correlation between the amount of public trust in an organisation, individual or brand, and the number of retweets that a particular account is likely to receive for any given tweet.

It follows that trust plays an important role in retweeting behaviour on Twitter and might therefore be seen as a kind of currency on the social network. In other words, the more trusted (highly regarded) the individual or organisation in question is perceived to be, the more likely other Twitter users are to retweet news that the individual or organisation will tweet about.

This is likely good news for the traditional news media still reeling from dwindling print sales due to the transition to online content; as well as for scientists and science communicators who enjoy a fair amount of public trust already. It also has implications for how modern audiences behave on social media and how they should be viewed.

5.2 Audience implications

The behaviour of Twitter users who, on the whole, seem to prefer sticking with traditional news media and other sources they trust (and most likely trusted before the advent of social media), is somewhat at odds with the argument made earlier (in Chapter 2) that social networks have taken media fragmentation to new extremes and that audience members are now as actively participating and powerful as any official news outlet.

From the evidence provided here it seems the truth is that although individual audience members now possess the *potential* to follow a very tailored niche media diet and to become a powerful news outlet at any given moment, the reality is that the social media audience landscape much more closely resembles the traditional print media audience than is often claimed.

What social media does seem to have achieved is to give trusted non-media organisations such as Nasa and the WHO, who, in the past, did not have audiences to rival that of the print media giants, a much louder voice and media power that they never had before.

Nasa, for instance, has a myriad of different Twitter accounts each related to a different project or research topic, as well as Instagram and Facebook accounts. In the example of the Juno spacecraft entering Jupiter's orbit (4.3.3), Nasa was a more dominant voice in terms of retweets than even BBC News, who itself is a big player on the network.

This presents a massive opportunity for scientific organisations, scientists and science communication specialists to communicate with Twitter's audiences. If a scientific organisation (such as the NICD or CSIR) invests in fostering a social media following and regularly tweet updates and findings, and can build trust in the public to keep them accurately and timeously informed about relevant, interesting science and technology developments, such organisations can have voices as powerful as those of traditional media giants. The same can be said for individual journalists or scientists (some of whom already have more followers on Twitter than many news outlets).

This is because, as the data here has shown, social media audiences go where they trust to go, and they most often retweet what they trust to be accurate and truthful. The amount of trust that an organisation, media outlet, brand or individual can foster among the Twitter audience, will therefore determine, to a large extent, how big a role that particular account will play in the spread of news on Twitter, and maybe even more so when it comes to science news through links to original peer-reviewed research on Twitter. These links give users who normally do not have access to expensive scientific publications, insight into original science. In this way science becomes much more democratised and less of an elite closed corps.

The fact that audience members on social networks are more actively participating than at any time in the history of news media holds true, but the fact that they seem to prefer giving their attention to those whom they trust, creates a manner of predictability that lends itself to purposeful future research. One could, for instance, investigate the possibility of creating a new audience theory for news audiences on social media, based on measurable factors that determine levels of trust and the willingness to retweet.

This obviously also has implications for how South African scientists, scientific institutions, journalists and science communicators should engage with the social media audience.

5.3 Implications for South African science communication

Clearly, there is much to be done.

From the 20 science stories that were chosen it is already clear that South African science news gets far less retweet traffic (and by implication distributed reader traction) than science news that originated elsewhere. Also noteworthy is the fact that some of the South African science news stories, such as the discovery that black holes are mysteriously aligned (4.4.9) and the creation of cheaper, quicker TB tests (4.4.6), would have received vastly more traction on Twitter had they originated in say, the US or Europe. Had it been Nasa or ESA scientists that had made the discovery about black holes being aligned, there would have probably been thousands of tweets captured (instead of 78 in that case).

The fact that in several cases the (known and trusted) South African scientific institutions responsible for scientific advancements and announcements did not seem to be bothered to tweet about it themselves at all (the CSIR in 4.4.8, UCT and UWC in 4.4.9), definitely contributed to the low reach and retweet traffic for these stories. That in many cases it was rather international scientists and science news media who tweeted most about these South African science developments, is also very telling.

Providing further evidence that South African science communicators are not doing enough to convey science on social media is the fact that there were many stories that were considered for analysis and inclusion in this study but they were discarded because the stories received nary a single tweeted mention at all.

For example, when Dr. Nick Walker received a Global Impact Award in April 2016 for his work on developing a potential cure for HIV, only two or three tweets mentioned it. In the same month, The Conversation Africa published a story warning that climate change poses serious risks to the survival of Cape frogs, but only two tweets about it was recorded. When the University of Pretoria (UP) earlier in the year tweeted about a study showing that fly maggots can serve as a viable protein supplement for livestock (to enhance food security), the tweet received a single reply and no local media picked up the story. And when another UP scientist used the local grains sorghum and cowpea to create a truly indigenous, instant superfood ideal for poor, undernourished rural children, the story received a single tweet, and no responses. Lastly, when the UCT together with the Southern African Large Telescope (SALT) discovered an ancient star, also in April, three tweets were recorded about it.

All of these stories concern topical, interesting and arguably easy-to-sell science content (relevant or entertaining to the general public) that might have received far more coverage had more effort been made to promote the science in question. Had Nasa announced the discovery of a previously undiscovered ancient star, it no doubt would have been tweeted about around the globe and had made headlines.

It is easy to say that institutions such as Nasa, the ESA and the WHO simply has a much larger global following and audience than for instance the CSIR, the South African National Space Agency (Sansa) or the NICD, but on Twitter this argument does not hold water. The fact that even individual scientists like Richard Dawkins, Neil deGrasse-Tyson and Lee Berger have amassed large Twitter followings and huge social media audiences, prove that any organisation that invests some time in social media, can achieve the same.

CERN serves as a good example in this regard. Before the advent of the Large Hadron Collider (LHC) the general public knew little about CERN. As the LHC was built, and increasingly as it was being readied for switch-on, the CERN communications team did much to hype what the LHC might uncover once it starts working. Even with particle accelerators and particle collisions representing very complicated physics (that in general terms cannot even be seen or witnessed by the media or public) CERN has managed to garner a huge Twitter following, over many different accounts. This is of course in large part due to the discovery of the Higgs boson, but if the CERN scientists and communications team had done a poor job of conveying the significance of the discovery, the story would have probably received far less attention simply due to its complicated nature.

Similarly, by creating a compelling narrative with his six female ‘underground astronauts’ and in running a comprehensive social media campaign right from the start of excavations at the Rising Star Cave where the hominin mandible was found that would later be revealed as *Homo naledi*, Prof. Lee Berger managed to create a massive online following – and so did each of his young female scientists, who were up to then largely unknown. It can, in other words, be done.

Here then, follows some general recommendations for South African scientists, journalists and scientific institutions, based on the analyses and findings of this study:

- Creating and maintaining a Twitter account (or a Facebook page) has no costs (apart from internet data or the hiring of a social media manager if needed) and is one of the most cost-effective means of communicating science to a potentially global audience. Investing time in social media will increase public interest in scientific work, will most likely eventually create opportunity for collaboration with other scientists and institutions and can quite possibly help to increase funding simply because it is easy for investors to see what work is being done, and that efforts are made to communicate results.
- Creating connections with prominent news media in order to give proper exposure to the science in question, is vital. When tweeting science, make sure for instance to tag relevant local news media such as @EWN, @eNCA, @News24 etc. into posts about new findings or announcements. This will ensure that at least someone from each of those trusted media outlets will read the tweet, creating a much higher probability that the story will be picked up or retweeted. From the data in this study it is clear that if a tweet by a science organisation can get retweeted by a major, trusted news outlet, it will instantly expand the audience reach and potential further retweets of the story significantly.
- Build embargo hype. Do not wait for an embargo to be lifted before first tweeting about an announcement. Start tweeting a week beforehand to get followers and journalists excited about what might be revealed. News media need to plan what they are going to cover and if they know that a major announcement is coming they are much more likely to cover it. The same applies for scientists and science journalists who want to let their followers know they are about to publish a significant or interesting development.
- Keep tweets short, sweet and to the point, and include hyperlinks to stories or press releases that explain the Why and the How in understandable detail.
- Keep in mind what type of search terms or hashtags users are most likely to associate with a story and be sure to include them in tweets, ie. to make tweets searchable and accessible.
- Consider creating more than one Twitter account in order to separate research projects or topics. News media and science institutions that have done so (Nasa, BBC News, CERN, ESA) seem to be very successful on Twitter.
- Consider learning to use TAGS v6.0 or similar software to quickly and easily study how tweets are spread and retweeted, in order to over time learn what works and does not work for the individual or organisation in question.
- Lastly, and most importantly, scientists, institutions and science journalists need to *continuously foster trust* among the social media public by providing regular updates on work

being done, by ensuring information is accurate, by building hype when announcements are imminent, by making science interesting and compelling and understandable (the content of SciBraai and IFLScience are good examples), by responding to public questions and queries, by linking with other trusted organisations and media with an online and social network presence and by generally showing the public that you are an accurate, trustworthy source of scientific news. Because scientists and science institutions are generally some of society's most trusted authorities, they already possess built-in social media wealth that ought to be utilised for effective science communication.

5.4 Further study needed

The findings of this study, and the recommendations above, create clear avenues for further needed research that might be pursued.

Further study is needed to properly understand how scientific institutions, science journalists and scientists from different disciplines should go about building trust in the social media sphere, and what a social media audience theory based on public trust in various types of social media accounts might look like. To do this, a method will also have to be established for measuring trust (and retweet probability) on social media.

A good starting point might be to partner with a scientific organisation such as the CSIR and to then implement some of the recommendations from this paper and to study, over the course of a year, the effects on the institution's social media following, whether it helped to improve science communication from the institution, and whether it might be successfully implemented by other scientific organisations.

Alternatively, one could use a popular science news aggregator such as IFLScience as a case study to see what works best in order to gain maximum reach across multiple social networks in terms of accurate, understandable and entertaining science communication.

Even without further research however, this study makes it clear that Twitter can be a valuable platform for science communication and that South African scientists, journalists and institutions have not yet tapped its full potential.

Chapter 6 – Conclusion

From the data presented here it is clear that, in terms of retweet potential, trust in the individual or organisation associated with a Twitter account is much more important than the actual content of a specific tweet. People retweet what they trust to be true and accurate and evidently the same holds true for science content. This should be encouraging for all science communicators.

Twitter is a powerful, cost-effective science communication tool and scientists, science communicators and journalists, who already have a measure of public trust by the nature of their work, will do well to exploit its potential.

What needs to be remembered though, is that social networks are an evolving media prone to rapid changes and new trends. This means if science communicators decide to invest time into social media, they should be cognisant of the fact that audience trends and preferences can quickly change. For instance, the Reuters Digital News Report 2016 (Newman, 2016) recently indicated that Facebook, rather than Twitter, is currently the most important social network for finding, reading/watching and sharing news. Due to its succinct nature Twitter obviously remains a more powerful medium when it comes to breaking news but for science communicators to only focus on Twitter and to ignore Facebook, Youtube, Instagram and the like, would be a mistake.

Nevertheless, this study's results show that tweeting science is important and that it can pay dividends for scientists, scientific institutions and science journalists to become more Twitter and social media savvy, for example through social media training.

The fact that Twitter's audiences mostly retweet the news they get from sources they seem to know and trust, can be seen as evidence that social media audiences are smarter than they are often given credit for, which also means that these audiences can play a big role in helping to ensure the healthy spread of sound, evidence-based South African science, should the country's scientists, institutions and journalists make a concerted effort to tweet about the science that matters.

For scientists, science institutions and science journalists who already enjoy a manner of public trust based on their knowledge and expertise, this should be good news indeed.

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REFERENCES

Abutaleb, Y. 2016. Twitter to keep 140-character limit, CEO says. *Reuters* home page: <http://www.reuters.com/article/us-twitter-character-limit-idUSKCN0WK275>. Accessed: 2016-04-06.

Alejandro, J. 2010. Journalism in the age of social media. *Reuters Institute* home page: <https://reutersinstitute.politics.ox.ac.uk/sites/default/files/Journalism%20in%20the%20Age%20of%20Social%20Media.pdf>. Accessed: 2016-06-15.

Allgaier, J., Dunwoody, S., & Brossard, D. 2013. Journalism and social media as means of observing the contexts of science. *Oxford Journals* home page: <http://bioscience.oxfordjournals.org/content/63/4/284.full>. Accessed: 2016-06-08.

Barthel, M., Shearer, E., Gottfried, J. & Mitchell, A. 2015. The evolving role of news on Twitter and Facebook. *Pew Research Center* home page: <http://www.journalism.org/2015/07/14/the-evolving-role-of-news-on-twitter-and-facebook/>. Accessed: 2016-05-07.

Bell, E. 2016. Facebook is eating the world. *Columbia Journalism Review* home page: http://www.cjr.org/analysis/facebook_and_media.php. Accessed: 2016-04-02.

Bik, H.M., & Goldstein, M.C. 2013. An introduction to social media for scientists. *PLOS Biology* 11(4) online edition: <http://journals.plos.org/plosbiology/article?id=10.1371/journal.pbio.1001535>. Accessed: 2016-06-10.

Blair, E. 2014. #Ebola lessons: How social media gets infected. *Information Week* home page: <http://www.informationweek.com/software/social/-ebola-lessons-how-social-media-gets-infected/a/d-id/1307061>. Accessed: 2016-04-09.

Blue, A. 2012. UA study examines how news spreads on Twitter. *University of Arizona* home page: <https://uanews.arizona.edu/story/ua-study-examines-how-news-spreads-on-twitter>. Accessed: 2016-05-08.

Bohannon, J. 2016. The frustrated science student behind Sci-Hub. *Science* home page: http://www.sciencemag.org/news/2016/04/alexandra-elbakyan-founded-sci-hub-thwart-journal-paywalls?utm_source=sciencemagazine&utm_medium=facebook-text&utm_campaign=frustrated-394. Accessed: 2016-06-11.

Bombaci, S.P., Farr, C.M., Gallo, H.T., Mangan, A.M., Stinson, L.T., Kaushik, M. & Pejchar, L. 2015. Using Twitter to communicate conservation science from a professional conference. In: *Conservation Biology* 30(1): 216-225.

- Bruns, A. 2012. How long is a tweet? Mapping dynamic conversation networks on Twitter using Gawk and Gephi. In: *Information, Communication & Society* 15(9):1323-1351.
- Claassen, G. 2011. Science and the media in South Africa: Reflecting a 'dirty mirror'. *Communicatio* 37(3):351-366.
- Collins, K. 2014. Do scientists use Twitter? *Tweet Your Science* home page: <http://www.tweetyourscience.com/do-scientists-use-twitter/>. Accessed: 2016-06-11.
- Coyle, J. 2016. Is Twitter the news outlet for the 21st century? *ABC News* home page: <http://abcnews.go.com/Technology/story?id=7979891&page=1>. Accessed: 2016-04-02.
- Deller, R. 2011. Twittering on: Audience research and participation using Twitter. In: *Participations: Journal of Audience & Reception Studies* 8(1):216-245.
- Du Plooy, G. 2009. *Communication research*. Cape Town: Juta.
- Gephi 2016. *Gephi* home page: <https://gephi.org>. Accessed: 2016-08-12.
- Guibourg, C. 2015. Tutorial: A network analysis of a Twitter hashtag using Gephi and NodeXL. *Clara Guibourg* home page: <https://cguibourg.wordpress.com>. Accessed: 2016-04-15.
- Hawksey, M. 2016. Twitter's API and TAGS. [m.hawksey@gmail.com]. 2016-03-10.
- Harrington, S., Highfeld, T., & Bruns, A. 2013. More than a backchannel: Twitter and television. In: *Participations: Journal of Audience & Reception Studies* 10(1):405-409.
- Hartz, J., & Chappell, R. 1997. *Worlds apart: How the distance between science and journalism threatens America's future*. Nashville, Tennessee: First Amendment Centre.
- Heleta, S. 2016. How academics can change the world. *Rand Daily Mail* home page: <http://www.rdm.co.za/lifestyle/2016/03/09/how-academics-can-change-the-world>. Accessed: 2016-06-08.
- Honan, M. 2015. This is Twitter's top secret Project Lightning. *Buzzfeed* home page: https://www.buzzfeed.com/mathonan/twitters-top-secret-project-lightning-revealed?utm_term=.kgAmDYmL3#.ginKMRK15. Accessed: 2016-05-07.
- Hu, M., Liu, S., Wei, F., Wu, Y., Stasko, J., & Ma, K. 2012. Breaking news on Twitter. In: *Proceedings of the SIGCHI conference on human factors in computing systems*, ACM:2751-2754
- Ingram, M. 2012. If you think Twitter doesn't break news, you're living in a dream world. *GigaOm* home page: <https://gigaom.com/2012/02/29/if-you-think-twitter-doesnt-break-news-youre-living-in-a-dream-world/>. Accessed: 2016-04-03.
- Jarreau, P.B. 2016. Using Twitter to interact, but science communication to preach. *SciLogs* home page: http://www.scilogs.com/from_the_lab_bench/using-twitter-to-interact-but-science-communication-to-preach/. Accessed: 2016-04-09.
- Knip, K. 2002. De kunst van het onvolledige: Keuzes van wetenschapsredacteurs vallen opvallend vaak hetzelfde uit. *NRC Handelsblad*, 19 October: 35.

- Koh, Y. 2016. Twitter to expand tweet's 140-character limit to 10,000. *The Wall Street Journal* home page: <http://blogs.wsj.com/digits/2016/01/05/twitter-to-expand-tweets-140-character-limit-to-10000/>. Accessed: 2016-04-06.
- Kwak, H., Lee, C., Park, H., & Moon, S. 2010. What is Twitter, a social network or a news media? In: *Proceedings of the 19th international conference on World Wide Web*, ACM, 26-30 April 2010:591-600.
- Laurie, M. 2010. How social media has changed us. *Mashable* home page: <http://mashable.com/2010/01/07/social-media-changed-us/#Ha6pTW2W58q2>. Accessed: 2016-06-15.
- Liang, X., Yi-fan-Su, L., Yeo, S., Scheufele, D., Brossard, D., Xenos, M., Nealey, P., & Corley, E. 2014. Building buzz: (Scientists) communicating science in new media environments. In: *Journalism and Mass Communication Quarterly* 91(4):772-791.
- Littlejohn, S., & Foss, K. 2009. *Encyclopedia of communication theory*. London: Sage.
- Luckerson, V. 2014a. Fear, misinformation, and social media complicate Ebola fight. *Time* home page: <http://time.com/3479254/ebola-social-media/>. Accessed: 2016-04-10.
- Luckerson, V. 2014b. Watch how word of Ebola exploded in America. *Time* home page: <http://time.com/3478452/ebola-twitter/>. Accessed: 2016-04-10.
- M&G staff, 2016. Meet 15 of Africa's most brilliant young scientists – one of them could be the next Einstein. *Mail & Guardian* home page: <http://mgafrika.com/article/2016-03-04-africas-best-young-scientists>. Accessed: 2016-06-11.
- Marwick, A. 2011. I tweet honestly, I tweet passionately: Twitter users, context collapse, and the imagined audience. In: *New Media & Society* 13(1):114-133.
- McQuail, D. 2005. *McQuail's mass communication theory*. London: Sage.
- Murdock, H. 2014. Nigeria using Facebook, Twitter to inform people about Ebola. *Voice of America* home page: <http://www.voanews.com/content/nigeria-embarks-on-mass-communications-to-prevent-ebola-spread/1969796.html>. Accessed: 2016-04-10.
- Murthy, D. 2011. Twitter: Microphone for the masses? In: *Media, culture and society* 33(5):779-789.
- MyBroadband staff, 2016. A quick science lesson for the #ScienceMustFall idiots. *MyBroadband* home page: <http://mybroadband.co.za/news/science/182962-a-quick-science-lesson-for-the-sciencemustfall-idiots.html>. Accessed: 2016-10-17.
- Napoli, P. 2003. *Audience economics: Media institutions and the audience marketplace*. New York: Columbia University Press.
- Nelkin, D. 1995. *Selling science: How the press covers science and technology*. New York: W.H. Freeman and Company.

- Newman, N. 2016. Reuters Institute: Digital News Report 2016. *Digital News Report* home page: <http://www.digitalnewsreport.org/survey/2016/overview-key-findings-2016/>. Accessed: 2016-08-12.
- Novak, R. 2015. Communicating #science on Twitter works. *Colorado State University* home page: <http://source.colostate.edu/communicating-science-on-twitter-works/>. Accessed: 2016-04-09.
- Ogodo, O. 2012. Improving science communication for Africa's development. *SciDev Net* home page: <https://scidevnet.wordpress.com/2012/09/17/improving-science-communication-for-africas-development/>. Accessed: 2016-04-19.
- Paper staff. 2014. Introducing our winter cover star: Kim Kardashian. *Paper* home page: <http://www.papermag.com/introducing-our-winter-cover-star-kim-kardashian-1427448936.html>. Accessed: 2016-04-10.
- Pouris, A. 1991. Understanding and appreciation of science by the public in South Africa. *South African Journal of Science* 87(7):358-359.
- Pouris, A. 1993. Understanding and appreciation of science among South African teenagers. *South African Journal of Science* 89(2): 68-69.
- Pouris, A. 2001. Interests, public attitudes and sources of scientific information in South Africa. *CERN* home page: <http://visits.web.cern.ch/visits/pcst2001/proc/Pouris.doc>. Accessed: 2011-05-03.
- Ram, S., & Bhattacharya, D. 2012. Sharing news articles in 140 characters: A diffusion analysis on Twitter. In: *2012 IEEE/ACM International Conference on Advances in Social Networks Analysis and Mining (ASONAM)*, 26-29 August 2012:966-971.
- Ram, S., & Bhattacharya, D. 2015. RT @News: An analysis of news agency ego networks in a microblogging environment. In: *ACM Transactions on Management Information Systems (TMIS)* 6(3):Article 11.
- Risen, T. 2014. Mobile phones, social media aiding Ebola fight. *US News* home page: <http://www.usnews.com/news/articles/2014/10/10/phones-social-media-aiding-in-ebola-fight>. Accessed: 2016-04-10.
- Rosenstiel, T., Sonderman, J., Loker, K., Ivancin, M. & Kjarval, N. 2015. Twitter and breaking news. *American Press Institute* home page: <https://www.americanpressinstitute.org/publications/reports/survey-research/twitter-and-breaking-news/>. Accessed: 2016-04-03.
- Rudat, A., Buder, J., & Hesse, F. 2014. Audience design in Twitter: Retweeting behaviour between informational value and followers' interests. In: *Computers in Human Behavior* 35(6):132-139.
- Russell, J. 2015. Topsy, the popular social analytics service bought by Apple, closes down. *TechCrunch* home page: <http://techcrunch.com/2015/12/15/rip-topsy/>. Accessed: 2016-04-10.
- Rutenberg, J. 2016. For news outlets squeezed from the middle, it's bend or bust. *The New York Times* home page: http://www.nytimes.com/2016/04/18/business/media/for-news-outlets-squeezed-from-the-middle-its-bend-or-bust.html?_r=1. Accessed: 2016-06-15.

Shezi, L. 2016. SA's 26.8 million internet users spend almost three hours a day on social media. *HTXT* home page: <http://www.htxt.co.za/2016/04/29/the-stuff-south-africa-26-8-mil-internet-users-spend-most-their-time-doing-online/>. Accessed: 2016-05-07.

Shukla, R., & Bauer, M. 2007. *The Science Culture Index (SCI): Construction and validation. A comparative analysis of engagement, knowledge and attitudes to science across India and Europe* (concept paper). London and Delhi: The British Royal Society.

Smith, A. 2015. "Wow, I didn't know that before; thank you": How scientists use Twitter for public engagement. In: *Journal of Promotional Communications* 3(3):320-339.

Spaull, N. 2015. Say what? Pseudo-science in KZN education. *Daily Maverick* home page: <http://www.dailymaverick.co.za/opinionista/2015-01-26-say-what-pseudo-science-in-kzn-education/#.VxaD1XgRreQ>. Accessed: 2016-04-19.

Tags 2016. TAGS home page: <https://tags.hawksey.info>. Accessed: 2016-08-12.

Titcomb, J. 2016. Removing Twitter's 140-character limit is Jack Dorsey's biggest gamble yet. *The Telegraph* home page: <http://www.telegraph.co.uk/technology/2016/01/21/removing-twiters-140-character-limit-is-jack-dorseys-biggest-ga/>. Accessed: 2016-04-06.

Turner, A. 2013. 9 breaking news tweets that changed Twitter forever. *Mashable* home page: <http://mashable.com/2013/10/31/twitter-news/#QcUf0qolc5qD>. Accessed: 2016-04-03.

Turow, J. 2011. *Media today: An introduction to mass communication*. New York: Taylor&Francis.

Uren, V., & Dadzie, A. 2015. Public scientific communication on Twitter: Visual analytic approach. In: *Aslib Journal of Information Management* 67(3):337-355.

Vinas, M. 2011. Why should scientists use Twitter? *American Geophysical Union (AGU) Blog* home page: <http://blogs.agu.org/sciencecommunication/2011/07/20/why-scientists-use-twitter/>. Accessed: 2016-06-10.

Vis, F. 2013. Twitter as a reporting tool for journalists. In: *Digital Journalism* 1(1):27-47.

The Wellcome Trust. 2000. Science and the public – a review of science communication and public attitudes to science in Britain. *Wellcome* home page: <http://www.wellcome.ac.uk/stellent/groups/corporatesite/@msh>. Accessed: 2016-08-12.

World Wide Worx staff. 2016. South Africa's social media landscape 2016. *World Wide Worx* home page: <http://www.worldwideworx.com/socialsa2016/>. Accessed: 2016-05-07.

Wu, B., & Shen, H. (2015). Analyzing and predicting news popularity on Twitter. In: *International Journal of Information Management* 35(6):702-711.

You, J. 2014. The top 50 science stars of Twitter. *Science* home page: <http://www.sciencemag.org/news/2014/09/top-50-science-stars-twitter>. Accessed: 2016-06-11.