RESEARCH

Faking the News: Intentional Guided Variation Reflects Cognitive Biases in Transmission Chains Without Recall

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Two potential forms of mutation in cultural evolution have been identified: 'copying error', where learners make random modifications to a behaviour and 'guided variation' where learners makes non-random modifications. While copying error is directly analogous to genetic mutation, guided variation is a specifically cultural process that does not have a close parallel in biological evolution. It has been suggested that the decision-making processes underlying intentional guided variation may produce similar results to cultural transmission as both are likely to be influenced by cognitive biases. This study uses a unique linear transmission chain design, without any influence of recall, to examine intentional guided variation. Participants were asked to alter news stories however they wished in order to make them more interesting, the product of their modification was then passed to the next participant and so on down the chain. The products of the chains were then compared with the original material so as to assess any underlying biases in the changed content. Through this process of guided variation, original material which scored low for bias-exploiting content significantly increased in at least one known content bias, whereas original material which scored high for bias-exploiting content was not significantly altered in this respect.

Keywords: cultural evolution; cultural transmission; cognitive biases; fake news

Introduction

Recent research has shown that false news spreads more widely online than genuine news (Vosoughi, Roy & Aral, 2018) but offers little explanation as to why. Cultural evolution theory proposes that culture represents a second system of heritable variation that evolves through Darwinian processes of mutation, selection and inheritance (Mesoudi, 2011, Richerson & Boyd, 2005) and offers an excellent theory through which we can examine how processes in individuals result in population level patterns. As such a Cultural Evolution approach provides a useful means to understanding the socio-cognitive mechanisms behind the spread of misinformation (Acerbi, 2016).

To date, most theoretical and empirical work in Cultural Evolution has focused on the processes of selection and inheritance (see Kendal et al., 2018 for a review). For example, researchers have used a range of methods, from mathematical modelling (e.g. Boyd & Richerson, 1985) and controlled experiments (Wood, Kendal & Flynn, 2013) to ethnographic fieldwork (Henrich & Broesch, 2011), to investigate how one makes decisions about *what* to copy ('content biases') and *who* to copy ('context biases'). Other researchers, meanwhile, have employed techniques of phylogenetic analysis to trace lineages of cultural descent and modification in various socially learned traditions (e.g. Currie, 2013; Lycett, 2009; Lyman & O'Brien, 2003; Tehrani, 2013; Tehrani, Collard & Shennan, 2010), and establish long-term trends in cultural, economic and political systems (e.g. Jordan, Gray, Greenhill & Mace, 2009). However, comparatively little research has been carried out on the processes of cultural mutation, and to what extent this process may reflect the characteristics of others. The present study aims to shed more light on this problem by examining processes of innovation in

artificially generated narrative traditions. Previous research in innovation and creativity in cultural evolution has primarily focused on problem solving or technological applications (see Fogarty, Creanza & Feldman, 2015 for a review), as such this study represents a novel examination of innovation in narrative transmission.

Current theory (e.g. Mesoudi, 2011) suggests there are two main mechanisms of cultural mutation. The first of these is copying error, which is defined as the random, non-intentional modification of a demonstrated behaviour. Copying error can result when a learner is less adept than a model (for example, the father of the bride attempting to imitate Michael Jackson's 'moonwalk' at his daughter's wedding party), due to an accidental mishap (a pianist accidentally hitting the wrong key during a performance), or as a consequence of the constraints of the human perceptual system (for example, believing two lines to be the same length when they are not). An example of the latter is provided by Eerkens and Lipo's (2005) case study of Paleo-Indian projectile points from Owens Valley, California between 1500 and 650 BCE. They demonstrated that patterns of variance and cumulative change in these projectile point forms is consistent with a model of pure copying error derived from research into shape perception, which shows that humans are unable to discriminate between line lengths that differ by less than 3% (known as the Weber Fraction), regardless of scale. The second mechanism for generating cultural variation is known as 'guided variation' (Boyd & Richerson, 1985), which involves the non-random modification of a demonstrated behaviour by the learner. For example, someone may be taught how to cook a particular dish, and decide to alter the recipe to make it tastier or healthier by adding or substituting ingredients. This non-random modification can occur in both unintentional and intentional forms and also occur through learning processes such as trial-and-error (Mesoudi, 2013).

Whereas copying error is directly analogous to random mutation in genetics, guided variation is a specifically cultural process that does not have a close parallel in biological evolution. Goal-directed guided variation allows individuals to take short-cuts to solving adaptive problems that would take several generations to solve under pure natural selection. As Richerson and Boyd stated, guided variation is "like an imaginary genetic system in which mutations tend to be fitness-enhancing, rather than random" (2005: 116). They further suggest that the decision-making processes underlying guided variation may often produce similar results to biased cultural transmission because both are likely to be based on the same psychological mechanisms (ibid).

To date, only one study has directly tested whether traditions that evolve through guided variation exhibit the same dynamics as traditions that evolve through biased cultural transmission. Mesoudi (2008), inspired by Bettinger and Eerkens' (1999) classic archaeological analysis of variation in arrow-head designs in prehistoric Nevada and California, used an artificial hunting experiment to compare the evolution of virtual arrow-head designs under guided variation (in this case intentional modification informed by individual trial-and-error learning) versus a transmission bias for copying successful individuals. He found that intentional guided variation can produce similar outcomes to biased cultural transmission, but only under specific circumstances (i.e. when there is a single best variant of a particular behaviour). However, it is important to emphasise that the study focused specifically on context-based transmission biases. *Context* bias describes when the likelihood of cultural trait being transmitted is determined by its context or features of the model (i.e. conformist bias, where individuals copy the most common behaviour, or prestige bias where individuals copy prestigious models). This is distinct from *content* bias where the likelihood of a cultural trait being transmitted is determined by the intrinsic features of the material or behaviour itself. To date, no similar studies have examined whether guided variation exhibits the same dynamics as content-based transmission biases. The present research presents a study designed to address this gap.

Cognitive content biases in intentional guided variation have particular relevance to electronic communication as, unlike traditional forms of communication, electronic media potentially allows for the error-free replication of information. Despite this, however, electronic communication does not demonstrate perfect replication. Facebook status updates, for example, show a moderately high "mutation" rate of 11% and resemble an iterative, imperfect replication process, likely due to people deliberately altering the information before transmitting it themselves (Adamic et al., 2014). Previous research examining the cultural evolution and transmission of narratives and text have used transmission chain experiments in an attempt to replicate unintentional guided variation and have found evidence for the influence of content biases across three phases of transmission; choosing to receive, encoding and recall, and choosing to transmit (see Stubbersfield, Flynn & Tehrani, 2017 for a review). Only a small number have examined these phases separately (Eriksson & Coultas 2014, and Stubbersfield, Tehrani & Flynn, 2015). As such it is difficult to determine to what extent the role of content biases in selective recall plays in transmission and, therefore,

how relevant these previous studies are to the transmission of content in electronic communication. As the issues presented by "Fake News" and other forms of information become increasingly prevalent, it becomes increasingly important to understand the transmission processes involved in electronic communication. This study represents a useful first step towards adapting traditional experimental paradigms to be more relevant towards contemporary electronic communication and therefore be relevant to contemporary issues in electronic communication.

The Present Research

This study seeks to examine how modification through intentional guided variation may reflect the modification through unintentional guided variation demonstrated in previous studies. In particular, to what extent processes of intentional modification are influenced by the content biases which have been shown to influence unintentional modification. The term 'content bias' is used here to refer to the psychological concept of cognitive predispositions towards attending to, encoding in memory and transmitting to others certain types of information over equivalent others. It is therefore not directly related to similar terms from other fields within cultural, social and human sciences, such as ideological or political bias. While other biases such as political and ideological biases of course play an important role in the transmission of narratives and in particular misinformation and false news online, this study focuses on those cognitive content biases which have been identified in previous research from within the fields of psychology and cognitive anthropology: an ecological survival information bias (Stubbersfield, et al., 2015), a social information bias (Mesoudi, Whiten, & Dunbar, 2006); an emotional bias (Heath, Bell, & Sternberg, 2001; Stubbersfield, Tehrani & Flynn, 2017), a minimally counter-intuitive (MCI) bias (Boyer & Ramble, 2001), and a stereotype consistency bias (Kashima, 2000). Ecological survival information bias suggests that, as human memory has evolved to be 'tuned' towards encoding and recalling ecological information related to survival and fitness better than other forms of information, humans will be biased towards ecological information relevant to survival (Nairne & Pandeirada, 2008). While social information bias suggests that, as humans evolved greater intelligence in order to deal with complex social interactions they will be biased towards information related to social interaction (Mesoudi et al., 2006). Content which evokes a greater emotional response has been shown to grant a mnemonic advantage in individual recall tests (LaBar & Cabeza, 2006) and content eliciting a greater level of disgust has been shown to have an advantage in cultural transmission (Eriksson & Coultas, 2014; Heath et al., 2001; Stubbersfield, Tehrani & Flynn, 2015); such emotional content bias suggests that humans are biased in transmission towards content that evokes a greater emotional response. MCI bias suggests that humans are biased towards content which meets a cognitively optimal balance between a small number of counter-intuitive concepts which breach category level expectations (of folk physics, folk biology etc.) and a majority of intuitive concepts (Boyer, 1994). Stereotype consistency bias suggests that humans are biased towards content which is consistent with these cultural stereotypes (Bangerter, 2000; Kashima, 2000) (see Stubbersfield, et al., 2017, for a review of the biases).

   The study uses a paradigm adapted from the linear transmission chain design. Primarily developed by Bartlett (1932) to examine schema in memory, a traditional linear transmission chain design involves material being given to the first participant who then have to reproduce the material from memory, which becomes the material for the second participant in the chain, a process repeated down the 'chain' of participants (resembling the children's game "broken telephone"). This is a paradigm which has previously been used successfully to examine content biases in recall-based transmission (see Stubbersfield et al., 2017), here the paradigm is adapted in a novel way by not relying on reproduction through recall but instead by asking participants to alter the material however they wished. This novel paradigm therefore more closely replicates the 'creative transmission' seen in electronic communication. The nature of this paradigm means that the guided variation studied here is explicitly goal-directed and intentional and as such is not representative of all forms of guided variation, some of which may feature unintentional but non-random modification. In this sense, the guided variation studied here is similar to the version presented by Claidière, Scott-Phillips and Sperber (2014), who describe it as a constructive mental process which imaginatively anticipates the effects of a modification, ('cultural attraction'). The study addressed two key questions:

1. Will the product of intentional guided variation reflect the content biases demonstrated in recall-based experiments such as transmission chains and memory tests?
2. Will the choices made by participants when altering the material reflect the choices made by participants in 'choose-to-transmit'-based experiments?

Ethics Statement

All participants provided informed consent. Ethical approval was granted by the Research Ethics and Data Protection Committee, Department of Anthropology, University of Durham. All student participants were recruited through the psychology department recruitment scheme and compensated with course credits.

Methods

This study involved three distinct phases using different participants in each stage. In Stage 1, participants rated four news stories for various criteria related to their content. Stage 2 took the form of a linear transmission chain where participants were allowed to alter the original material however they wished without having to recall it. In Stage 3 participants rated the material that was produced by the transmission chains using the same questionnaire as Stage 1. For the results the data from the Stage 1 and Stage 3 questionnaires are compared. The methodological details of each stage are provided below.

Stage 1

Participants

Eleven participants (10 female) aged 18 to 25 years (M = 20, SD = 2.05) participated. All participants were students at the University of Durham.

Materials

Four news stories were collected from the *BBC News* website (www.bbc.co.uk/news/); two were expected to exploit content biases to a greater degree (high-pea and high-tiger) than the other two (low-bridge and low-trees) providing two groups of stories low-exploit and high-exploit. Material which was likely to vary in terms of content bias exploitation was selected to allow us to examine if the process of intentional modification is a general additive process or if they would be altered differently. One story (low-trees) describes a plan to plant thousands of trees on a Cumbrian fell to boost numbers of black grouse. Another (low-bridge) describes delays on the Kessock Bridge at Inverness due to two lorries carrying abnormal loads. Another (high-pea) describes an incident in Massachusetts where a man was found to have a pea plant growing in his lung. The fourth story (high-tiger) describes an incident where a US police sniper sedated a tiger found in a Harlem apartment. These stories were presented as narratives without headlines (see supplementary material (SM) 1). Questionnaires collected data on emotional content, plausibility, relevance, survival information, social information and gender stereotypes (see SM2). In each case they were asked to rate the stories for content on a 1–7 Likert scale. Participants were asked to state which emotion or emotions they felt while reading this story. This was a free response but examples of potential emotions were provided. These example emotions (interest, joy, anger, surprise, sadness, contempt, fear, disgust) are taken from Ekman's (1992) list of Basic Emotions with the addition of interest and contempt, which were included as they have previously been found to influence the transmission of anecdotes (see Peters, Kashima and Clark, 2009). See SM2 for the full questionnaire. The order of stories presented was counterbalanced to avoid order effects.

Procedure

Each participant read the material and completed a questionnaire for each of the four stories. The same set of five questions was asked for each of the stories presented. The questions were related to emotional content, plausibility, relevance, survival information, social information and gender stereotypes. Questions 2–5 involved participants rating the content of the story on a seven point Likert scale (see SM 2).

Stage 2

Participants

Thirty participants (21 female) aged 19 to 40 years (M = 21.67, SD = 4.2) participated. All participants were students at the University of Durham.

Design

A linear transmission chain design was used, however, unlike traditional transmission chain paradigms, participants were not required to recall material but were asked to alter the material as they wished. Each of the ten chains comprised of three participants or 'generations'. Three generations have been used successfully

in diffusion chains in previous research (Barrett & Nyhof, 2001; Nielsen, Cucchiaro & Mohamedally, 2012; Stubbersfield, Tehrani & Flynn, 2015, 2017).

Materials
The material presented to the first generation was the same as that used in Stage 1.

Procedure
Participants were asked to take part in a study regarding the cultural transmission of narratives. Participants were individually presented with the experimental materials on a computer. The participants were given the following written instructions:

> 'Please edit the story to make it as interesting as possible, so that another person would be likely to tell it to a friend. You have complete freedom to alter the story however you wish but please change at least two aspects of the story.'

Participants were asked to change at least two aspects of the story to ensure that some changes were made. This was repeated for each story presented to them.

Stage 3
Participants
One-hundred participants (81 female) aged 17 to 39 years (M = 20.48, SD = 3.89) participated. The majority (87) of participants were students at the University of Durham. Non-students were recruited through opportunity sampling.

Materials
The material used in this stage was that produced by the final generations of Stage 2. The questionnaire was the same as Stage 1.

Procedure
Each participant completed the questionnaires online. Each version of each story (ten chains for each story led to ten versions of each story, totalling 40 final stories) was rated by ten participants (each participant rating four stories).

Results
Before Transmission
Significant variation was found between the news stories in emotional content (Kruskal-Wallis one-way ANOVA, $\chi^2_3 = 20.76$, $p < .001$), plausibility ($\chi^2_3 = 15.02$, $p < .005$), survival information ($\chi^2_3 = 15.12$, $p < .005$) and gender stereotype consistent behaviour ($\chi^2_3 = 11.67$, $p < .01$). Pairwise comparisons using Dunn's (1964) procedure were used to examine the differences between individual stories. It was found that low-trees and low-bridge stories scored significantly lower than high-pea and high-tiger in emotional content ($ps < .05$). Low-trees scored significantly higher than high-pea in plausibility ($p < .005$). Low-bridge scored significantly lower than high-pea in survival information ($p < .005$). High-tiger scored significantly higher in gender stereotyped behaviour than low-trees ($p < .005$). See **Table 1** the mean ratings for each news story before transmission and SM3 for details of the significant differences between stories.

Table 1: Means and standard deviations of rating scores for each news story before transmission.

Story	Mean (SD)					
	Emotional	**Plausibility**	**Relevance**	**Survival**	**Social**	**Stereotype**
Trees	3.73(1.35)	6(1.1)	2.82(1.25)	2.73(1.62)	1.82(1.08)	1.36(.67)
Bridge	3.36(1.57)	4.91(1.87)	1.91(1.45)	1.91(1.22)	2.36(1.03)	1.91(.83)
Pea	5.55(.82)	2.82(2.04)	2.36(1.63)	4.55(1.29)	2.91(1.14)	1.91(.7)
Tiger	5.36(.67)	3.82(1.6)	1.64(.92)	3.55(1.44)	2.45(1.57)	3.09(1.38)

Note: Rating scale ran 1–7. For plausibility low scores represent less plausible.

After Transmission

Significant variation was found between the transmitted stories in emotional content (Kruskal-Wallis one-way ANOVA, $\chi^2_3 = 10.10$, $p < .05$), plausibility ($\chi^2_3 = 22.59$, $p < .001$), relevance ($\chi^2_3 = 28.47$, $p < .001$), survival information ($\chi^2_3 = 17.46$, $p < .005$), social information ($\chi^2_3 = 25.25$, $p < .001$) and gender stereotyped behaviour ($\chi^2_3 = 13.74$, $p < .005$). Dunn's (1964) procedure for pairwise comparisons was used to compare individual stories. High-pea scored significantly higher than low-trees in emotional content ($p < .05$). Low-bridge scored significantly higher than high-pea and high-tiger in plausibility ($ps < .05$) and high-pea also scored significantly lower than high-trees in the same score ($p < .005$). Low-trees scored significantly higher than high-pea and high-tiger in relevance ($ps < .001$). High-pea scored significantly higher than low-bridge in survival information ($p < .005$). Low-bridge scored significantly higher than all other stories in social information ($ps < .01$). High-tiger scored significantly higher than low-trees and high-pea in gender stereotyped behaviour ($ps < .05$). See **Table 2** the mean ratings for each news story after transmission and SM4 for details of the significant differences between stories.

Before and after transmission comparison

Low-Trees

The plausibility score was found to be significantly lower after transmission (Mann-Whitney $U = 105$, $p < .001$). No other significant differences were found ($Us = 690–380$, $ps > .05$).

Low-Bridge

The plausibility score was found to be significantly lower after transmission ($U = 235$, $p < .005$) and the social information score was found to be significantly higher ($U = 782.5$, $p < .05$). No other significant differences were found ($Us = 713–584.5$, $ps > .05$).

High-Pea

No significant differences were found ($Us = 384.5–502.5$, $ps > .05$), although the relevance score was marginally significantly different after transmission ($U = 384.5$, $p = .051$).

High-Tiger

The emotional content score was found to be significantly lower after transmission ($U = 354$, $p < .05$) as was the plausibility score ($U = 245.5$, $p < .005$). No other significant differences were found ($Us = 621.5–394.5$, $ps > .05$).

Qualitative Analyses

During coding it was observed that certain additions and changes frequently occurred and were common across the stories. As such a qualitative analysis was conducted using NVivo 10 (QSR International, 2012). See **Table 3** for results. The common changes or additions considered were:

· The addition of Minimally Counterintuitive (MCI) concepts, here defined as concepts which breach category level expectations of folk physics, folk biology etc. (e.g. the inclusion of magical creatures, superhuman abilities and sci-fi elements).
· The addition of content intended to be found amusing by the reader.
· Exaggeration of elements in the story, either simply the physical dimensions of an element (e.g. the size of the pea in high-pea) or an exaggeration of the story's events (e.g. the landslide in low-trees being deadly).
· The addition of references to popular culture such as celebrities.
· A change to the location of the story's setting.

Table 2: Means and standard deviations of rating scores for each news story after transmission.

Story	Mean (SD)					
	Emotional	**Plausibility**	**Relevance**	**Survival**	**Social**	**Stereotype**
Trees	4.18(1.38)	2.77(1.85)	2.18(1.24)	3.09(1.81)	2.51(1.45)	2.09(1.56)
Bridge	4.21(1.59)	2.89(1.83)	1.91(1.18)	2.45(1.48)	3.56(1.63)	2.39(1.59)
Pea	4.76(1.6)	1.94(1.48)	1.54(.99)	3.59(2.04)	2.66(1.7)	2.14(1.54)
Tiger	4.54(1.45)	2.20(1.57)	1.48(.77)	2.82(1.7)	2.77(1.52)	2.78(1.73)

Note: Rating scale ran 1–7. For plausibility low scores represent less plausible.

Table 3: Results of the qualitative analysis. The table shows the percentage frequency common additions or changes made to the stories.

Addition/Change	Frequency in each story (% of stories)				Frequency in all stories (%)
	Low-Trees	Low-Bridge	High-Pea	High-Tiger	
MCI content	50	40	80	40	52.5
Amusing content	60	60	50	60	57.5
Exaggeration	40	50	60	60	52.5
'Pop culture'	20	40	20	40	30
Location change	20	10	0	10	10

Discussion

The aim of this study was to examine the effects of intentional guided variation on the evolution of narratives, in this case news stories. In particular the aim of the study was to test if the product of transmission based solely on individual modification rather than recall would reflect the content biases that have been suggested by previous research using recall-based paradigms. To do this two key questions were addressed:

1. Will the product of guided variation reflect the content biases demonstrated in recall-based experiments such as transmission chains and memory tests?
2. Will the choices made by participants when altering the material reflect the choices made by participants in 'choose-to-transmit'-based experiments?

Previous research examining unintentional guided variation using recall-based experiments such as transmission chains and memory tests has given support to a number of content biases in cultural transmission (see Stubbersfield, Flynn & Tehrani, 2017). Emotional content bias has been demonstrated in studies based on recall and also the 'choose-to-transmit' phases of transmission (Berger & Milkman, 2010; Erikkson & Coultas, 2014; Heath, Bell & Sternberg, 2001; Peters, Kashima and Clark, 2009). Lyons and Kashima (2006) found that stereotype consistency bias only emerged in a linear transmission chain where there was communicative intent but did not emerge in a recall-based chain. Here, it was tested whether participants would enhance the degree to which material contained emotionally-arousing information, stereotypically-consistent information, social information, survival information and MCI concepts.

In order to examine this, a novel 'creative transmission chain' paradigm was used. Participants in a linear transmission chain were given material (original material being an article from the BBC News website) and were asked to alter this material however they wished, in contrast to having to recall it as in traditional linear transmission chain experiments. Before transmission the stories were separated into two groups: those which were rated as more plausible but less emotive (low-trees and low-bridge) and those which were rated as less plausible but more emotive (high-pea and high-tiger). This allows for a comparison between the two groups with regards to how they are altered through guided variation. After the material had been transmitted the differences in scores between the two groups was less marked. The low-exploit stories became less plausible and in one case (low-bridge) scores significantly increased in social information. The scores for the high-exploit stories were largely consistent between before and after transmission, the only significant change being that high-tiger's emotion score reduced. The only story not to reduce in plausibility was high-pea, although that story had the lowest plausibility score before transmission.

With regards to whether the product of guided variation reflects the content biases demonstrated in recall-based experiments such as transmission chains and memory tests, the results suggest, where biased content did increase, this was consistent with the findings of recall-based experiments and is therefore comparable to unintentional changes in transmission. The biases that increased, social information and stereotyped content, have both been demonstrated in recall-based experiments. The fact that this was not consistent across all stories suggests that while certain biases may provide a recall advantage, both individually and cumulatively, these biases are not deliberately added or enhanced when recall is not necessary for transmission and may be uniquely unintentional changes made in recall-based transmission. The finding that stereotype consistent content increased in one story is consistent with Lyons and Kashima (2006) who found that this bias emerged when there was communicative intent.

With regards to whether 'the choices made by participants when altering the material reflect the choices made by participants in 'choose-to-transmit'-based experiments, the results were not consistent with these

studies. While 'choose-to-transmit' studies have found that more emotive content is more likely to be chosen to be transmitted over less emotive content (Erikkson & Coultas, 2014; Heath, Bell & Sternberg, 2001; Peters, Kashima and Clark, 2009), the degree to which the stories in this study evoked emotion did not alter.

Qualitative analysis provides insight into how the stories were altered and how this may have affected the individual bias scores. Frequently changes were made with the apparent intention of making the story more amusing, in some cases using punch lines, (e.g. having a clown being taken into "CUSTARDy"). This is consistent with an analysis of content biases in urban legends which found amusement to be the most frequently evoked emotion (Stubbersfield et al., 2017). Amusement is considered by Ekman (1999) to share characteristics with the Basic Emotions and the addition of amusing content could be seen as an attempt to increase how emotive the stories are. These attempts at inducing amusement, however, did not increase emotion scores, suggesting that they were unsuccessful. Another common alteration was to exaggerate elements of the story, such as increasing the physical dimensions of a story element (e.g. the growth mentioned in high-pea is ½ an inch in the original material but became as large as three miles), or exaggerating events (e.g. the landslides in low-trees becoming deadly). Again, however, these exaggerations did not increase the evoked emotion and are likely to have reduced the plausibility score. Exaggeration of narrative elements has been observed in a recall-based transmission chain study, with elements becoming more explicitly violent (Stubbersfield, Tehrani & Flynn, 2015), suggesting that the intentional exaggeration found here is comparable to unintentional changes made in recall-based transmission.

Another common alteration that probably reduced plausibility scores was the inclusion of MCI elements (here defined as content which breaches category level expectations) which were found in close to half of the material produced by the chains. The MCI elements ranged from mythical creatures, such as unicorns, to more sci-fi like elements, such as space-craft or superheroes. Although this probably reduced the plausibility scores, the inclusion MCI elements could enhance the transmission success of the stories. The introduction of MCI elements (where there were none before) has not been observed in recall-based transmission studies suggesting that it is a unique to intentional change. The fact that MCI elements are preserved in recall-based transmission, however, suggests that this intentional inclusion of MCI elements reflects cognitive biases or an unconscious appeal to cognitive biases. Other, less frequently observed changes reflect tropes commonly seen in urban legends. These include references to popular culture, references to celebrities such as actor Charlie Sheen and location changes. The introduction of celebrities appears to reflect social information bias. By introducing real people likely to be known to the reader, the author increases the social relevance of the information provided in the narrative, thereby exploiting social information bias.

An unexpected result of the study was that there was not a general increase in the biased content across all stories. Instead it was found that only one exploit-low story showed an increase in biased content and that this was not across all biases. This story only increased in social information but in a number of examples both low-exploit and high-exploit stories had MCI elements added to them. One might expect guided variation to work in a similar manner to traditional recall-based transmission and enhance how transmissible the material is by increasing all biases. However, an analysis of urban legends found that even in narratives which have been transmitted multiple times in an online environment the majority only exploited between one and three content biases (Stubbersfield et al., 2017) so this low degree of change reflects what is observed in 'real world' material. Future research should examine the effect of multiple biases by examining which combination of biases make a narrative more memorable and more transmittable, and whether a large number of biases actually make material less transmissible.

The finding that the exploit-high group did not increase in any biases (although MCI content was added to a number of versions) can be explained in a number of ways. First, the participants may not be skilled in creatively making stories that already exploited biases even more entertaining. Altering a narrative that may already be successful in transmission so that it is even more appealing to an audience could be a challenge and in a real environment only the most successful versions would be selected for transmission by readers. A second explanation draws on a methodological issue. The use of a Likert scale to assess the content means that material which already scored high on this scale had less opportunity to increase after transmission.

This study is the first to examine how transmission without recall, allowing participants to deliberately alter the material however the wish, may reflect cognitive content biases found in recall-based transmission. As such it is also the first study to explicitly examine content biases in intentional guided variation. Previous research by Mesoudi (2008) compared arrow-head designs produced through context bias and through guided variation and found that under certain circumstances guided variation can produce similar outcomes to cultural transmission. This study found that guided variation is effective in increasing the degree to which material exploits content biases to some extent but only when the original material does not exploit biases to

a great extent. Only the suggested content biases of social information and MCI were found to be increased. No other content biases were increased. Unlike recall-based experiments where aspects of material either are retained or degrade, here new material was introduced increasing the number of biases that material may exploit. Material which already exploits biases to a greater degree was found not to be enhanced by guided variation. The results of this study suggest the importance of both deliberate changes and selection in the evolution of a culturally successful narrative as intentional guided variation alone appears not to enhance narratives to any great degree in terms of their exploitation of content biases.

As with many other studies in this field (and more broadly in the social sciences), the participants recruited were from a WEIRD population (Western, educated, industrialised, rich and democratic, see Henrich, Heine, & Norenzayan, 2010) and could be considered to be broadly homogenous, especially when compared to humans as a whole. We are therefore limited in terms of how various individual, demographic and contextual variations may influence these results. We acknowledge this as a limitation of the current study in terms of representation and generalisability, especially as electronic communication and the issue of misinformation online is particularly global in scope. Future research should endeavour to recruit participants from a wider pool to enhance representation. Further, while the present experimental approach has advantages in terms of internal comparison and confounding variable control, the examination of 'creative transmission' could be enhanced through the qualitative and quantitative examination of extant datasets of electronic communication, which could be then compared to experimental results while offering insights into contextual factors.

Future research could address these issues more directly by using the same material in both intentional modification transmission chains and traditional recall-based transmission chains. Further, it would be interesting to examine the modifications at each generation, to assess trends in the changes made to stories, rather than simply the total cumulative effects examined here. Additionally, future research should examine the effects of motivation on this process as perhaps one of the most interesting aspects of the alterations made to electronic material when it is transmitted is why some would change it at all, rather than simply forwarding it or choosing not to transmit it. With specific audiences or motivations in mind the creative changes made by participants could be very different to those made in this study. In particular, how the cognitive biases examined here may interact with the political or ideological biases examined in other fields of cultural science would be a valuable avenue of future research. For instance by examining if content biases in guided variation operate differently on material reflecting one's own ideological biases compared to martial which opposes them. Further, with reference to motivations and concepts of audience, it would be interesting to examine how the alterations made by individuals trained in creative arts or journalism differ from those who do not possess such training. Another potential avenue for future research would be to examine the interaction between the choose-to-receive phase of transmission and guided variation in transmission so as to investigate the roles of both selective and mutational processes in cultural evolution.

This study represents a first attempt to empirically examine how individual cognitive processes can result in population patterns in electronic communication. This area of research is vital as, while data science approaches such as Vosoughi, Roy and Aral (2018) can give fascinating insights into the nature of largescale patterns they are limited in answering how and why these patterns emerge. The findings here suggest that when the story in question already exploits content biases it may not be modified in electronic transmission and will be preserved. However, if someone feels motivated to transmit a story which does not appear to exploit content biases, it may be modified to gain greater appeal, likely through the inclusion of content to appeal to social bias, as such its accuracy may be lost. This study provides, therefore, provides a useful insight into how misinformation online could be produced through mutational cultural evolution, such as through intentional guided variation, and what direction these changes are likely to take. As such it gives greater understanding of an element of the wider phenomenon of online false news and misinformation.

Additional Files
The additional files for this article can be found as follows:

· **SM 1.** News stories used as original material. DOI: https://doi.org/10.5334/csci.109.s1
· **SM 2.** Questions used in questionnaires for Stage 1 and Stage 3. DOI: https://doi.org/10.5334/csci.109.s1
· **SM 3.** Table showing the significant mean differences between each news story before transmission (at $p < .05$). DOI: https://doi.org/10.5334/csci.109.s1
· **SM 4.** Table showing the significant mean differences between each news story after transmission (at $p < .05$). DOI: https://doi.org/10.5334/csci.109.s1

Competing Interests

The authors have no competing interests to declare.

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