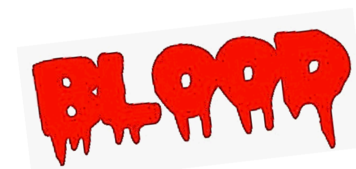
The viral spread of a zombie media story

Stacey Smith?



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The outbreak...

- Like any huge event, it started small
- In August 2009, an online blog for a newspaper and an article in *National Geographic* triggered a wave of reports:
- A group of Canadian researchers had created a mathematical model of zombies!
- (It was a slow news month.)

A viral infection

- The story was reported in *Wired*, which acted as a hub for spreading it significantly further
- It was picked up in Canada's *Globe and Mail*
- Then spread to *The Toronto Star*, *The Wall Street Journal*, BBC News...

  ...where it was the number one story in the world for 24 hours
- Twitter was a-flutter, blogs went into overdrive, Google searches spiked.

Shock new revelation! (?)

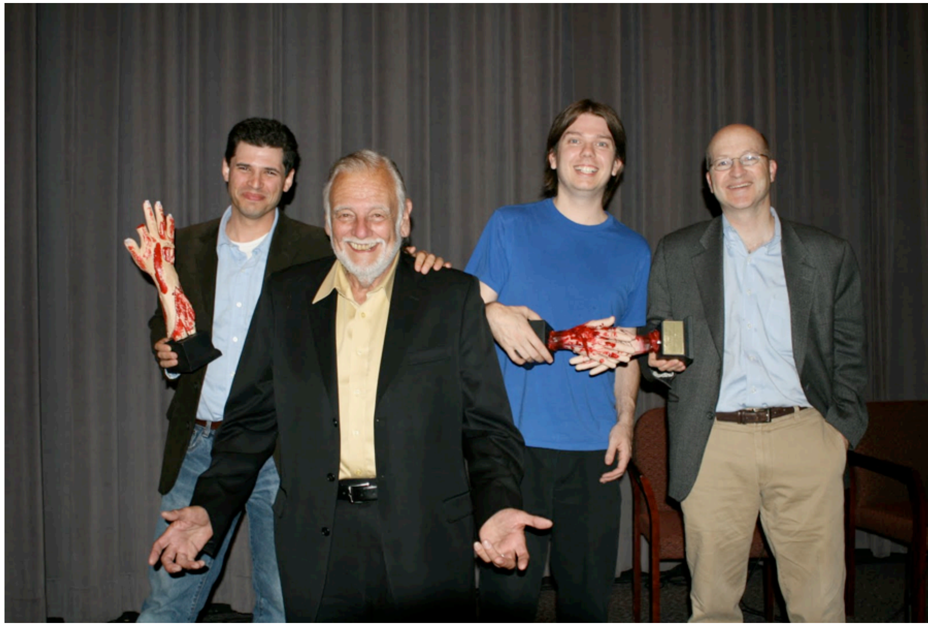
- The story gathered more steam when it was discovered that the lead researcher’s name had a question mark in it
- From here it spread worldwide:
  - National Public Radio
  - The UK’s *Daily Mail*
  - *The Melbourne Herald Sun*
  - *Hungry Beast* (Australian TV show)
  - Finnish news.

A further hook

- Upon reaching Australia, the story gathered another boost
- The senior author was Australian, so the Australian media became particularly interested
- This extended the lifespan of the story even further.

The fallout

- Agents came calling
- Book deals were offered
- The Hollywood Science and Entertainment Exchange arranged a panel at the Director's Guild of America
  - This put the senior author in a discussion with George Romero and Max Brooks



- In every sense of the word, the story went viral.

The aftermath

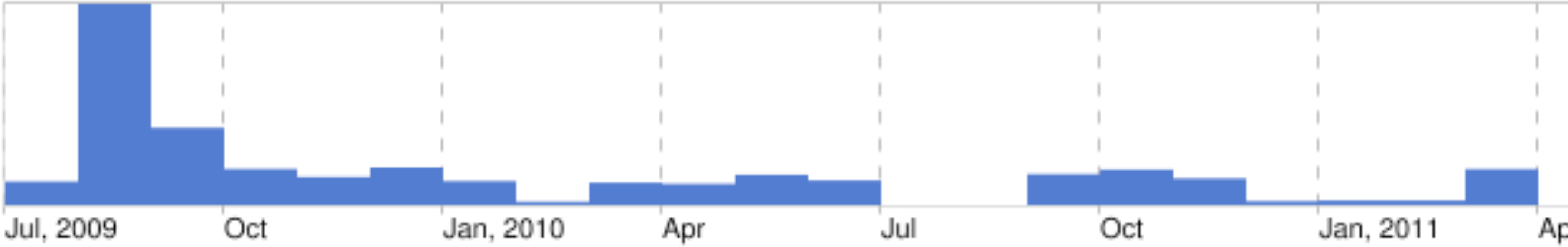
- August 2009 was a slow news month
- There were no natural disasters
- No political scandals
- Hallowe'en occurred a few months later, sparking a brief re-interest in the story
- It was also discussed at the end of the year in the summary for the year (and decade)
- Occasional reports surfaced intermittently thereafter
- Quotes continue to be solicited to this day.

What does it mean to go viral?

A story is said to go viral when it has

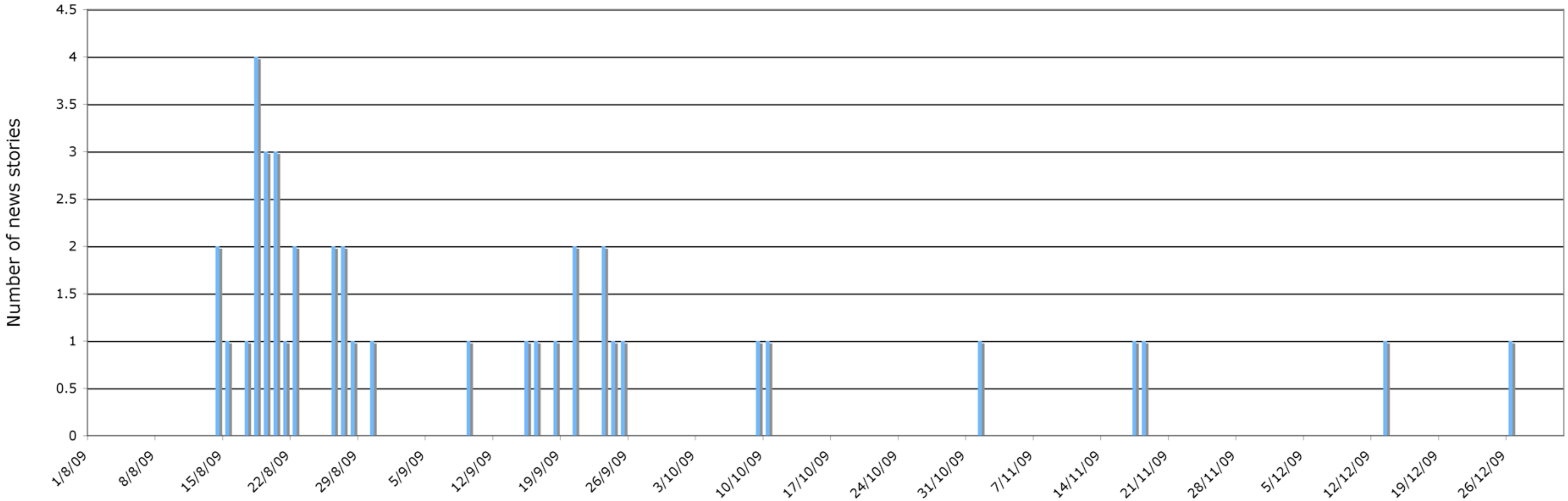
- an initial outbreak
- significant reach
- remains in the public eye for a long time.

Timeline



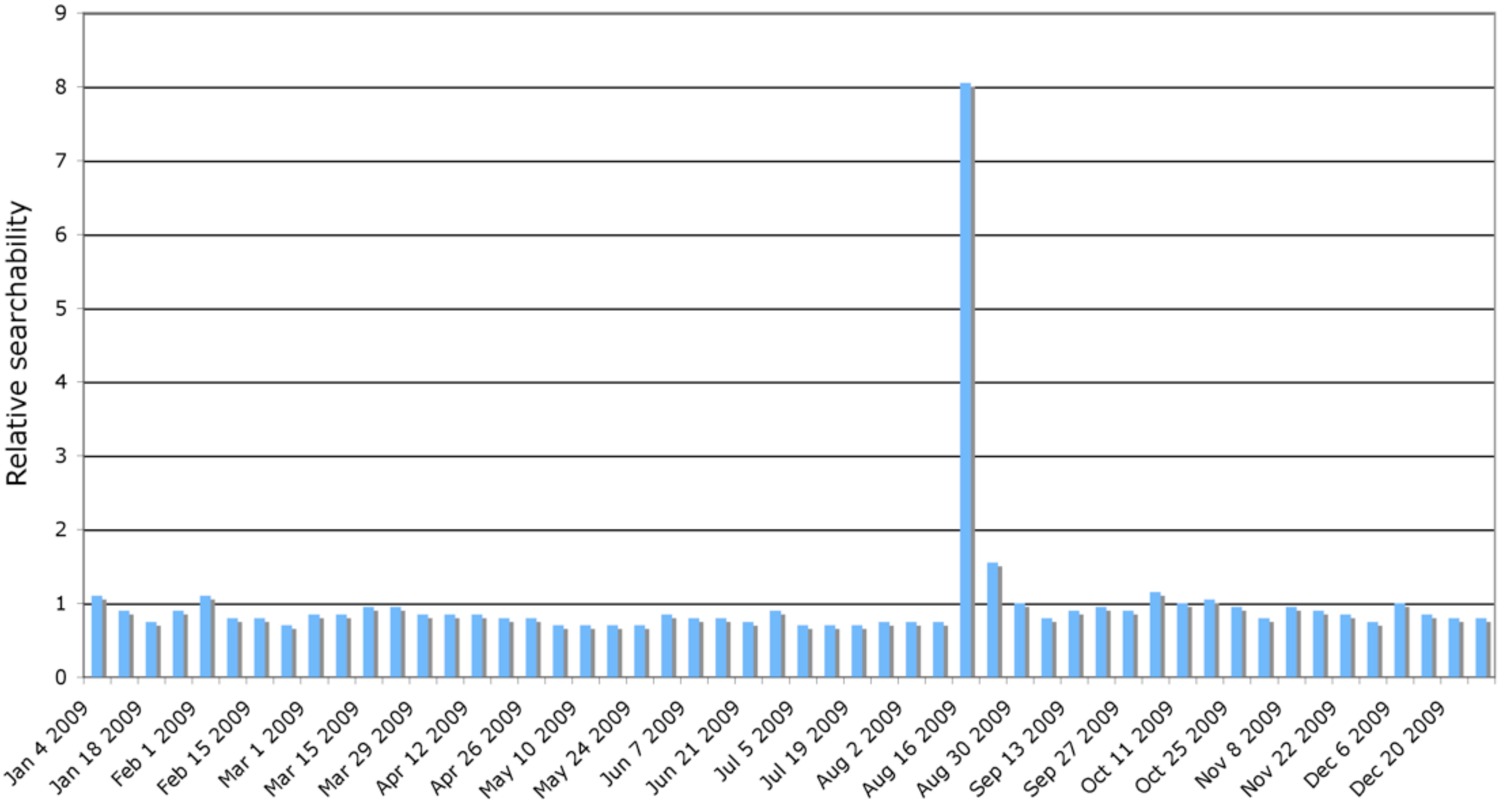
- Timeline of stories in Google News archives featuring keywords “zombies” and “mathematics” since July 2009.

News stories per day



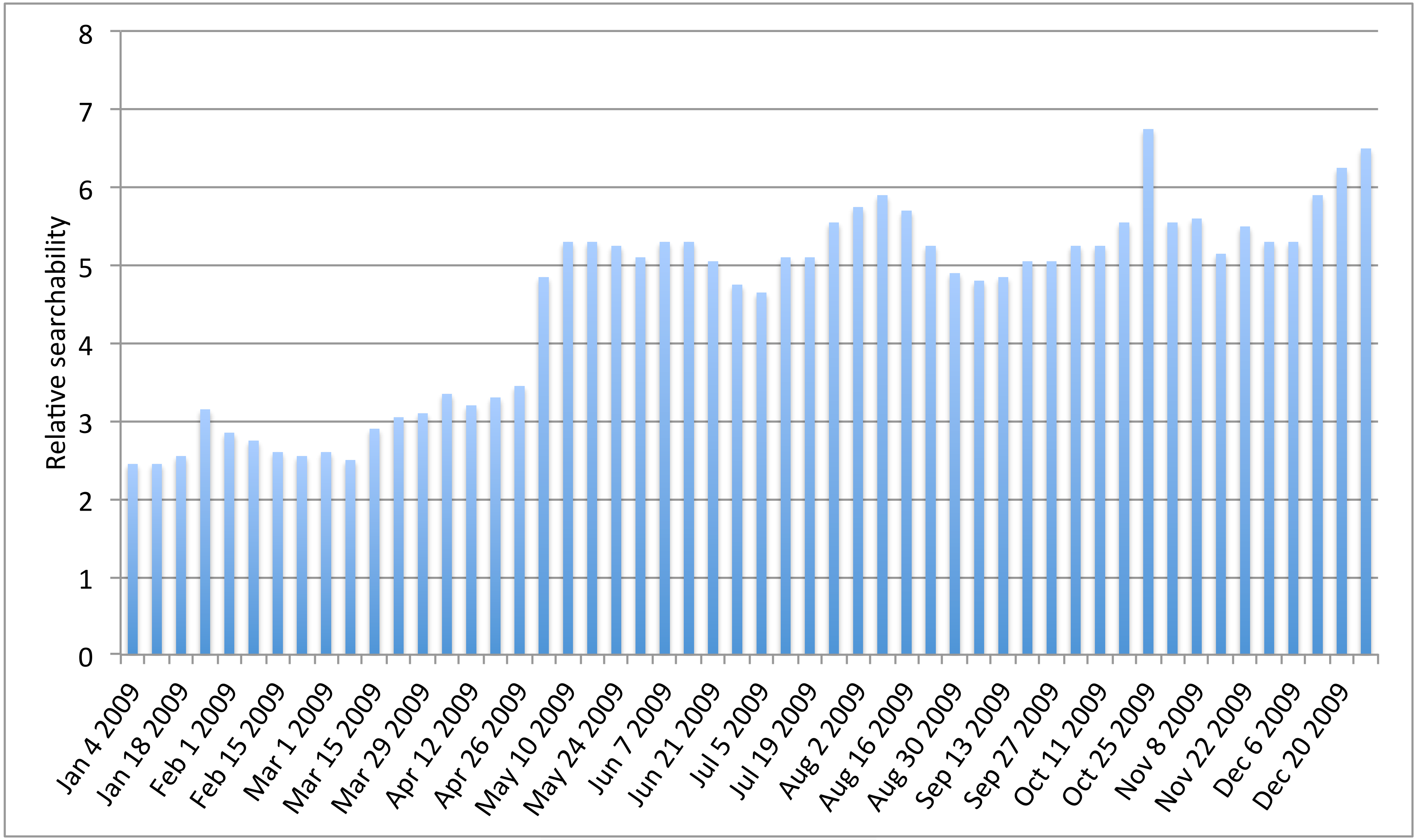
- Number of stories per day in Google News archives featuring keywords "zombies" and "mathematics"
- Covers the latter part of 2009.

Google trends for the word "Smith?"



- Searches for "Smith" produced different results.

Google trends for the word “zombies”



Research question

What makes a story go viral?

- I'm using my own zombie story as a case study, since I have data
- Although a story going viral is not a disease, it has the hallmarks of one
- Thus models can be adapted to account for a story that is "infecting" a variety of media outlets.

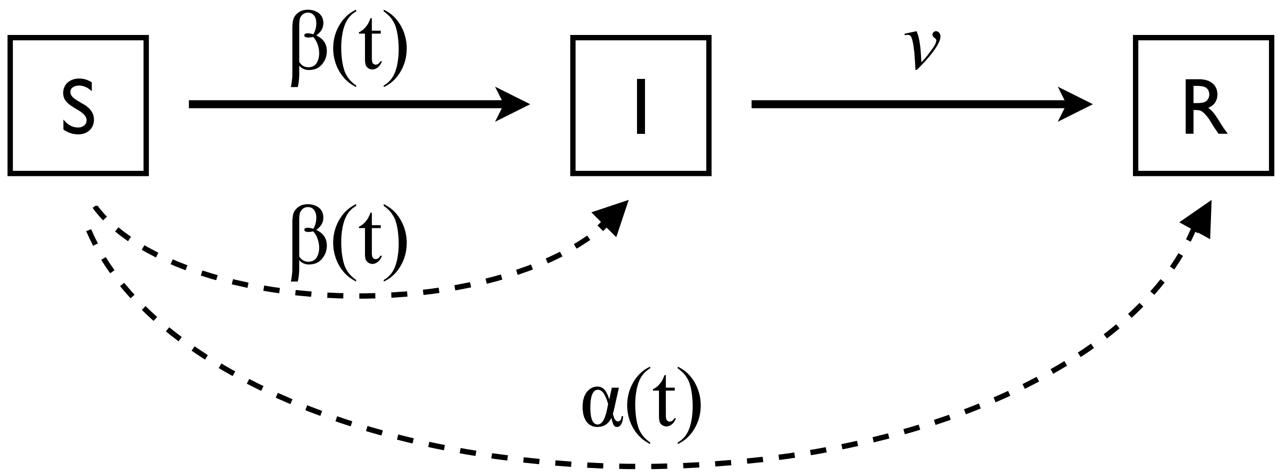
Zombie media

- A story that's currently running can be considered "infectious"
  - in the sense that other media outlets may pick it up and run their own version
  - journalists often write about what their competitors have recently written about
- Stories that have recently run may also "infect" susceptible media outlets
  - this effect will lessen the more time passes
- Hence susceptible media outlets can be infected by those who have recovered.

Parameters

- β measures how newsworthy the story is
  - based on whatever criteria the media decide on how "interesting" a story is
- α measures the durability of the story
  - driven in part by how good the interview subject was once the interview has run
- ν measures how quickly the story ages out
  - so the story's natural lifespan is $1/\nu$
- We assume α and β are time-dependent, with $\alpha(t) \to 0$ over time.

The model



$$S' = -\beta(t)SI - \alpha(t)SR$$
$$I' = \beta(t)SI + \alpha(t)SR - \nu I$$
$$R' = \nu I.$$

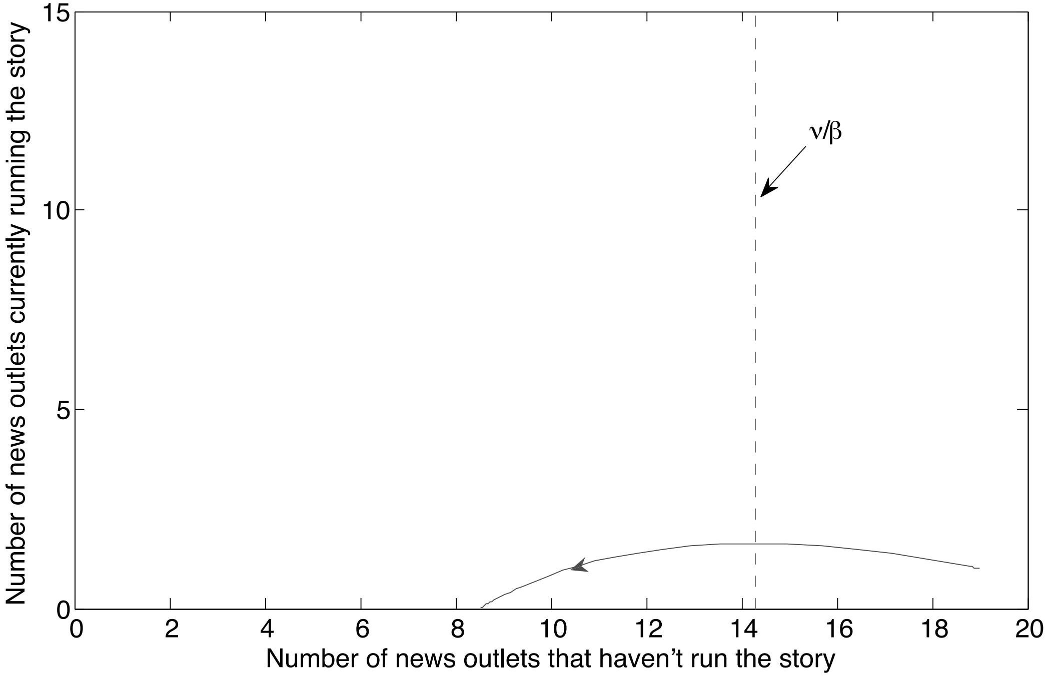
S=susceptibles I=infecteds R=recovered
β=newsworthiness α=durability ν=leaving rate

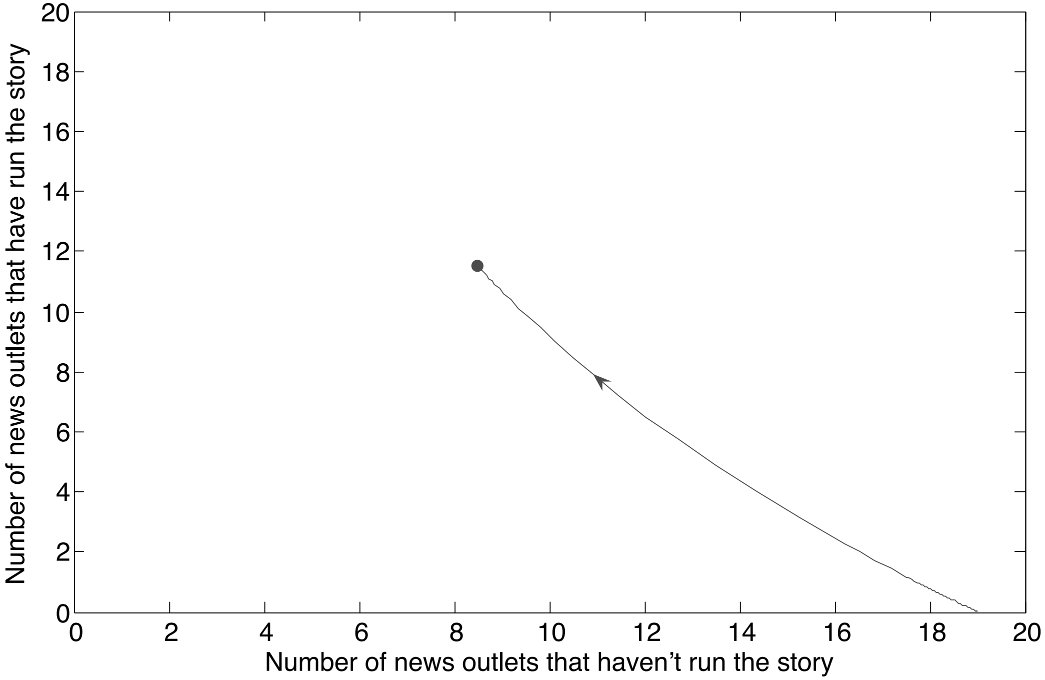
The durability of a media story

- The following conditions on the durability were assumed:
  1. $\alpha(0)=0$
  2. $\alpha(t)\rightarrow 0$ as $t\rightarrow\infty$
  3. α is not uniformly zero.

α=durability

Current and past stories when α≡0





- In the absence of a good interview subject, a story cannot go viral.

β=newsworthiness α=durability ν=leaving rate

A good interview subject

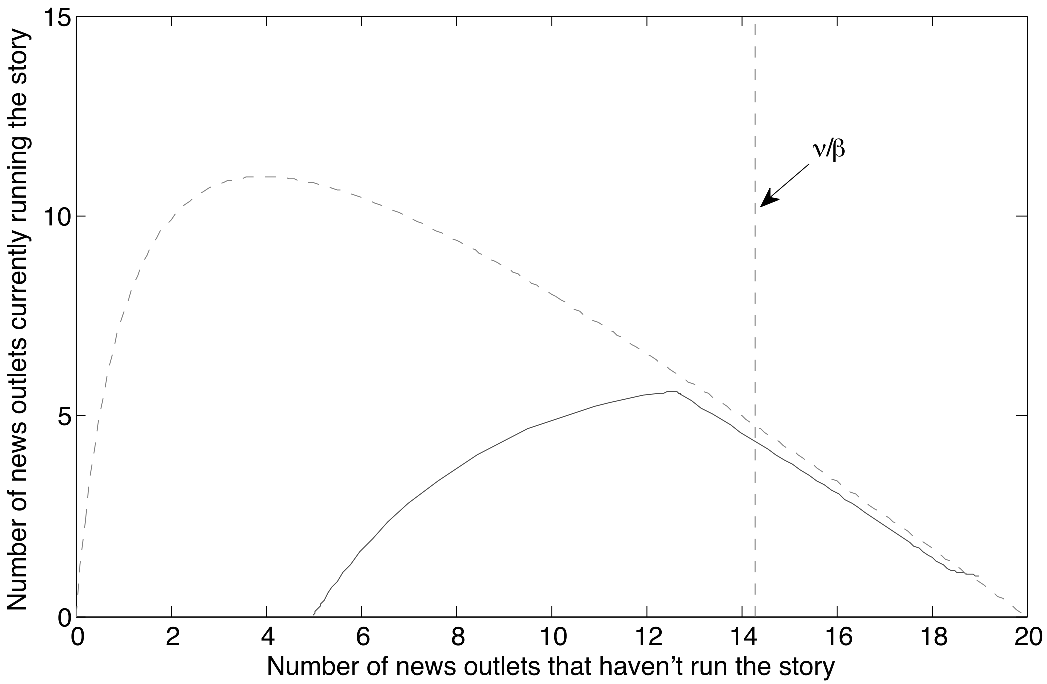
- A reasonable form for α(t) might be:

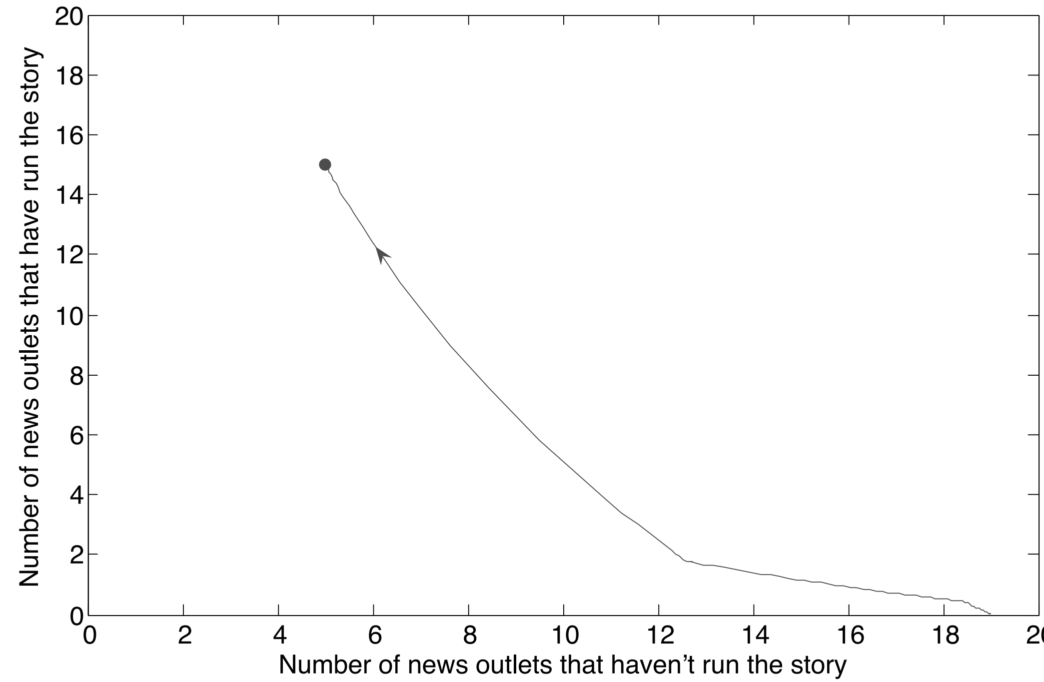
$$\alpha(t) = \begin{cases} 0 & 0 < t < t_0 \\ \bar{\alpha} & t_0 < t < t_f \\ 0 & t > t_f, \end{cases}$$

  where $[t_0, t_f]$ is the time during which the interviewee provides added value to the story
- That is, when a story breaks, a good interviewee initially adds no effect
- The interviewee's skills are discovered at t_0
- The interviewee remains a hot property until t_f, when their interview skills are irrelevant.

α=durability

The effect of a good interviewee





- Here α=0.1 for 3<t<6 and zero otherwise
- The dashed curves are the nullclines (only applicable in some regions)
- The majority of outlets are infected, but the story doesn't go viral.

β=newsworthiness α=durability ν=leaving rate

Newsworthiness

- The following conditions on the newsworthiness were assumed:

1. $\beta(0) > 0.$
2. $\lim_{t \to \infty} \beta(t) = \bar{\beta} \geq 0$

- Unlike durability, newsworthiness starts at t=0, so β(0)>0
- A reasonable form is simply to take β constant
- This suggests that a story is newsworthy if anyone is currently reporting it.

β=newsworthiness

Natural lifespan of a story

- The parameter ν measures how quickly a story becomes old
- This takes into account other news stories that may compete for media space
- Eg a sports story that would have been quite popular may have a significantly shorter lifespan if a tsunami has hit.

Stability

- Equilibria are of the form $(S, I, R) = (\hat{S}, 0, \hat{R})$
- We can calculate the stability of the disease-free equilibrium, where perturbations are applied initially

$$\det(J(\hat{S}, 0, \hat{R}) - \lambda I) = \det \begin{bmatrix} -\lambda & -\beta(0)S & 0 \\ 0 & \beta(0)S - \nu - \lambda & 0 \\ 0 & \nu & -\lambda \end{bmatrix}$$

$$= \lambda^2(\beta(0)\hat{S} - \nu - \lambda) = 0$$

- It follows that equilibria with $\hat{S} > \dfrac{\nu}{\beta(0)}$ will be unstable.

S=susceptibles I=infecteds R=recovered
β=newsworthiness ν=leaving rate

An initial rise in infections

- Thus stories that have the potential to go viral are:
  - those that are particularly newsworthy (high $\beta(0)$)
  - or those that have the potential to run for a long time (low ν)

$$\hat{S} > \frac{\nu}{\beta(0)}$$

- Such stories will have an initial rise in the number of infections
- This is a necessary but not sufficient condition.

S=susceptibles
β=newsworthiness ν=leaving rate

A competing story

- Two stories may compete for media space
  - eg the sports/tsunami stories mentioned earlier
- For simplicity, suppose $\alpha=0$, since we are only interested in the initial viral properties
- The model becomes

$$S' = -\beta_1(t)SI_1 - \beta_2(t)SI_2$$
$$I_1' = \beta_1(t)SI_1 - \nu_1 I_1$$
$$I_2 = \beta_2(t)SI_2 - \nu_2 I_2$$

- We can show that the DFE is unstable if

$$\max\{\beta_1(0)\hat{S} - \nu_1, \beta_2(0)\hat{S} - \nu_2\} > 0.$$

S=susceptibles I=infecteds
β=newsworthiness ν=leaving rate

Final size

- Dividing the equations, we have

$$\frac{dI}{dS} = -1 + \frac{\nu}{\beta(t)S}$$

- Letting β be constant and integrating, we find

$$I_\infty = I(0) + S(0) - S_\infty + \frac{\nu}{\overline{\beta}} \ln\left(\frac{S_\infty}{S(0)}\right)$$

- Since $S_\infty=0$, this implies $I_\infty=-\infty$
- However, since I(0)>0, there must exist a finite time t_a such that $I(t_a)=0$
- Thus, whether all media outlets run the story or not, the eventual outcome is that I reaches zero in finite time.

S=susceptibles I=infecteds
β=newsworthiness ν=leaving rate

Different natural lifespans

- Suppose both stories are equally newsworthy
- However, Story 2, the tsunami, has a longer natural lifespan than Story 1 (so $\nu_1 > \nu_2$)
- In this case, if $\hat{S} > \nu_2/\bar{\beta}$ but $\hat{S} < \nu_1/\bar{\beta}$, then Story 2 can go viral but Story 1 cannot
- Hence the tsunami eats up the oxygen that might have allowed the sports game to go viral.

S=susceptibles at equilibrium
β=newsworthiness ν_j=leaving rates

Subsequent "hook"s

- A crucial element of media is the appearance of a subsequent hook
  - i.e., more information that makes the story more appealing
- Results in a rapid transformation in the number of susceptible media outlets
- Those that may not have thought the story newsworthy before may suddenly decide the story now is
- Those that ran the story before now have a new story to run.

Impulsive differential equations

- These near-instantaneous changes to the system can be described using impulsive differential equations
- The model thus becomes

$$
\begin{aligned}
S' &= -\beta(t)SI - \alpha(t)SR && t \neq t_k \\
I' &= \beta(t)SI + \alpha(t)SR - \nu I && t \neq t_k \\
R' &= \nu I && t \neq t_k \\
\Delta S &= S_k && t = t_k,
\end{aligned}
$$

where t_k ($k=1,2,\ldots,n$) are the times at which the hooks occur

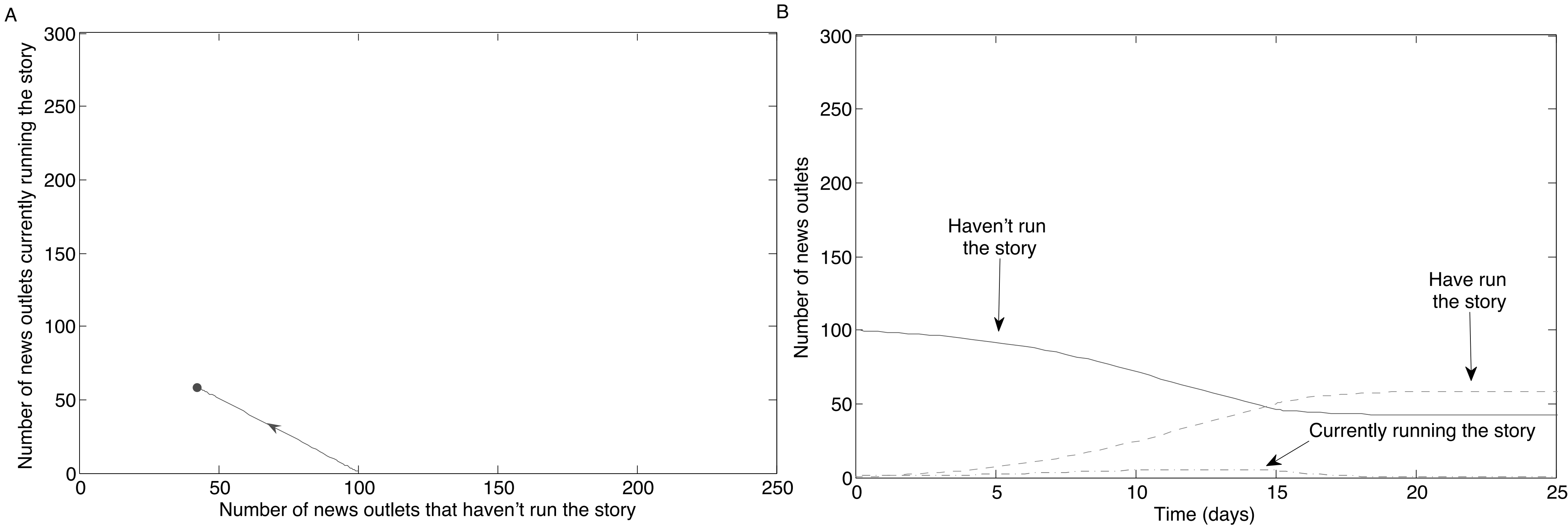
- S_k is the strength of the kth hook.

S=susceptibles I=infecteds
R=recovered
β=newsworthiness
α=durability ν=leaving rate

The power of a right hook

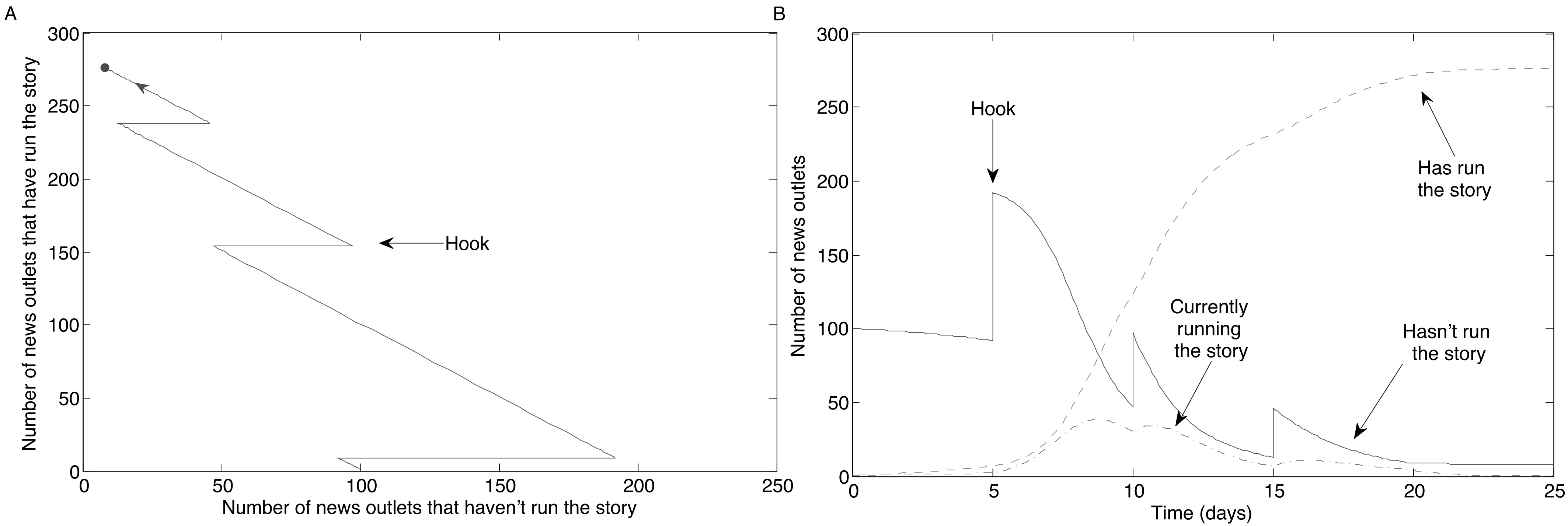
- We assume only finitely many hooks
  - however, the times may not be fixed and the hooks may have different strengths
- Although a hook may increase a story's attractiveness, the net effect is that the initial conditions are reset
- However, a series of hooks may prolong the story's lifespan
- This may result in a significantly larger number of media outlets covering it than would otherwise be the case.

The absence of hooks



- Without further hooks, the story plays out similarly to the classical SIR infection curve.

The effect of multiple hooks

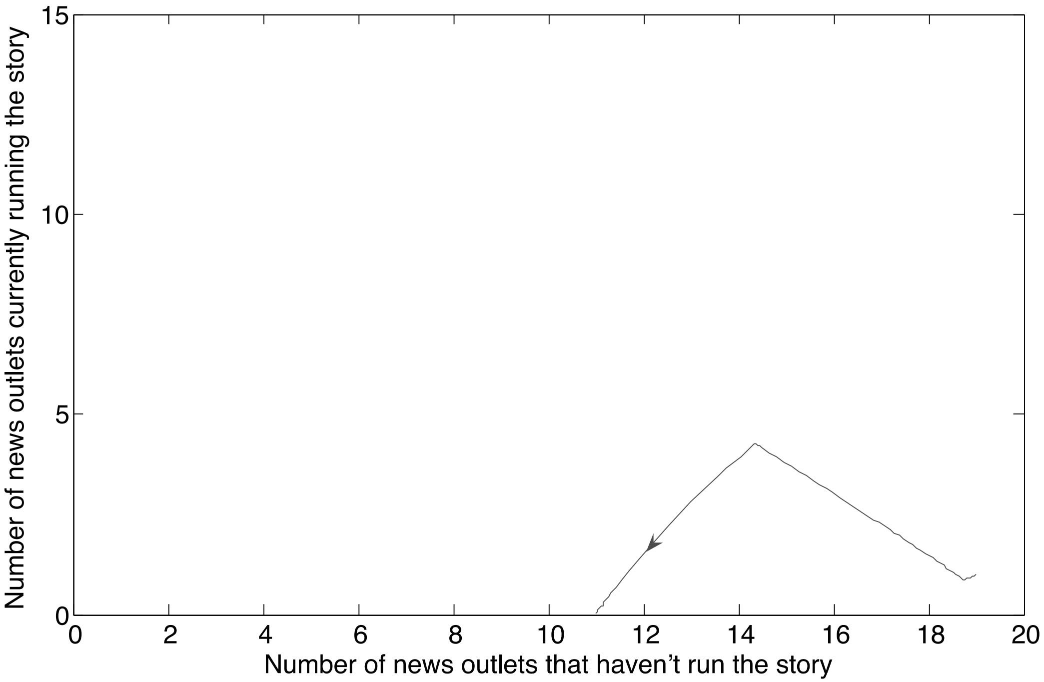


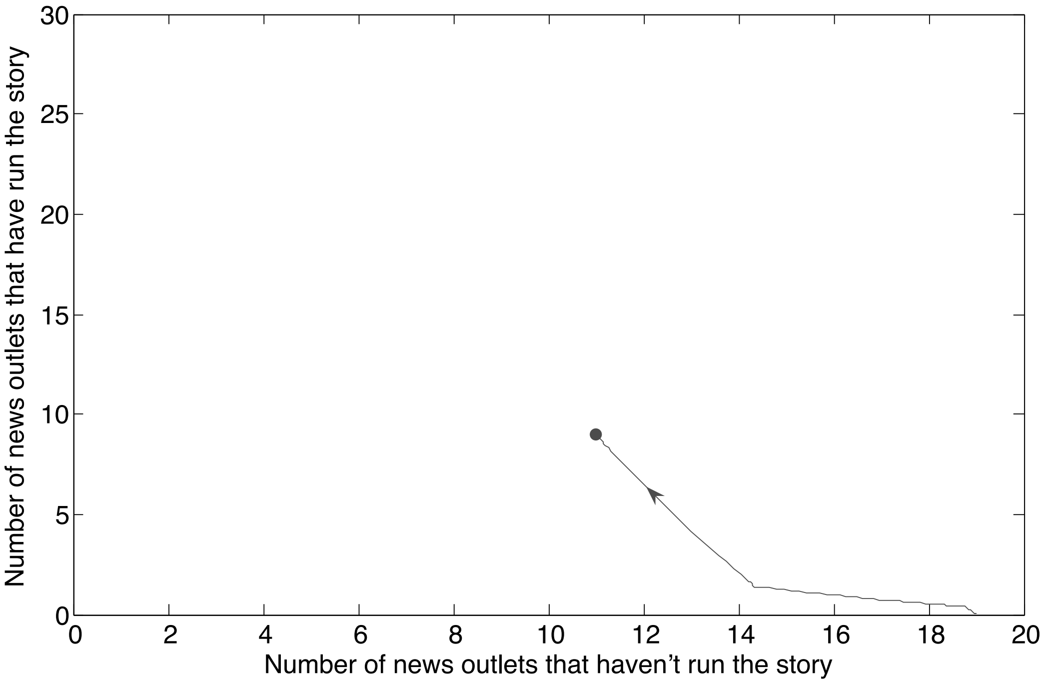
- The story can be kept alive for significantly longer
- When successive hooks revive interest, the story gets picked up by more media outlets.

Sample scenarios

- We now use the model to examine some potential scenarios
- News stories do not exist in isolation
- Instead, they exist in the context of other stories happening at the same time
- Additional information may subsequently surface
- We investigate what happens if one or more of the factors is limited.

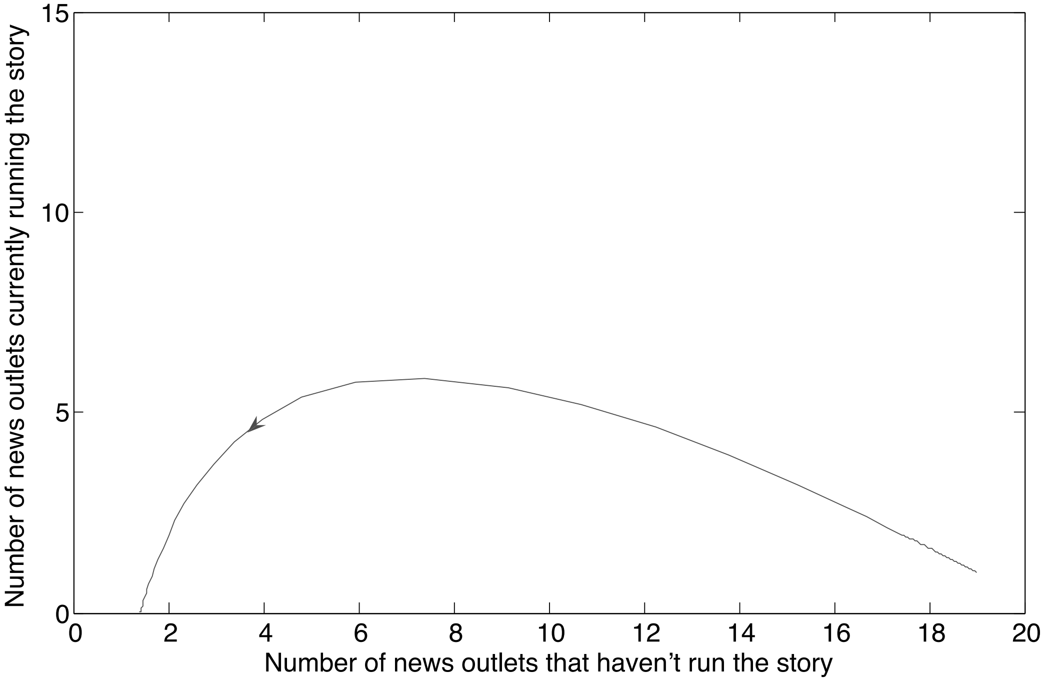
Good subject, not newsworthy

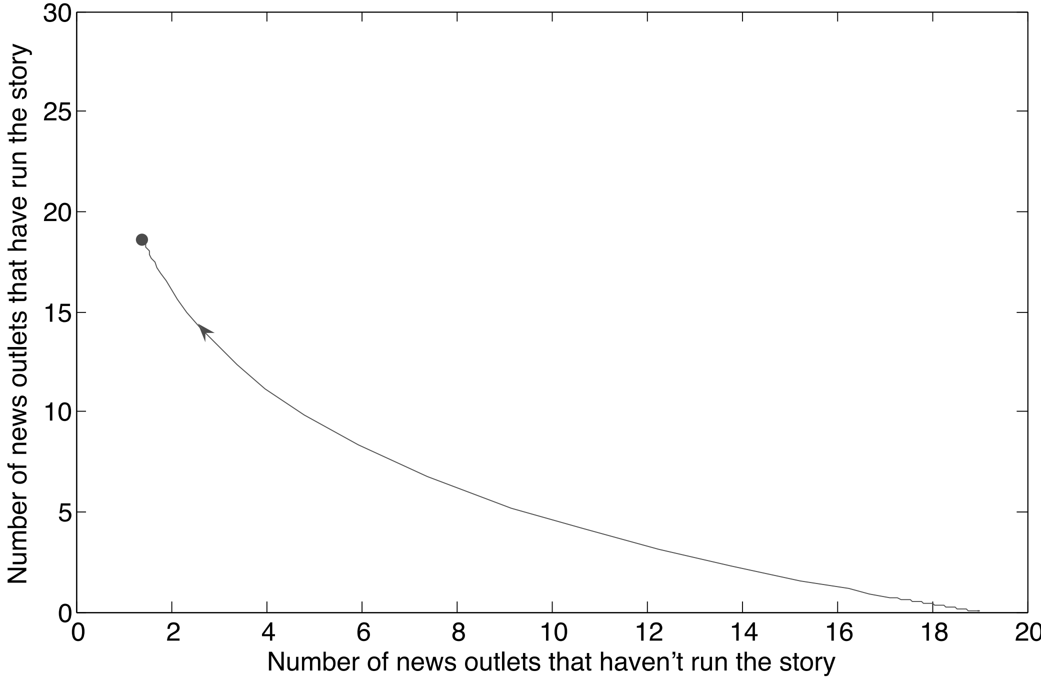




- The story never gets off the ground
- Regardless of the skills of the interviewee
- This illustrates the power of media to shape the cultural narrative.

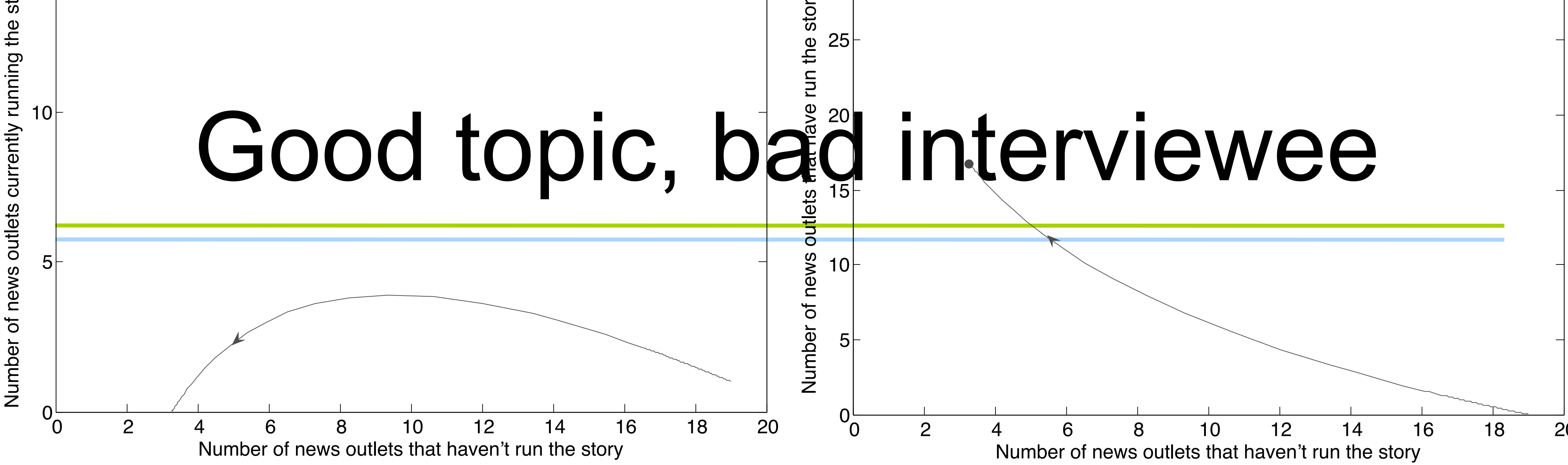
Slow news week





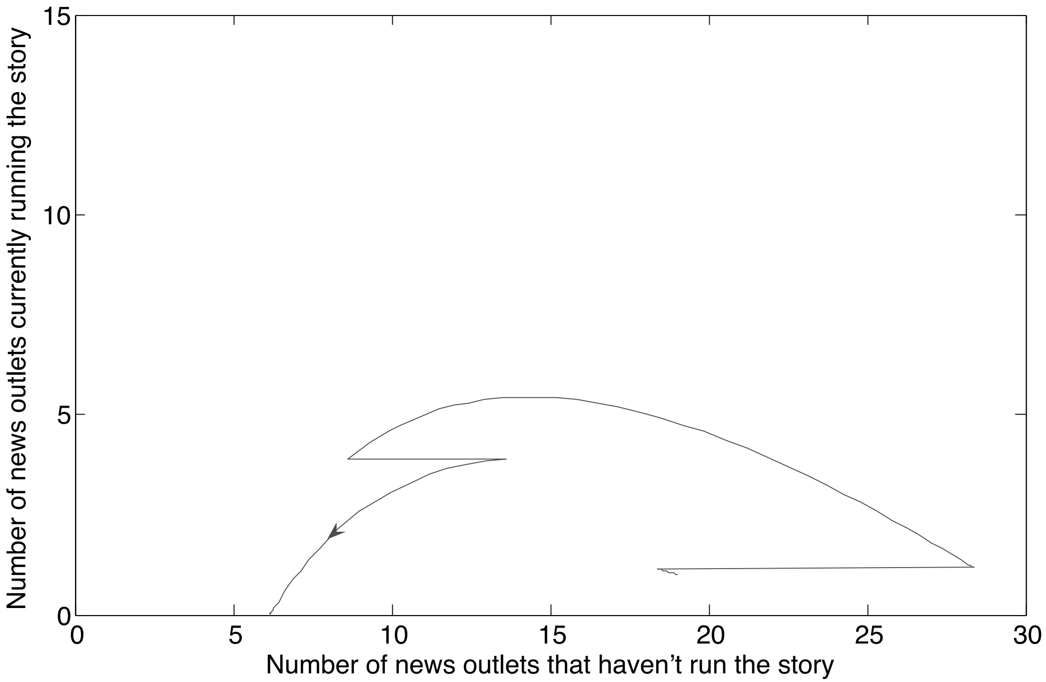
- The story remains infectious for significantly longer than it otherwise would
- The story can reap close to its maximum potential, with almost all outlets running it.

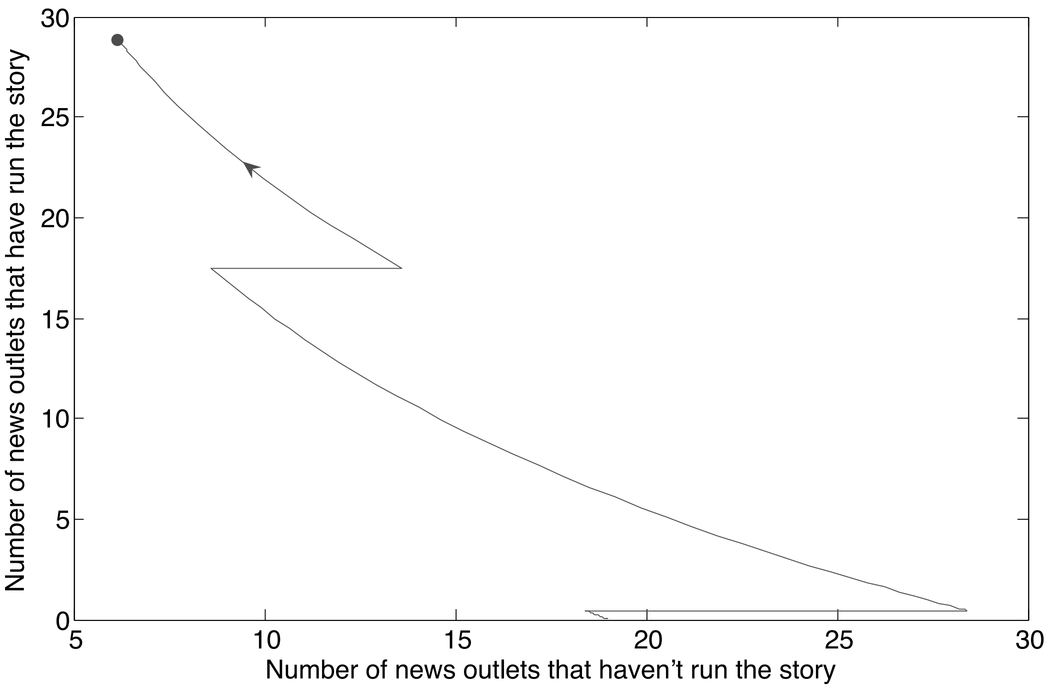
Good topic, bad interviewee



- Even with no durability, if the story has sufficient initial interest, it can reap close to its maximum potential.

Secondary hooks, bad interviewee





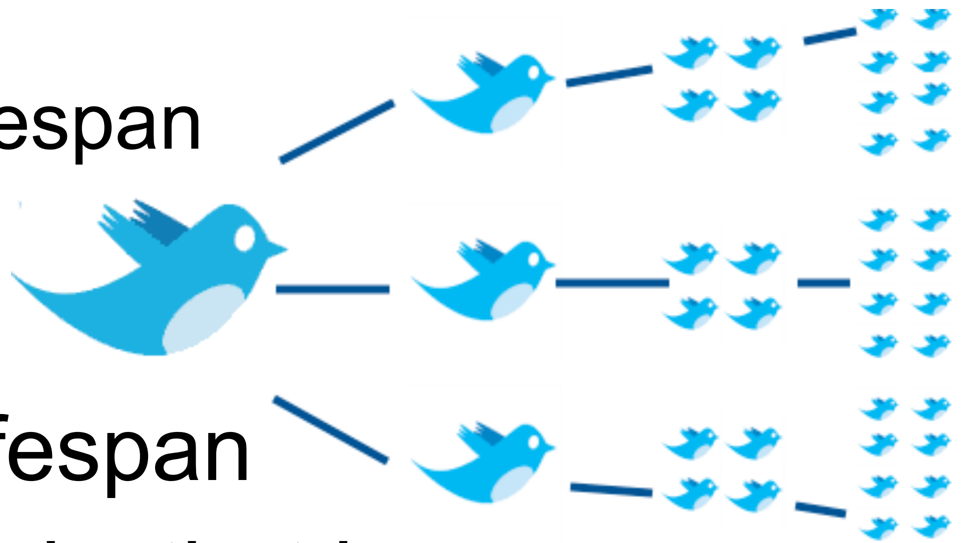
- A story on its way out can receive new life
- If a hook occurs early enough, the story can be revived
- Even without any long-term durability.

Summary

- Ultimately, the story of a mathematical model of zombies going viral was a confluence of circumstances:
  - a diverting topic that happened to occur in a slow news week
  - a media-savvy interview subject
  - a major secondary hook that occurred early in the story's lifespan
- Being a fairly self-contained phenomenon, it forms a useful case study for the effects of media.

Generalisations

- For a story to go viral, it needs
  - to be newsworthy
  - to have a long natural lifespan
- Once the story is under way, a good interview subject can extend its lifespan



- However, a series of hooks that increase a story's appeal can breathe new life into it
- This effect is particularly significant if such a hook appears early in the news cycle.

A counterexample

- Eg lead in the water
- This story was studied intensively
  - a reporter followed it for two years, writing 175 articles on the subject
- This story featured briefly on TV but had no national followup
- It had several hooks, most notably when lead was found in the newspaper-printing process.

Why the water story didn't go viral

- Despite several hooks, it had no durability
- It was swamped by Evel Knieval's 1974 motorcycle leap across Snake River Canyon
  - this was covered by hundreds of reporters
- Thus, although β was high, α was low (or zero) and the lifespan (1/ν) was low.

S=susceptibles I=infecteds R=recovered
β=newsworthiness α=durability ν=leaving rate

How can a story go viral?

- It needs a perfect storm of events:
  - it must be deemed newsworthy in the first place
  - it needs room to breathe
  - it needs a good interview subject
  - it needs at least one hook

- Given an arbitrary topic, the only controllable factors are
  - the skills of the interviewee (via media training)
  - perhaps the timed release of further information
- Otherwise, whether a story goes viral is at the mercy of the media's inherent randomness.

“Most egotistical talk ever given — math shocker!”

- Just like the zombies themselves, articles about zombies are the gifts that keep on giving
- Every time you think they’re finally dead, they seem to come back to life
- Incidentally, if there are any reporters in the audience, please speak to me afterwards
  - you could write an article about an article about zombies
- So if we play this right...

...we could be on the zombie gravy train for life.

Key references

- R.J. Smith? The viral spread of a zombie media story (in: R.J. Smith?, ed, Mathematical Modelling of Zombies 2014, pp1–25)
- P. Munz, I. Hudea, J. Imad and R.J. Smith? When zombies attack!: Mathematical modelling of an outbreak of zombie infection (in: J.M. Tchuenche and C. Chiyaka, eds, Infectious Disease Modelling Research Progress 2009, pp133–150).

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