Competition Dynamics in the Meme Ecosystem

Trenton Ford, Rachel Krohn, and Tim Weninger
Department of Computer Science and Engineering
University of Notre Dame
{tford5, rkrohn, tweninger}@nd.edu

Abstract

The creation and sharing of memes is a common modality of online social interactions. The goal of the present work is to better understand the collective dynamics of memes in this accelerating and competitive environment. By taking an ecological perspective and tracking the meme-text from 352 popular memes over the entirety of Reddit, we are able to show that the frequency of memes has scaled almost exactly with the total amount of content created over the past decade. This means that as more data is posted, an equal proportion of memes are posted. One consequence of limited human attention in the face of a growing number of memes is that the diversity of these memes has decreased at the community level, albeit slightly, in the same period. Another consequence is that the average lifespan of a meme has decreased dramatically, which is further evidence of an increase in competition and a decreasing collective attention span.

Introduction

With the rise of social media platforms, the cost historically associated with producing and consuming information has decreased to unprecedented levels; users and organizations can easily share their thoughts, stories, and others’ content with diverse and widespread audiences with very little effort. Due to the ease of production, the volume of content produced has increased to the point that any individual user can only see a small portion of what is available. The reduction in content production cost and increase in availability has induced a change in scarcity dynamics: from content scarcity to consumer scarcity [30]. This shift in scarcity has birthed new research areas to help users see relevant content – such as recommender systems – as part of the broader attention economy [27].

The attention economy seeks to explain the allocation of cognitive resources in the creation and consumption of information. Though this concept existed long before the advent of social media [29], recent work has focused on how this model governs the dynamics of content consumers and curators in the socio-digital space [8, 9]. The main focus has been on the consumption of information [34, 36, 12], but others focus on the production and curation of information [4, 17, 10, 28, 13].

One of the primary questions at the center of online social media is this: how does the limited attention of users shape the information landscape?

One particularly compelling subset of the information landscape is the production and resharing of compelling memes, which are short phrases and images. For example, the image in Figure 1 is a meme with text that is meant to be condescending to the subject; oftentimes, the text of the meme is independent of its image and is written in plaintext in comments and tweets. The dynamics of these viral messages are not well understood despite widespread attempts to predict and simulate their spread or popularity [3, 1]. Yet this narrow subset of the information landscape is an increasingly visible and influential communication mode with exciting properties. A meme’s popularity can be quantified by how many times it is reproduced or shared, how long it stays relevant, and how many times it is mutated – in the case of meme images.

Intuition about how memes are created, transmitted, consumed, or mutated are often derived from their association with genes and the process of gene evolution [5] and more recently, memes have been considered through the lens of epidemiology and disease transmission [33, 16]. Indeed, its etymology is a portmanteau of mind+gene, which begs the question: rather than continuing the economic analogy, are memes better situated in the realm of ecology? And if so, what kind of understanding can be gleaned from this perspective?

In the present work, we derive findings about competition
and diffusion of information from the ecological perspective. There are many compelling examples that motivate this perspective. Foremost is the concept of competition, which is a driving force in genealogical, economic, epidemiological, and ecology fields [22]. In analogical terms, the goal of competing memes is their continued existence within the minds and communication patterns of people. Survival, therefore, follows as a natural extension of competition, which presumes that memes are designed with survival in mind [35, 17].

The differences between the ecological perspective and others are nuanced. Fundamentally, each perspective offers a unique interpretation of information dynamics. For example, within the economics perspective, human behavior (e.g., attention) is the primary focus, and memes just one of many possible factors. From an epidemiological perspective, memes are treated as a contagion (e.g., a virus), but epidemiological models typically do not consider landscapes with multiple viruses and their interactions. The genealogical perspective treats memes as genes and explores gene-gene interactions, but the gene perspective does not natively consider gene-environment interactions.

In taking the ecological perspective, we consider a meme to be a single species existing within the same environment or habitat. The ecological perspective shifts the focus away from the human users and back to the memes and the environments they exist within – wherein memes seek both longevity and a large population, competing for limited environmental resources – human attention.

Within the perspective of the **meme ecology**, we ask the following research questions:

**RQ1**: How does the collective user attention scale? Do more users permit a larger or smaller number of memes?

**RQ2**: How do memes compete for attention? How does the introduction of a new meme impact the ecosystem of existing memes?

**RQ3**: How have the dynamics of collective attention changed over time?

In summary, by using well-known metrics and concepts from ecology, we perform an ecological analysis of the dynamics of text-memes on Reddit. The results of this analysis and the behavior they suggest are compelling and strongly support the case for the ecology of memes. We find that memes comprise a relatively constant fraction of all activity on the platform, even as social media increases in popularity. This suggests that as more memes are created their lifecycle duration becomes shorter, which further suggests that the collective human attention span on social media is decreasing.

Although the current work focuses on short, frequently repeated texts, i.e., memes, we further hypothesize that our findings are likely to apply to a number of other communication modalities like image-memes and hashtags.

---

### Data Collection

Using a comprehensive dataset of the 352 most popular memes from KnowYourMeme.com, we identified their individual occurrences on Reddit. The memes were selected from the Confirmed category on KnowYourMeme, and include text-based memes that ranged from 250 thousand to 13 million page views each. Note that the tracking of rapidly-evolving image templates is outside the scope of the present work; therefore, image-memes are not included in this analysis. Extended meme text (e.g., copypasta) is truncated to include only the 8-token prefix. The final set contains meme-phrases that range in length from 1 to 8 tokens. Some memes reference current pop-cultural events, while others seem unconnected to trends of the time.
The questions raised in the present work are considered human subjects research, and relevant ethical considerations are present. We sought and received research approval from the Institution Review Board of redacted.

Collective Attention to Memes is Stationary

Previous work has shown that innovation and technological development is accelerating. Moore’s Law is one example of this phenomenon where a compounding increase in circuit density has led to remarkable increases in computational power [26]; similar effects have been shown in genome sequencing [21] and telecommunications bandwidth [6]. In online social systems, the early empirical evidence suggests that a similar pattern exists: that social innovations are accelerating [18, 24, 14, 25].

This is the basis for RQ1: How does collective user attention of memes scale? Does the presence of larger groups result in super-scaling effects like those found in population densities [25] and software development [32] where collections of individuals produce more than the sum of their parts?

At first glance, Figure 2 appears to show that our data supports these claims: more posts, comments, and memes are being made at an accelerating pace year over year. But how much attention is paid to individual memes? To answer this question, we first need to measure collective attention.

Measuring Collective Attention

Because we cannot collect the number of users who viewed or thought about a particular meme, instead, we estimate the collective attention for each meme by the number of times it appears, i.e., its frequency. So our first task is to extract the daily frequency $F_m(t)$ of each meme, such that $F_m(t)$ is the frequency of meme $m$ on day $t$. Given the scale variance of social media sites, simply counting tokens would be insufficient to fully determine whether memes are truly increasing in prevalence or if their frequency increases mirror the increase in content that Reddit has experienced overall. In order to produce as accurate assessment of the meme ecology, we need to carefully normalize the frequency of meme occurrences.

To do this, we constructed a set of 5000 randomly selected words from Reddit to serve as a background language model. Then, for each day, we count the number of occurrences of each token in the background set, such that $B(t)$ gives the background sum of all 5000 words on day $t$. As the number of posts and comments on Reddit grows over time, so do the occurrences of the background set. As seen in Figure 2, the background growth closely mirrors the growth of Reddit.

Likewise, we expect the number of meme occurrences to increase at a similar rate. In order to control for the growth of Reddit over time we compute the normalized meme-frequency for each meme $F_m(t) = F_m(t)/B(t)$.

Figure 3 illustrates the mean average normalized meme-frequency along with its 95% confidence interval from 2010 to 2020. A selection of individual memes are also plotted in light grey. We find that the occurrence of memes remains remarkably consistent when controlled for Reddit’s overall activity, even as the occurrence of individual memes varies widely. Correlation analysis finds almost no association between time and the normalized meme-frequency (Pearson $R = +0.03$, $p$-value $<0.01$).

Competition for limited attention is not a new concept in socio-digital media studies. However, much of the previous analysis has focused on network-level simulation or mathematical modelling as an attempt to predict the behavior of large social systems [14, 7]. User-level attention analysis seeks to understand the impact of competition and content volume on individual actors [12]. Other work attempts to determine which features will make a meme successful within a competitive environment [1, 2]. These works are valuable extensions of the classic attention economy, yet fail to demonstrate the system-wide effect of competition. By showing that meme activity accounts for a stable fraction of all Reddit content, we have demonstrated the ability for competition to act as a kind-of global bandwidth cap. Even with a rapidly expanding user base, and a seemingly insatiable hunger for fresh content, Reddit appears only to sustain a relatively limited population of memes.

Competition Among Memes

The prevalence of individual memes rises and falls over time. Popularity is fleeting, but as a meme dies out, another always seems to rise to take its place. The ebb and flow of what is or is no longer popular has long been studied as the diffusion of innovations [7]. The study of the production and evolution of innovations (e.g., new ideas, behaviors, memes, and other information patterns) has recently become particularly com-
pelling because of the availability of vast amounts of human behavior happening through online social platforms.

The dynamic behavior of memes, in particular, suggests that these ideas exist in constant competition with one another. The competition among memes is not unlike competition observed in markets, where innovations eventually replace outdated products, or ecological systems, where competition among individuals in a group exerts a selective pressure that rewards certain genetic innovations.

Continuing the ecological analogy, one way to assess the health of an ecological system is to examine the diversity of the species living within the system. From this perspective, the ecology of a social media environment ought to have several different memes simultaneously appearing in abundance. This leads us to RQ2: How do memes compete for attention? Specifically, as Reddit grows and new memes are introduced, does the overall diversity increase or decrease?

One way to measure the diversity of an ecological system is with Simpson’s Diversity Index \( D \) \[^{[11]} \]. This index takes into account both the number of species present, as well as the population of each species. It is formally defined as:

\[
D = 1 - \left( \frac{\sum_{i=1}^{R} n_i(n_i - 1)}{N(N-1)} \right)
\]

(1)

Where \( R \) is the total number of species in a community (numbered 1 through \( R \)), \( N \) is the total number of organisms, and \( n_i \) is the number of individuals belonging to species \( i \). For our purposes, we consider a subreddit to be a community, each meme as its own species, and each meme occurrence as a species entity. \( D \) ranges from 0 to 1, where 0 indicates no diversity and 1 indicates infinite diversity.

We compute the Simpson’s Diversity Index for each subreddit in each month. We then compute the average monthly Simpson Diversity across all subreddits, resulting in a monthly average diversity of Reddit at the community level. Figure 4 shows the average diversity and 95% confidence intervals over time. Overall, the diversity of Reddit communities appears to be decreasing at a small (0.48% per year) but steady rate (Pearson \( R = -0.63 \), p-value < 0.001).

This indicates that subreddit communities, on average, are using slightly less diverse meme subsets. This finding, coupled with the growth in the number of subreddits using memes, suggests a slow Balkanization of Reddit communities. That is to say, as more subreddit communities come into existence, human attention – and the memes which that attention supports – moves towards more niche subreddits, which aligns with findings from other subreddit analysis \[^{[20]} \].

Innovative Communities

Ecological research focuses on the environments in which species exist; the communities and biomes that spawn new species are often the focus of study because they can host exotic species along with high levels of species diversity \[^{[19]} \]. The same is true in social media, where the study of the creation and diffusion of innovations within social environments is a central topic of research. The detection and analysis of highly innovative communities are of great interest in this line of work \[^{[15]} \]. As a direct consequence of our findings in RQ2 we further ask: Are there certain communities that consistently introduce new memes? These meme-nurseries are the places where many new linguistic and cultural innovations are born and cultivated. We further ask: do these innovative communities persist over time, or is their high-innovation only temporary?

To answer these questions, we first define a meme entry event as the first time that a meme is used within the Reddit ecosystem. The subreddit in which it first appears is defined as the landing space or beachhead for the new meme. From an ecological perspective, a new meme is analogous to new species, and subreddits are the host habitats. Because Reddit itself exists within the even larger environment of the social internet, tracing the true spread of a meme between specific communities is intractable. For this reason, it is necessary to consider that a single meme may have multiple beachheads within Reddit.

Under these circumstances, we elect to rank subreddits based on the order in which a meme first appears; this methodology reasonably controls for the uncertainty about which community was first, second, etc., to articulate the innovation. We constrict our analysis to the first 1000 subreddits to use each meme. Based on this ordering, we compute the mean reciprocal rank (MRR) of each community with respect to each of our 352 memes. These MRR values consider the rank for each subreddit for each year in the dataset. The top 10 most innovative subreddits in the odd-numbered years (due to space constraints) are given in Table 2.

It is clear that certain subreddits contribute a disproportionate number of new memes to Reddit. The colors in Table 2 represent the top 10 subreddits from all 10 years combined. It is unclear why these subreddits are more innovative than others, but there may be conditions within these particular communities that increase their ability to produce viral content more regularly than others. No matter the cause, optimal meme-
Table 2: Top 10 most innovative subreddits by year. Colored subreddit names show the top 10 most innovative subreddits from 2010 to 2020 in aggregate.

nursery conditions appear to be transient, as subreddits can be highly innovative one year, and not the next.

There are a few conclusions to be drawn here. Early in Reddit’s history, massive and highly contributive subreddits – like /r/reddit.com and /r/AskReddit – were the primary beachheads for new memes. However, as years progressed the set of top contributing subreddits became less consistent. Each new year comes with new meme beachheads.

We quantify the degree of change in subreddit ranks by computing Kendall’s ($\tau$) coefficient between consecutive years. Larger $\tau$ values indicate more similarity, smaller $\tau$ indicates less similarity, and a negative $\tau$ represents dissimilarity. Figure 5 illustrates $\tau$ for each pair of years where solid bars represent $p < 0.01$ and hollow bars vice versa $p > 0.05$; there were no $p$-values between 0.01 and 0.05. Until the 2017/2018 pairing the rank correlation trended downward, indicating increased turnover in the topmost innovative subreddits.

The 2017 to 2018 evaluation showed a return to high-rank correlation, indicating less change in the top-ranked subreddits. There are a few potential explanations for this behavior. First, this may be due to a major Reddit policy change: beginning in June 2017, Reddit removed the default subreddits, which included many /r/pics, /r/funny, and many of the other most innovative subreddits, and instead introduced /r/popular, which was a mix of posts from various subreddits as a means to expose new users to a wider variety of communities. This change essentially means that users “subscribe” to a wider variety of subreddits by default, providing a greater opportunity for innovations from niche subreddits to become more easily accessed. Another potential explanation for this trend reversal is due to the fact that the meme set used for our analysis is biased towards more popular, and therefore older, memes. Memes created during the last years of our analysis window are less likely to have become popular enough to appear in our top-memes dataset. This may result in fewer meme entries in more recent years.

Figure 5: Kendall’s rank correlation coefficient ($\tau$) of subreddit innovation rankings for pairs of consecutive years. Solid bars represent $p < 0.01$ and hollow bars represent $p > 0.05$. Subreddits that consistently use new memes before other communities are ranked higher, but rankings change each year. A higher $\tau$ means more correlation between year-pairs, while lower indicates more change in their relative rankings. In general, subreddit beachhead rankings have become less stable, indicating greater turnover in the top subreddits.

Changing Dynamics of the Meme Ecosystem

Now that we have established some of the consequences of the competition of memes in a social media ecosystem, we turn our attention towards the dynamics of collective attention. Existing recent work suggests that these dynamics are accelerating [18], that is, new concepts are becoming viral faster and stay viral for a shorter duration. Instead of focusing on specific cultural artifacts like memes, the previous work on general collective behavior focused on hashtags on Twitter, comments on Reddit, and n-grams in books, etc. Does this acceleration hold true for memes? This is the basis for RQ3: How have the dynamics of collective attention on memes changed over time? Are we cycling through memes faster than we were a few years ago?

While we find this to be true in some ways, it is not true

[https://www.reddit.com/r/announcements/comments/6eh6ga/reddits_new_signup_experience/](https://www.reddit.com/r/announcements/comments/6eh6ga/reddits_new_signup_experience/)
Investigating Meme Dynamics

Lorenz-Spreen et al. [18] used a variety of methods to analyze collective dynamics in the online social sphere. Here, we apply their methodology to our meme dataset.

First, we focus on the peaks of memes on Reddit to assess the pace of collective attention. For each meme, we compute its frequency across all of Reddit each day, such that $F_m(t)$ gives the frequency of meme $m$ on day $t$. We also identify the peak frequency for each meme $F_{m\text{peak}}$ and when this peak occurred. To ensure all memes are on the same scale, the frequencies of each meme are then normalized by that meme’s peak to get a relative meme-frequency: $R_m(t) = \frac{F_m(t)}{F_{m\text{peak}}}$.

In Figure 6(A), we illustrate the average relative peak frequency $\overline{R_m}$ for all memes in our dataset and group by the year of each meme’s peak. Overall, there appears to be no change in peak dynamics over time. The difference between the peak and the baseline frequency (i.e., frequency before and after the peak) remains relatively stable, nor does it change a statistically significant amount from year to year. Furthermore, the changes seen do not show a trend over time. This suggests that memes have not exhibited a significant acceleration over the past decade.

Next, we look closer at the velocities of memes. For each meme we compute relative gains $\Delta F_m = \frac{F_m(t) - F_m(t-2)}{F_m(t-1)}$ and relative losses $\Delta L_m = \frac{F_m(t) - F_m(t+1)}{F_m(t)}$. We analyze the distributions of gains and losses of all memes at all times, grouped by year. Both distributions fit well to a log-normal distribution. Gains and losses are shown in Figure 6(B). While we observe some shift in gains and losses with small magnitudes, the larger velocities do not change significantly or regularly across years.

Taken together, both of these analyses indicate that once the growth of Reddit is controlled for, the collective dynamics of Reddit memes have not accelerated. Rather, meme dynamics have remained remarkably consistent, even surrounding its peak.

Meme Lifespans are Shrinking

The previous analysis raises another interesting question about the collective dynamics of memes: Are meme lifespans growing or shrinking?

To answer this question we define the lifespan of a meme as follows. For a meme with a peak frequency of $F_{m\text{peak}}$, the lifespan begins on the first day $u$ where $F_m(u) \geq \alpha F_{m\text{peak}}$. Recall that $\hat{F}_m(t)$ is the normalized meme-frequency and is computed as $\hat{F}_m(t) = \frac{F_m(t)}{F_{m\text{peak}}}$. The lifespan ends on the last day $v$ where the frequency experiences a normalized frequency $\hat{F}_m(v) \leq \alpha \hat{F}_m(t_{\text{peak}})$, such that all days between the beginning, peak, and the end are continuous and above $\alpha \hat{F}_m(t_{\text{peak}})$. The threshold value $\alpha$ is very small; here we present results for $\alpha = 0.005, 0.01, \text{and } 0.02$. Other values produced similar results.

By defining the lifespan this way, each meme’s lifespan captures the majority of its occurrence, but does not include very early, late, or anomalous uses. The lifespan is also determined using normalized meme-frequencies to control for Reddit growth. We compute the lifespan length in number of days for each meme. For a threshold of $\alpha = 0.005$, these lifespans range from a high of 4140 days to a low of 1 day. (For completeness, we include the full history of Reddit beginning in 2005 when defining lifespans.)
Based on this definition, we consider a meme as active on all days contained within its lifespan. On any single day within our analysis window, there may be many active memes. Figure 7(A) illustrates the number of memes active within each month. As expected, the number of active memes has increased over time.

To more accurately assess the number of active memes, it is important to control for Reddit’s growth. Figure 7(B) shows the normalized count of active memes, i.e., the number of active memes per month divided by \( B(t) \). With this normalization applied, it is apparent that over time, the relative number of active memes is decreasing. This decrease in the normalized number of active memes occurs despite our finding that normalized meme-frequency has remained stable (Figure 3). The most likely explanation for these contrasting findings is that the lifespan of memes is decreasing.

We can test this hypothesis directly by computing how lifespans have changed over time. Figure 7(C) plots the average meme lifespan and 95% confidence interval in days for the active memes within each month. For example, if there were 40 memes active in June 2012 and the mean-average lifespan of these 40 memes was 2,400 days, then we would plot 2,400 for June 2012 (and the confidence interval). The lifespan is heavily dependent on the \( \alpha \) threshold. So, we repeat these calculations for \( \alpha = 0.005, 0.01, \) and 0.02. In all cases, we found that the average lifespan decreased over time (\( \alpha = 0.005: \) Pearson \( R = -0.85, p\text{-value} < 0.01; \alpha = 0.01: \) Pearson \( R = -0.77, p\text{-value} < 0.01; \alpha = 0.02: \) Pearson \( R = -0.59, p\text{-value} < 0.01), indicating that memes are cycling faster.

Simply put, memes are rising and falling more quickly now than in the past.

To recap: the relative fraction of Reddit focused on memes has not changed over time (Figure 3), the meme diversity of subreddits has decreased (Figure 4), and the relative number of active memes has declined (Figure 7(B)). These results indicate that the production and consumption of new memes are accelerating. There is simply not enough attention to go around. As fast as new content is created, old content must be forgotten. Given the increasing volume of content on Reddit every day, the necessary consequence is that the collective attention span of Reddit is decreasing.

An exception to this rule can be found in long-lasting memes, many of which live beyond the end of our data analysis window. For example, the meme ‘cool story bro’ is still active on the last day of 2019, following an extended lifespan beginning in 2009; this is true for all \( \alpha \) values tested. These long-lasting memes have transcended their origins and evolved from memes into slang, maintaining a consistent presence even as Reddit grows, and other memes come and go. However, despite their seemingly ‘undying’ status, these durable memes must still compete for attention within the broader ecosystem.

In a content-consumption system driven by user attention, memes are forced into competition with one another for scarce...
attention. As collective attention decreases, memes appear to rise and fall at an accelerated rate. In a system that favors the newest, freshest content, no meme is immortal.

Conclusions

The three research questions in the present work coalesce into an emerging theory of meme dynamics in online social bulletin boards like Reddit. Taking an ecological perspective, we have shown that although Reddit as a whole continues to grow, the fraction of Reddit devoted to text memes is consistent. This reinforces the notion of a meme ecology, which, like the economic and epidemiological perspectives of information diffusion, has consequences that derive from limited user attention.

We have also shown that the diversity of memes across communities is decreasing slightly, even as the number of communities continues to grow. This represents yet another consequence of the ecological perspective: as social media communities continue to Balkanize, i.e., split into narrow and self-referential communities, the number of shared references to memes appears to be decreasing.

The competition among memes is also evident in the increasing turnover of beachhead communities. As memes fight for user and subreddit attention, cycling in and out of collective attention faster, large and general communities are unable to consistently integrate new memes before other smaller communities. Instead, subreddits may rise to the top if they happen to introduce the meme-of-the-moment, only to quickly fade into obscurity.

Finally, we have shown that meme lifespans have decreased significantly. Yet, unlike similar work on general n-grams, hashtags, citations, etc., we do not find that all aspects of meme dynamics are accelerating, and even the accelerations are bounded by the effect of increasing competition for limited user attention. The patterns of relative meme growth, even surrounding a meme’s peak, remain relatively unchanged by the expansion of Reddit. And although the absolute number of memes active on Reddit has increased over time, this growth has been outpaced by the growth of Reddit itself.

It is important to recognize the limitations of this study. Our evaluation is principally limited by the KnowYourMeme dataset. Because the popularity metric is accumulative on KnowYourMeme, it is likely that newer memes, which have not yet accumulated their full/final popularity, are less likely to appear in our dataset. Our focus on the textual artifacts of memes may also limit the generalizability of our findings. Much of the online meme culture, especially recently, is conveyed through visual depictions of memes [31]. We necessarily assume that textual representations of visual memes follow proportionately, but we are unable to validate this claim in the current work. Future work should endeavor to confirm these findings on visual imagery. Finally, the present work used a strict text-matching algorithm to identify memes. Additional follow-up work is needed to better understand and trace how these memes evolve and how the shape of a meme’s popularity and evolution affects its lifespan and reach.

Acknowledgements

We would like to thank Satyaki Sikdar for his help preparing this manuscript. This work is funded by the US Army Research Office (W911NF-17-1-0448) and the US Defense Advanced Research Projects Agency (DARPA W911NF-17-C-0094).

References

[1] Competition and success in the meme pool: a case study on quickmeme.com, volume 7, 2013.

[2] What’s in a name? understanding the interplay between titles, content, and communities in social media, volume 7, 2013.

[3] Jim Blythe, John Bollenbacher, Di Huang, Pik-Mai Hui, Rachel Krohn, Diogo Pacheco, Goran Muric, Anna Sapienza, Alexey Tregubov, Yong-Yeol Ahn, et al. Massive multi-agent data-driven simulations of the github ecosystem. In International Conference on Practical Applications of Agents and Multi-Agent Systems, pages 3–15. Springer, 2019.

[4] Giovanni Luca Ciampaglia, Alessandro Flammini, and Filippo Menczer. The production of information in the attention economy. Scientific reports, 5:9452, 2015.

[5] Richard Dawkins. The selfish gene. Oxford university press, 2016.

[6] Charles A Eldering, Mouhamadou Lamine Sylla, and Jeffrey A Eisenach. Is there a moore’s law for bandwidth? IEEE Communications magazine, 37(10):117–121, 1999.

[7] James P Gleeson, Jonathan A Ward, Kevin P O’sullivan, and William T Lee. Competition-induced criticality in a model of meme popularity. Physical review letters, 112(4):048701, 2014.

[8] Maria Glenski, Corey Pennycuff, and Tim Weninger. Consumers and curators: Browsing and voting patterns on reddit. IEEE Transactions on Computational Social Systems, 4(4):196–206, 2017.

[9] Maria Glenski, Greg Stoddard, Paul Resnick, and Tim Weninger. Guessthekarma: a game to assess social rating systems. Proceedings of the ACM on Human-Computer Interaction, 2(CSCW):1–15, 2018.

[10] Maria Glenski and Tim Weninger. Rating effects on social news posts and comments. ACM Transactions on Intelligent Systems and Technology (TIST), 8(6):1–19, 2017.

[11] Hans-Rolf Gregorius and Elizabeth M Gillet. Generalized simpson-diversity. Ecological Modelling, 211(1-2):90–96, 2008.
[12] Nathan Oken Hodas and Kristina Lerman. How visibility and divided attention constrain social contagion. In 2012 International Conference on Privacy, Security, Risk and Trust and 2012 International Confernece on Social Computing, pages 249–257. IEEE, 2012.

[13] Bernardo A Huberman, Daniel M Romero, and Fang Wu. Crowdsourcing, attention and productivity. Journal of Information science, 35(6):758–765, 2009.

[14] Brett Hutchins. The acceleration of media sport culture: Twitter, telepresence and online messaging. Information, communication & society, 14(2):237–257, 2011.

[15] Nina Kolleck. Social network analysis in innovation research: using a mixed methods approach to analyze social innovations. European Journal of Futures Research, 1(1):25, 2013.

[16] Masao Kubo, Keitaro Naruse, Hiroshi Sato, and Takashi Matubara. The possibility of an epidemic meme analogy for web community population analysis. In International Conference on Intelligent Data Engineering and Automated Learning, pages 1073–1080. Springer, 2007.

[17] Jure Leskovec, Lars Backstrom, and Jon Kleinberg. Meme-tracking and the dynamics of the news cycle. In Proceedings of the 15th ACM SIGKDD international conference on Knowledge discovery and data mining, pages 497–506, 2009.

[18] Philipp Lorenz-Spreen, Bjørke Mørch Mønsted, Philipp Hövel, and Sune Lehmann. Accelerating dynamics of collective attention. Nature communications, 10(1):1–9, 2019.

[19] Robert H MacArthur. Patterns of species diversity. Biological reviews, 40(4):510–533, 1965.

[20] Nahema Marchal. The polarizing potential of intergroup affect in online political discussions: Evidence from reddit r/politics. Available at SSRN, 2020.

[21] Elaine R Mardis. A decade’s perspective on dna sequencing technology. Nature, 470(7333):198–203, 2011.

[22] Asaf Nissenbaum and Limor Shifman. Internet memes as contested cultural capital: The case of 4chan’s/b/board. New Media & Society, 19(4):483–501, 2017.

[23] Wei Pan, Gourab Ghoshal, Coco Krumme, Manuel Cebrian, and Alex Pentland. Urban characteristics attributable to density-driven tie formation. Nature communications, 4(1):1–7, 2013.

[24] Hartmut Rosa. Social acceleration: ethical and political consequences of a desynchronized high–speed society. Constellations, 10(1):3–33, 2003.

[25] Hartmut Rosa. Social acceleration: A new theory of modernity. Columbia University Press, 2013.

[26] Robert R Schaller. Moore’s law: past, present and future. IEEE spectrum, 34(6):52–59, 1997.

[27] Carl Shapiro, Shapiro Carl, Hal R Varian, et al. Information rules: a strategic guide to the network economy. Harvard Business Press, 1998.

[28] Matthew P Simmons, Lada A Adamic, and Eytan Adar. Memes online: extracted, subtracted, injected, and recollected. icwsm, 11:17–21, 2011.

[29] Herbert A Simon. Designing organizations for an information-rich world. Brookings Institute Lecture, 1969.

[30] Tiziana Terranova. Attention, economy and the brain. Culture Machine, 13, 2012.

[31] William Theisen, Joel Brogan, Pamela Bilo Thomas, Daniel Moreira, Pascal Phoa, Tim Weninger, and Walter Scheirer. Automatic discovery of political meme genres with diverse appearances. arXiv preprint arXiv:2001.06122, 2020.

[32] Pamela Bilo Thomas, Rachel Krohn, and Tim Weninger. Dynamics of team library adoptions: an exploration of github commit logs. In Proceedings of the 2019 IEEE/ACM International Conference on Advances in Social Networks Analysis and Mining, pages 470–473, 2019.

[33] Lin Wang and Brendan C Wood. An epidemiological approach to model the viral propagation of memes. Applied Mathematical Modelling, 35(11):5442–5447, 2011.

[34] Lilian Weng, Alessandro Flammini, Alessandro Vespignani, and Fillipo Menczer. Competition among memes in a world with limited attention. Scientific reports, 2:335, 2012.

[35] Bradley E Wiggins and G Bret Bowers. Memes as genre: A structurational analysis of the memescape. New Media & Society, 17(11):1886–1906, 2015.

[36] Fang Wu and Bernardo A Huberman. Novelty and collective attention. Proceedings of the National Academy of Sciences, 104(45):17599–17601, 2007.