Researcher Communication Strategies Via Twitter to Bridge the Knowledge Barrier Between Scientists and Citizens Amidst the COVID-19 Infodemic

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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In the face of the COVID-19 pandemic, access to accurate information is critical for promoting public safety practices, distributing critical resources, and sharing cutting edge research among scientific and community leaders. Only roughly 50% of published research articles are read by anyone outside of the authors, referees, and journal editors alone (Meho, 2007), highlighting the need for more accessible information sharing outside of traditional publications. Although researchers recognize the importance of information distribution to help the public "understand the nature of the threat and to develop new medical countermeasures," laboratories often enter periods of overdrive during which the demand to produce results overshadows the sharing of this information to the greater public (Elbe, 2017, 34). These contributors are consumed by their institutional responsibility to produce publications and earn funding, and as a result, stray away from their disciplinary responsibility to promote public health findings to the broader community.

Conversely, the excess of unreliable and inaccurate information has become a concern. According to the Director-General of the World Health Organization, "We're not just fighting an epidemic; we're fighting an Infodemic" or an overabundance of information that makes it difficult to access trustworthy, accurate data in the midst of uncertainty (Tangcharoensathien et al, 2020). In an Infodemic, information is spread to the public at a rapid pace with little fact checking or gate keeping, muddying the waters of decision making in public health practices and individual actions. This allows ill-informed and even malicious actors to produce and promote false information without proper scientific backing, only increasing the difficulty to share accurate, relevant scientific work to an external audience. This can prove deadly in the context of a pandemic, as this misinformation decreases adherence to preventative measures and creates life-

threatening rumors, such as the rumor that drinking highly concentrated alcohol could cure COVID-19, which led to over 5,800 hospitalizations and 800 deaths (Islam et al., 2020).

Although the COVID-19 Infodemic threatens the dissemination of critical public health information, the existence of rapid-sharing social media platforms like Twitter can serve as venues to alleviate this concern. Tangcharoensathien et al. (2020) note that these social media platforms "can help us gauge public sentiment towards different public health measures, analyze adherence to prevention approaches, develop effective public health campaigns, … and detect and combat misinformation". With almost 70% (Shearer et. Al, 2020) of the roughly 192 million active daily Twitter users (Twitter, 2021) using the platform as their primary source of news and information, the potential to reach millions of users with public health findings is quite clear. Thus, this thesis aims to determine the methodology and purpose behind researcher communication strategies via Twitter to bridge the knowledge barrier between scientists and citizens amidst the COVID-19 Infodemic.

The Methodology Behind these Researchers' Communications: Who Researchers Target, How They Engage the Audience, and the Tools at Their Disposal

Researchers use targeted tone and Twitter functionalities to communicate messages to groups across all levels of society.

Researcher communication strategies evolve depending on the target audience (Tangcharoensathien et al, 2020). These audiences can be defined as peer groups (other researchers in their respective, neighboring, or non-related fields) and out-groups (journalists, politicians, and civilians). Studies surveying researchers and conducting network analysis of their interactions suggest that researchers communicate frequently to both their own peer groups (Leiterce, 2010) and out-groups (Walter et al.,2019. Additionally, scientists with more popular, well networked profiles have greater interaction rates with the public (Letierce, 2010), suggesting

that they communicate more frequently with out-group audience members than lesser-known researchers. After establishing the targets of these scientific communication strategies, one can begin to break down how researchers communicate to these groups.

Public health experts carefully tailor the tone of their communications to different audiences. Scientists appear more likely to use negative, expressive, and colloquial language when addressing out-groups and more neutral language in addressing peers according to computerized text analysis with the LIWC dictionary (Walter et al, 2019). These findings establish the basis for how scientists deploy certain Twitter functionalities to achieve these respective tones and share their findings.

Researchers have an extensive tool belt to draw from in structuring their communications over Twitter. They utilize basic platform-specific functionalities including "retweets" and "quote tweets" in their daily communications to emphasize or expand upon relevant messages (Letierce, 2010), deploy visualizations extensively to translate complex concepts into digestible images, and use hashtags to associate their work with others and tie their work into the larger conversation (Letierce, 2010). Researchers also apply threading functionalities to communicate messages beyond the 141-character limit and condense full scientific literature into brief takeaways, deploy comments to connect and engage with peers and out-groups alike, and utilize link sharing to extend the knowledge presented beyond the characters available.

What's the Point? The Purpose Behind the Deployment of These Strategies

In investigating the means through which these strategies are deployed and the purpose behind them, one can begin to understand how and why scientists communicate effectively amidst widespread misinformation. The following analysis is conducted through a synthesis of existing literature to examine the motivations and implications of these communication strategies. Additionally, the twitter account of Linsey Marr's (@linseymarr), an expert in viral aerosol

transmission and the Charles P. Lunsford Professor at Virginia Tech (Virginia Tech, 2021), was examined over the past month (3/22/21 – 4/23/21) to pull relevant, concrete examples of these communication strategies amidst the COVID-19 Infodemic.

The Reason These Researchers Cast a Wide Net

One of the primary differentiators in scientific communication is whether the audience falls under peer groups or out-groups. Peer groups consist of other scientists familiar with the more complex, nuanced components of the research presented. Out-groups consist of journalists, politicians, and civil society, individuals predominantly unfamiliar with the technical topics at hand. In determining which groups scientists spend their time targeting, studies from Letierce (2010) demonstrated that in the context of a scientific conference, the majority of interviewed scientists communicated with the intent of sharing to their own community (89%), to reach students (52.2%) and technical audiences (50.41%), and to address a general audience (45.9%). While these findings suggest that scientific perception of social media communications in 2010 may have favored sharing among peers, the work of Walter et al. (2019) demonstrated that scientists actually address individual users (out-groups) as much if not more than they address their own peer groups. Their network analysis found that the "in-degree in all networks is either equal to or lower than the out-degree" (Walter et al., 2019), demonstrating researchers' eagerness to share findings outside of their own communities and suggesting that researcher perception of the benefits of social media may have changed. In tweets and replies from her Twitter account over the past month, Linsey Marr actively addresses ("mentions") both out-groups (16.3% of total tweets and replies) and peer groups (42.2%), demonstrating the effort she puts forth to engage with both audiences. Additionally, Marr offered on her Twitter account and hosted a Reddit "Ask Me Anything" with two peers to actively respond to any questions from curious civilians or other out-group members, further supporting her willingness to connect with the greater public.

Interestingly, Marr has clearly communicated with individuals in her field both publicly and privately, demonstrated by the prevalence of publications on her feed in which she has collaborated with the same researchers she retweets. This suggests that a substantial portion of communication between peer groups could occur outside of the public Twitter domain.

The purpose and reasoning behind these communications to different groups was also investigated. Scientists frequently communicate with peer groups for the purpose of collaboration (demonstrated by Marr), networking potential (Liertece, 2010), and to receive feedback and discuss results on the work they've completed (Darling et al, 2013). Researchers also have specific reasons for communicating their message to varying levels of the out-group. They target citizen groups to educate the broader public and to promote and affirm established scientific knowledge (Scheufele, 2014; Tsfati et al*.)*. Scientists target media outlets and journalists to foster positive public attitudes toward science and affirm established knowledge (Peters et al. 2008), and they target politicians to influence policy decisions and public health practices. By establishing why researchers communicate to these different audiences, a scientist new to sharing over social media can adopt target audiences based on their own personal motivation for sharing scientific knowledge.

Tone Matters: The Reasoning Behind these Tailored Strategies

Researchers employ a broad range of strategies related to tone and word choice in communicating with their target audiences. After analyzing emotions used in tweet content, Walter et al. (2019) suggest scientists are more likely to communicate with peers in a neutral tone (only 1.64% tweets using negative tone), whereas they are more likely to communicate with journalists (2.33% negative) and civic society (2.68% negative) in a more expressive, negative tone. With respect to politicians, scientists tend to communicate with more certainty (1.26% tweets expressing certainty) in their messages than towards journalists (1.16% certain) and civil

society (1.09% certain). These findings suggest that researchers intentionally deploy a more expressive tone in communications to out-group members than in messages to their peers.

The biological basis of the human attention span dictates the importance of communicating to these non-expert groups differently than peer groups. Since Twitter users are constantly bombarded with eye-popping visuals and attention grabs, scientists are constantly vying for attention through the platform, a "scarce resource" for any prospective audience member as "people are physically capable of paying attention to only a tiny fraction of their environment" (Lupia, 2013). A human's ability to pay attention is directly influenced by his or her working memory, which consists of a finite number of chunks that can be used to retain information for short periods of time (Lupia, 2013). As experts on a research topic are more familiar with the material at hand, they are able to process higher quantities of information in their working memory chunks than a non-expert audience member could in their own chunks. As other pieces of information are in constant competition for these limited number of non-expert chunks, these scientific messages should be displayed as "stimuli that a person perceives as being immediately relevant to their ability to achieve high-value aspirations or ward off significant threats," which are "far better positioned than other stimuli to win a person's attention" (Lupia, 2013). This establishes the need for an expressive and sometimes even negative tone when communicating to the non-expert out-group, as the more critical or relevant a communication comes across, the more likely the audience member will pay attention to it. However, scientists must do so carefully as "if audience members also see such information as threatening" then they will "devote mental energy to the production of reasons for discounting the relevance of, or ignoring, threatening information," counterproductively driving away the target audience (Lupia, 2013).

Scientists also deploy catered, purpose-driven tones towards journalists and politicians. The negative tone expressed in communications to journalists "might imply that scientists adapt to journalistic news factors such as negativity, or that they dramatize their findings in order to

promote them or to act as issue advocates" (Walter et. al, 2019). Scientists deploy a tone of certainty in their messages to politicians "in line with previous research suggesting that scientists do not mention the uncertainties associated with climate change when communicating in public" (Post, 2016). As the response to COVID-19, like the response to climate change, is politically polarized, scientists take measures to ensure that they only convey fact-based messages to their political audience to avoid messages taken out of context in the media and to provide little room for baseless discreditation.

While many researchers make active attempts to communicate in impassioned and tone specific ways, evidence suggests there is little relationship between the tone employed by an author over social media and how effective the message is in influencing the target audience (Bode et al., 2020). When exposed to corrections of misinformation over social media, viewers ended up doubting the misinformation following the correction regardless of tone employed as long as concrete facts were presented in the counter argument. This suggests that conveying accurate facts in scientific communications is the most important part of influencing reader perceptions, a strategy Linsey Marr takes to heart. She's been noted to "exude a sense of calm about managing risks" and mentions that "we could drive ourselves crazy thinking about all the what-ifs. I try to explain what we do know and what we don't know" and that "it's good to err on the safe side, but also to not be paranoid" (Parker-Pope, 2020). Marr relies on the facts to speak for themselves, and strives to ensure she can present these facts in an easily interpretable way.

Marr employs a more colloquial, relatable tone in her communication to out-groups, and as many have acknowledged "part of the reason Dr. Marr has become so popular in public forums is her ability to explain difficult scientific concepts in easy-to-understand terms" (Parker-pope, 2020). Marr relies on simple metaphors and anecdotes to convey complicated concepts related to airborne virus transmission. She draws upon the example of smoking a cigarette to explain viral plumes, compares the concept of Brownian motion in masks' particle filtration to a drunk person

stumbling into chairs and tables at a bar, and utilizes complex mathematical models to establish safe strategies for hugging, and then shares personal images of hugging her daughter in various positions to express the risk and convey her findings (Parker-Pope, 2020). In going beyond pure discovery of scientific knowledge to creatively communicate findings in an easily interpretable way, Marr's strategies set an example for any researcher to follow in disseminating critical and complicated scientific findings to a broader audience. These observations and analyses demonstrate that researchers can utilize tone to capture audience attention, but must rely on the facts they portray, communicated simply, to effectively convey the scientific knowledge.

The Function of the Functionalities: Implications of Different Twitter Tools

Researchers frequently deploy retweets and quote tweets, visualizations, and hashtags to convey their messages.

Retweets and quote tweets seem to set themselves apart as widely renowned, popular, and effective functionalities used to communicate scientific findings. In Marr's recent Twitter activity, she has used retweets and quote tweets in 83% of her seventy-six total tweets to promote and build off the work of her peers, share her own work (34% of tweets related to her own papers, interviews, events), share relevant, cutting-edge publications (32% of tweets), and promote reputable media articles regarding airborne spread of COVID-19 (38% of tweets). As demonstrated by Marr's activity and included in the established motivations, scientists deploy retweet and quote tweet functionalities to promote the work of others in their field and increase overall public knowledge surrounding these topics. Scientists also utilize these functionalities to promote their own personal work, as there is a direct correlation between the number of times a piece of literature is retweeted and the number of citations that literature receives (Klar et al., 2020). While this may not directly contribute to the altruistic component of sharing scientific research with the greater community, it can serve to further establish this individual in the circles

of academia and ultimately allow them to increase their sphere of influence to promote knowledge to a larger audience.

Visualizations are at the forefront of modern communication strategies, particularly over social media. In Marr's account alone, 37% of her tweets over the last month have included an explanatory visualization to aid in communicating scientific knowledge. Instead of bombarding audience members with complicated formulas and terms, she's emphasized and deployed easily interpretable graphics, allowing the lay reader to interpret more at a first glance. Visualizations are becoming popular because they are "a common universal language that breaks through language barriers, allowing for more effective and efficient scientific communication" (Nayak et. al, 2019). The benefits of visualization have also been broken down into four broad themes including providing access to spatial and non-spatial complex information, enhancing cognition and allowing for a deeper understanding by invoking visual thinking, facilitating communication through dissemination of information and persuasion, and improving the memorability of these messages in comparison to traditional verbal representation (Nayak et. al, 2019). These findings suggest that researchers across all fields should deploy visualizations in their communication strategies, especially in the context of a global public health crisis.

Hashtags also play a role in sharing scientific communications via Twitter. Marr and her colleagues employ hashtags in their messaging (12% of tweets) with particularly relevant hashtags appearing more than others (#COVIDisAirborne 3 times and #COVID19 twice). Letierce (2010) found that the primary motivations for using hashtags include incorporation into a larger scientific conversation, associating their messages to with similar tweets, and increasing the visibility of their messages for those interested. However, it appears hashtags have taken a backseat in the conversation of powerfully descriptive functionalities as some scientists don't see them as an effective way to promote findings (Letierce, 2010), which is likely why they've been deployed so infrequently by Marr and her colleagues.

While the aforementioned tools were the predominant functionalities deployed in Marr's and related accounts, individuals also use tweets to promote live conferences and events (8% of Marr's tweets), use comment threads to share more detailed literature findings (17%), and use other widely accepted tools like emojis to promote tone and relate to their user base.

These findings pinpoint ways to communicate effectively to peers and the greater public in the midst of an Infodemic, guiding scientists to deploy a proven communication framework so they may focus primarily on active research and the production of knowledge.

Let's Recap: What We've Learned So Far and Why it Matters

This analysis has established that researchers communicate with experts and non-experts in specific ways for specific purposes. Researchers communicate with peers in their field over Twitter in a neutral tone predominantly using retweet and quote tweet functionalities to promote one another's work, collaborate on relevant research topics, and bolster their internal and external network within the scientific community. They communicate with non-experts in expressive, sometimes negative, and easily-interpretable tones primarily using visualizations and metaphors to promote general public health knowledge for the common good, increase public interest in science, and empower decision makers with accurate and relevant information. These findings establish a basis for effective scientific communication to reach a massive audience over one of the world's most popular social media platforms.

These findings can be incorporated into the greater conversation of the importance of scientific communication. Similar to the issues presented by the COVID-19 Infodemic, the "communication gap is easy to see in many current public debates involving the climate crisis, vaccination, and transgender individuals' existence, among others" in which these "public scientific debates have real life-and-death consequences" (Abraham, 2020). While politicians and community leaders are often charged with setting agendas and promoting guidelines in the

response to the ever-present pandemic, the work of public health experts and researchers in relevant fields drives many of the decisions and policies made. Thus, by pinpointing ways to effectively alleviate this knowledge gap, society can overcome these struggles, foster knowledge creation across all parties, and ultimately address significant public health concerns. The communication strategies presented above can also be adopted directly by these community leaders to communicate their own messages, increase public outreach, and effectively utilize the digital presence that citizens and individuals increasingly maintain.

Researchers must also bear in mind the inherent power and ethical responsibility they have in distributing these findings. They play a prominent role in the dissemination of information and shaping of human values, two cornerstone pillars of ethical technical assessment (Palm et al., 2006), and as a result their actions have significant societal implications. Through communicating findings relevant to a monumental event in global history, these scientists convey extremely critical information that impacts the way citizens carry on in their daily lives and perceive the lives of those around them. As the pandemic has been at the forefront of recent memory regarding individuals' perception and decision making since March, 2020, the ways citizens observe social distancing measures, behave in public, and perceive the behavior of others are often direct reflections of the values they live by. In learning more about the pandemic and how one should carry themself (or feel they should carry themself), core values (care for others, patience, care for oneself, social nature, external perception) are often tested, and in some cases even modified. It is in this potential for value modification that the success of these researchers' communication styles has serious implications with regard to impacting human values, and the overall sharing of critical information and findings.

Several limitations exist within the work presented including how well these communications are received by the public, inequitable access to technology, and the typical usage of the Twitter platform itself. Apart from acknowledging the success of presenting concrete

facts to influence audience perception, this analysis only scratches the surface of how presented knowledge is received and how the beliefs and actions of the reader are impacted. While one can make the assumption that the strategies deployed are effective to a certain degree, this paper does not quantify how effective these messages are in changing the beliefs of perceptions of the reader. This work is also limited in scope because a small portion of the greater society has access to a reliable internet connection, thus inherently excluding them from the share of scientific knowledge via Twitter. Many mainstream topics and points of conversation on Twitter revolve around social phenomena, comedy, entertainment, and other more "appealing" offerings likely to draw the attention of mainstream platform users and inherently make it more difficult for scientific findings to reach the greater public. Additionally, the ease of sharing information via Twitter allows the promotion of misinformation, and therefore ill-informed or malicious use sof the platform contribute to the Infodemic. Thus, while sharing knowledge over Twitter can be seen as a partial solution in the context of information sharing, is it not a perfect solution to the problem at hand.

This synthesis of existing research backed by recent and relevant examples from Marr, a researcher at the forefront of knowledge sharing during the COVID-19 Infodemic, presents an effective approach to scientific communication across all user groups of Twitter. An extension of this work could include further research into the efficacy of these strategies to determine how target audience beliefs and actions are impacted by these communications. In taking the next steps to actively educate researchers worldwide on how to effectively use Twitter, a monumental share of information from experts to non-experts could quickly follow suit and break down the knowledge barrier we experience today.

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