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Original Article

The sky is falling: evidence of a negativity bias in the social transmission of information

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ABSTRACT

The method of serial reproduction has revealed that the social transmission of information is characterized by the gradual transformation of the original message. This transformation results from the preferential survival of certain types of information and the resolution of ambiguity. Here we present evidence of a bias favoring the social transmission of negatively-valenced information across multiple transmission episodes. Ninety-two, four-person chains transmitted a story containing unambiguously positive and unambiguously negative story events, along with ambiguous story events that could be interpreted positively or negatively. Analysis using mixed-effects modeling revealed the preferential survival of unambiguously negative events over positive events, and the increasingly negative resolution of ambiguous events across successive transmission episodes. Contrary to predictions, elevated state anxiety did not enhance the social transmission of negatively-valenced information. We also found that the survival of unambiguously negative story events was positively correlated with the negative resolution of ambiguous story events, reflecting a general negativity-bias in the social transmission of information.

1. Introduction

The social transmission of information contributes to the evolution of culture. The corpus of knowledge, beliefs and norms that define a culture, not only accumulates but changes across generations as the result of imperfect information transfers from one person to another. Such social transmission is evident in the oral histories of various social groups. For example, socially transmitted folktales and urban legends serve to shape our expectations and beliefs about people, institutions and sources of potential threat. Viral messages on social media platforms are perhaps the most modern expression of social transmission, and serve to rapidly shape our culture. While cultural stability relies on the faithful transmission of knowledge (Tan & Fay, 2011), research suggests that the social transmission of information rarely involves perfect reproduction of the information that was received. Rather it is a reconstructive process, during which certain details are transformed or lost (Bartlett, 1932). Imperfect reproduction, coupled with differential survival of particular elements across successive generations, represents the two cornerstones of cultural and biological evolution.

Extensive research indicates that social transmission is biased, such that certain types of information tend to survive better than others, thereby shaping cultural change (for a review, see Mesoudi & Whiten, 2008). There is evidence of selectivity in the way people process information that may contribute to biased transmission, such that the product of social transmission reflects these underlying patterns of processing selectivity (Kalish, Griffiths, & Lewandowsky, 2007). It is clear that people exhibit patterns of processing selectivity that favor negatively-valenced information over positively-valenced information (Baumeister, Bratslavsky, Finkenauer, & Vohs, 2001). Some theorists have suggested that an information processing advantage for negative information may enhance our survival because it enables us to readily identify and avoid potential threat (Rozin & Royzman, 2001). However, whether there is a bias in the *social transmission* of information, such that negative information is preferentially transmitted over positive information, has not been established. The current study tests this hypothesis, by assessing the social transmission of negatively-valenced information compared to positively-valenced information. In addition, the impact of elevated state anxiety on the selective transmission of negative and positive information is investigated to test the hypothesis, derived from the emotion and cognition literature, that heightened anxiety may be associated with a greater bias favoring the enhanced social transmission of negative information relative to positive information.

1.1. Social transmission in the laboratory

The social transmission of information has been simulated experimentally in a wide range of studies that have adopted the method of serial reproduction, pioneered by Bartlett (1932). In a typical serial reproduction study, a participant is exposed to a novel stimulus, for example, a short story. The participant reads the story and, after a delay,

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communicates the story to a second participant. The second participant reads the first participant's version of the story and then communicates the story to a third participant, and so on. Examining the output generated by participants across successive transmission episodes allows researchers to experimentally test which elements survive social transmission, which are lost and which are transformed.

Caldwell and Millen (2010) argue that serial reproduction studies provide a better analogue of the processes involved in social transmission compared to designs that involve a single transmission episode. For example, using a single transmission experiment Horner and Whiten (2005) found that young children (3–4 years old) tend to copy all elements of a demonstration, regardless of whether these elements were relevant to the goal. In contrast, Flynn (2008), using a serial reproduction design, found that irrelevant elements were quickly lost over successive transmission episodes, with only causally relevant elements of the demonstration surviving. Serial reproduction studies have been used to examine a wide range of social processes in human and non-human populations. For example, this methodology has been used to study the evolution of communication systems in birds (Fehér, Wang, Saar, Mitra, & Tchernichovski, 2009) and humans (Caldwell & Smith, 2012; Garrod, Fay, Rogers, Walker, & Swoboda, 2010; Kirby, Cornish, & Smith, 2008). It has also been used to experimentally study the cumulative cultural evolution of concrete artifacts (Caldwell & Millen, 2008; Muthukrishna, Shulman, Vasilescu, & Henrich, 2014).

Of particular relevance to the present study is how this method can be used to identify the patterns of selectivity that operate during the social transmission of information (Kalish et al., 2007). A key finding is that during social transmission the content of messages becomes modified in systematic ways, with certain types of information surviving better than others. For example, Mesoudi, Whiten, and Dunbar (2006) found that social information survives across successive transmission episodes better than asocial information. Other investigators have shown that stereotype-consistent information survives better than stereotype-inconsistent information (Kashima, 2000; Lyons & Kashima, 2001, 2003, 2006), and this may help explain how cultural stereotypes are maintained. In addition to the preferential survival of particular types of information, processing selectivity is also evidenced with respect to how ambiguous information is resolved over multiple transmission episodes. In his classic early studies Bartlett (1932) showed that participants transformed ambiguous elements in a narrative to fit with their cultural understanding of objects and events. For example, 'something black' that came out of a man's mouth in Bartlett's original Native American script was disambiguated as his 'soul' in later stages of serial reproduction. Thus, social transmission may be associated with biases in the resolution of ambiguity, as well as biases in the relative survival of differing types of unambiguous information.

1.2. The social transmission of emotionally valenced information

People may be biased to favor the social transmission of negatively-valenced information over positively-valenced information. A large body of research indicates that negative information has a processing advantage over positive information (Baumeister et al., 2001). For instance, negative information is detected faster than positive information (Dijksterhuis & Aarts, 2003), and exerts a greater influence on impression formation (Peeters & Czapinski, 1990). Infants also exhibit a processing advantage for negative information. For example, a neurodevelopmental study that measured ERPs in response to adult displays of negative, neutral and positive affect, found that infants' responses to negative cues were significantly elevated compared to their responses to neutral and positive cues, suggesting greater attention to negative than to positive information (Carver & Vaccaro, 2007). These findings suggest that a processing advantage for negative information may serve important evolutionary and survival functions (Rozin & Royzman, 2001). Negative information may be of greater importance to our survival than positive information because processing negative information enables us to avoid potential dangers (Baumeister et al., 2001). Consistent with this, the decision-making literature indicates that people prefer to avoid losses over acquiring gains, a phenomenon known as loss aversion (Tversky & Kahneman, 1991). This suggests that people are more strongly motivated to detect and respond to negative information compared to positive information.

If negative information is preferentially processed, then we can predict that it will be more likely to survive across successive social transmission episodes. Evidence of such a negativity bias in the social transmission of information comes from studies examining the spread of rumors. For example, Walker and Blaine (1991) planted an equal number of negatively- and positively-valenced rumors among a cohort of college students. Students were more likely to report having heard a negative rumor than a positive rumor, one-week later. Similarly, Fessler, Pisor, and Navarrete (2014), found that urban legends typically contain three times as much information about hazards as they do about benefits. Such findings are consistent with the idea that the social transmission of information is distorted by a bias that favors negative informational elements. However, this evidence is indirect, as these methodological approaches only examined the products of social transmission, not the social transmission process itself, and therefore do not directly test whether such a bias operates to shape the evolution of the transmitted message content.

The method of serial reproduction has been used to capture the processes that operate, across multiple transmission episodes, to increase the prevalence of negative information compared to positive information during social transmission. Eriksson and Coultas (2014) examined the social transmission of stories that differed in their level of disgust content. Their key finding was that stories with greater disgust content were transmitted with greater fidelity than stories with lower disgust content. This is consistent with the possibility that a bias may operate that favors the transmission of negatively-valenced information during social transmission. However, because they did not include positive emotional information in their study, Eriksson and Coultas' findings could be attributed to a social transmission advantage for emotional information in general, rather than for negative emotional information in particular. To date, the survival of positive emotional information during serial reproduction has not been examined. The present study included positive and negative information to provide the first direct comparison of the survival of negatively-valenced and positively-valenced information using the method of serial reproduction. This permits a direct test of the Negative Survival Hypothesis, which predicts that negatively-valenced information, compared to positively-valenced information, will exhibit enhanced survival across social transmission episodes. There are two variants of this hypothesis. The general variant of the Negative Survival Hypothesis predicts that negatively-valenced information will be more common than positively-valenced information during social transmission (i.e., a main effect of Valence). The intergenerational variant of this hypothesis predicts that negatively-valenced information will become increasingly common compared to positively-valenced information across transmission episodes (i.e., a Valence by Chain Position interaction). The method of serial reproduction allows us to distinguish between the validity of these two variants by examining the survival of positive and negative information across multiple transmission episodes.

The selective survival of different informational elements is the most common focus of social transmission studies. However, other forms of transformation occur during social transmission, most notably the resolution of ambiguous information (Bartlett, 1932). Ambiguity, whether linguistic or behavioral, is a pervasive aspect of everyday human life. The method of serial reproduction can be used to reveal how ambiguity is resolved across multiple social transmission episodes. The manner in which social transmission affects the resolution of emotionally ambiguous information will have important consequences for the emotional tone of the evolving message. For example, the statement 'Brian's presentation made the class laugh' could be interpreted to mean that

Brian's presentation was witty and the class laughed with him (positive interpretation), or that Brian's presentation was so bad that the class laughed at him (negative interpretation). The method of serial reproduction can reveal whether the emotional valence of alternative candidate interpretations influences how such ambiguous information is resolved across multiple social transmission episodes.

Given the previously identified processing advantages for negatively-valenced information, we predict that negative resolutions of ambiguous information will be favored during social transmission. We term this the Negative Resolution of Ambiguity Hypothesis. As with the Negative Survival Hypothesis, two variants of the Negative Resolution of Ambiguity Hypothesis can be distinguished. The general variant of the Negative Resolution of Ambiguity Hypothesis predicts that negative resolutions of ambiguity will occur more often than positive resolutions of ambiguity (i.e., a main effect of Valence). The intergenerational variant of this hypothesis predicts that, as ambiguous story events are resolved across successive social transmission episodes, negative resolutions of ambiguity will become progressively more likely than positive resolutions of ambiguity (i.e., a Valence by Chain Position interaction).

1.3. The impact of anxiety on the transmission of emotional information

It is plausible that state anxiety will influence the selective transmission of emotionally valenced information. Extensive research has established that elevated anxiety is characterized by a range of biases that favor the processing of negative information (Mathews & MacLeod, 2005). For example, highly anxious people are faster to engage with and slower to disengage from negative information than less anxious people (Rudaizky, Basanovic, & MacLeod, 2013). In addition, compared to less anxious people, highly anxious people disproportionately favor negative interpretations of ambiguous information (Richards, 2004; Wilson, MacLeod, Mathews, & Rutherford, 2006). Hence, we propose the Anxiety-Linked Negative Transmission Hypothesis, which predicts that anxious mood state will amplify the bias favoring the social transmission of negatively-valenced information. To test this hypothesis, a state anxiety manipulation was used in the present study. This enabled us to directly examine whether, as predicted, when members of a social transmission chain experience elevated state anxiety, the preferential social transmission of negative relative to positive emotional information becomes more pronounced.

1.4. The current study

The current study used the method of serial reproduction to test three novel hypotheses related to the social transmission of emotionally valenced information. To test the Negative Survival Hypothesis, the survival of unambiguously negative and unambiguously positive information across multiple transmission episodes was measured. To test the Negative Resolution of Ambiguity Hypothesis we examined the prevalence of positive and negative resolutions of initially ambiguous information across multiple transmission episodes. Finally, to test the Anxiety-Linked Negative Transmission Hypothesis, the impact of state anxiety on the social transmission of valenced information was examined. To manipulate state anxiety participants in transmission chains were exposed to either a high or low state anxiety induction condition.

2. Method

2.1. Overview and design

Participants were randomly allocated to 92 four-person transmission chains (N = 368), and each participant was randomly assigned to a position in their chain (1–4). In addition, each chain was randomly allocated to either the elevated anxiety mood induction (N = 44 chains) or a reduced anxiety mood induction (N = 48 chains), with each member of a given chain receiving the same mood induction. The first person in each chain was presented with the target story, which contained a variety of negative, positive and ambiguous story events. This participant read and then reproduced the story in writing for the next person in their chain, by typing the story into a textbox on the computer screen. The second person in each chain read the first person's written account of the story and reproduced it in writing for the next person in the chain, who did the same until all four participants in each chain had produced a written account of the story. This allowed us to measure the relative survival of negative and positive story events across transmission episodes, as well as the proportion of negative and positive resolutions of the originally ambiguous story events.

2.2. Participants

Participants in this study were 368 undergraduate psychology students (269 female; 99 male) from the University of Western Australia, ranging in age from 18 to 49 years with an average of 20.74 years (SD = 4.22).[1] A one-way ANOVA revealed that that the age of participants assigned to the elevated anxiety and reduced anxiety mood induction conditions did not significantly differ, $F(1364) = 2.58$, $p = .11$. There was also no difference in gender ratio between participant groups allocated to each mood induction condition, $\chi^2(1) = .82$, $p = .37$.

2.3. Materials

2.3.1. Story

The story created for the present study centered on a young girl who was traveling to the UK from Australia, and described a sequence of 57 events that happened during her flight.[2] Eight unambiguously negative and eight unambiguously positive events were included in the story, and each event was described in a single statement. For example, “The man in the seat next to her seemed to have a nasty cold” described a negative event used in the story, and “When (the air hostess) returned she told Sarah that she would be moved to business class” described a positive event used in the story. The story also included eight ambiguous events that could be interpreted in either a negative or a positive manner. For example, the statement “Walking down the concourse, Sarah saw a young man take an old women's bag” described an ambiguous event that could be interpreted to mean that the young man stole the women's bag (negative) or that the young man helped the old women carry her bag (positive). Thirty-three filler statements were included that were neutral with regard to valence and were used to connect the negative, positive and emotionally ambiguous events in the story (e.g. “On the day of her trip Sarah arrived at the airport.”).

To verify that the unambiguously positive and negative events had the intended valence, descriptions of these events were rated by six independent judges. The judges indicated how pleasant they found each event on a 7-point scale ranging from ‘Very unpleasant’ (−3) to ‘Very pleasant’ (3), with a score of zero representing neutral valence. The mean rating for the negative events was −1.81 (SD = .62), which was significantly lower than zero, $t(7) = 8.27$, $p < .01$, confirming their negative valence. The mean rating for the positive events was 2.21 (SD = .58), which was significantly higher than zero, $t(7) = 10.70$, $p < .01$, confirming their positive valence.

For the ambiguous events, it was important to verify that the positive and negative resolutions had the intended valence. This was achieved by having the same six judges rate the positive and negative resolutions of the ambiguous events in the same manner they had rated the unambiguous positive and negative events. Raters were given descriptions of the negative and non-negative resolutions of each ambiguous statement, presented in random order, and were

[1] Age was not entered by two participants.
[2] See Supplementary Materials 1 for the original story script.

asked to indicate how pleasant they found each event on a 7-point scale from 'Very unpleasant' (−3) to 'Very pleasant' (3), with a score of zero representing neutral valence. The mean rating for the negative resolutions was −2.10 (SD = .47), which was significantly lower than zero, $t(7) = 12.66$, $p < .01$, confirming their negative valence. The mean rating for the positive resolutions was 1.44 (SD = 1.06), which was significantly higher than zero, $t(7) = 3.84$, $p < .01$, confirming their positive valence.

2.3.2. Anxiety manipulation videos

A video induction procedure was employed to induce differentially anxious mood. Previous studies have demonstrated the capacity of emotive videos to influence mood states, including anxiety. For example, a study by Wilson et al. (2006) used film clips of real-life rescue operations to elevate anxiety in undergraduate participants. The current study adopted a similar procedure. To select the video clips used in this study, an initial pool of 36 video clips was assembled. All video clips were edited to be one-minute long, and included full audio soundtracks. Videos clips were chosen because of their perceived capacity to either elevate anxiety (18 videos) or reduce anxiety (18 videos). Examples of videos clips we considered viable candidates for elevating anxiety include a rally car crash, daredevils scaling high-rise buildings without ropes and a boat accident. Examples of video clips we considered viable candidates for reducing anxiety include a documentary about birds, a cooking demonstration and a beach scene.[3] These candidate video clips were rated on the basis of their capacity to increase or reduce anxiety. Six independent judges, blind to the purpose of the experiment, indicated the extent to which each candidate video clip "would be likely to make you feel more or less tense". Responses were recorded on a 7-point scale that ranged from 'A lot more relaxed' (−3) to 'A lot more tense' (3). The terms used as anchors on this scale were taken from items on the short form of the Spielberger State–Trait Anxiety Inventory (Marteau & Bekker, 1992). Mean valence ratings were calculated for each of the 36 video clips. The four video clips with the highest mean ratings were chosen for use in the elevated anxiety mood induction condition (min rating: 2.17; max rating: 2.67). The four video clips with the lowest mean ratings (min rating: −2.30; max rating: −2.0) were chosen for use in the reduced anxiety mood induction condition. Two mood inductions were used during the study. In both inductions, participants viewed two videos, presented one after the other, without a break between. The first induction took place immediately before reading the story and will be referred to as the encoding phase induction. The second induction took place prior to reproducing the story and will be referred to as the transmission phase induction. This transmission phase induction was designed to reinstate the mood induced during story encoding, when participants reproduced the story.

2.3.3. Mood ratings

To verify that the anxious mood manipulation was successful, participants rated their level of anxiety before and after each induction using two visual-analogue mood scales (VAMS). These required participants to respond to the statements 'I am relaxed' and 'I am worried' by moving a cursor along a line from 'Not at all' to 'Very much'. These two items were chosen to capture the physiological and cognitive components of the experience of anxiety and were again taken from the Spielberger State–Trait Anxiety Inventory (Marteau & Bekker, 1992). Possible scores on the VAMs ranged from 1 to 60, with higher scores indicating higher levels of anxiety. Mean scores on the VAMs were computed for each participant, and were our measure of anxious mood.

2.4. Procedure

The procedure was the same for all participants, with the exception of the mood induction videos. The video clips presented were determined by the mood induction condition to which their transmission chain was allocated. All participants within a given chain were allocated to the same mood induction condition (though, participants were not informed of this). Participants initially completed a pre-task questionnaire that collected demographic information. They were then randomly allocated to a four-person transmission chain, and to their position in the chain. Participants first completed the VAMS to provide a baseline indication of their anxiety level. They next received the first mood induction. Participants then completed the VAMS again, to rate their anxiety a second time. Next, they were given the story to read. The first person in each chain, regardless of mood induction condition, received the same original story. All other participants received the story that had been produced by the participant who immediately preceded them in the transmission chain. Participants were asked to "… carefully read the story as you will later be asked to reproduce it for the next person in your chain."

Participants were given 165 seconds to read the story. This timing was based upon data from pilot testing of 20 participants, which revealed that participants took, on average, 131.84 seconds (SD = 32.80) to read the story. Participants were given the mean reading time plus one standard deviation to read the story. They were also presented with a progress bar that indicated how much time they had left to read the story. After reading the story, participants completed the VAMS for a third time, to record their anxiety level. Participants then received the second mood induction (in the same condition as the first) after which they completed the VAMS for a fourth, and final, time. Finally, participants were asked to "retell the story you read earlier for the next participant in your chain" by typing it out on the computer. They were told, "The next (participant) in your chain will not read the original story, they will only read your story and then retell it for another (participant)." Participants were told that they would have 10 minutes to retell the story and a progress bar indicated how much time was left. If participants finished retelling the story before the 10 minutes elapsed, they could click a button to end the experiment.

3. Results

Three issues were investigated in the present study. First, the survival of unambiguously negative and unambiguously positive story events (present in the original script) was examined. The general variant of the Negative Survival Hypothesis predicts that negative story events will show enhanced survival compared to positive story events. The intergenerational variant of the Negative Survival Hypothesis predicts that the survival of negative story events, relative to positive story events, will increase across transmission episodes. Second, the resolution of ambiguous story events was examined. The general variant of the Negative Resolution of Ambiguity Hypothesis predicts that the negative resolution of ambiguous story events will be more common than positive resolutions. The intergenerational variant of the Negative Resolution of Ambiguity Hypothesis predicts that negative resolutions of ambiguous story events, relative to positive resolutions, will increase across transmission episodes. Third, the impact of anxious mood state on the social transmission of valenced information was examined to test the Anxiety-Linked Negative Transmission Hypothesis, which predicts that the effects predicted by the Negative Survival Hypothesis and the Negative Resolution of Ambiguity Hypothesis will be disproportionately evident for participants in the elevated anxiety induction condition.

3.1. Mood manipulation

Fig. 1 shows the anxiety ratings at each assessment point and reveals a significant increase in anxiety following each induction for participants in the elevated anxiety induction condition and a significant decrease in anxiety following each induction for participants in the reduced anxiety condition. Separate 2 × 2 mixed design ANOVAs for

[3] These materials are available online at: http://comlab.me/ComLab/Negative-bias.html.

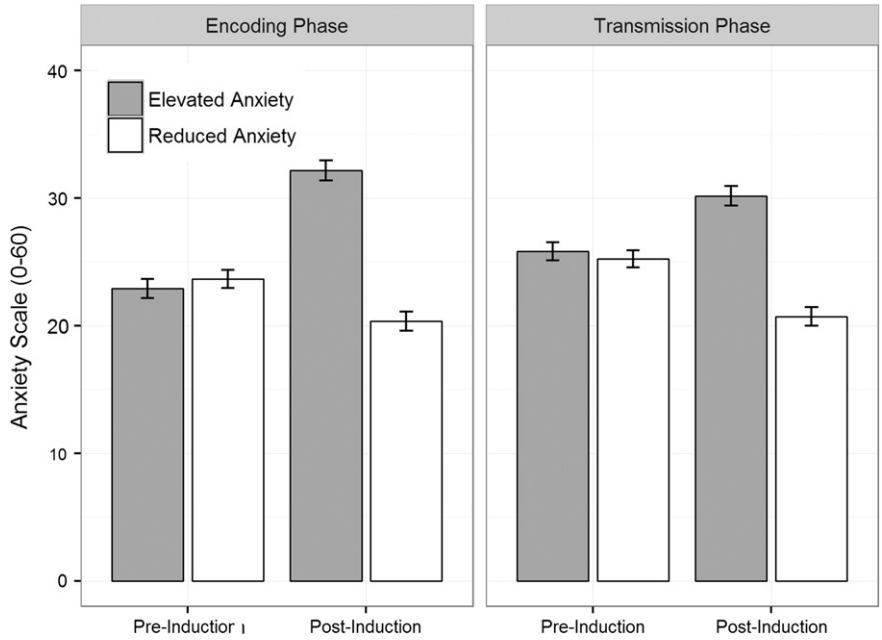

Fig. 1. Mean mood ratings for the anxiety VAMS reported during the experiment. Error bars represent standard error of the means.

each mood induction, that treated mood induction condition (elevated anxiety vs. reduced anxiety) as a between groups factor and mood assessment point (pre-induction vs. post-induction) as a within groups factor, confirmed these findings. Specifically, the ANOVA carried out on the encoding phase induction mood ratings revealed a significant interaction between mood induction condition and mood assessment point, $F(1366) = 220.46$, $p < .001$, $\eta^2 = .38$. Pairwise comparisons reveal that participants in the elevated anxiety condition reported a significant increase in anxiety after receiving the mood induction, $t(176) = 11.75$, $p < .001$, $d = .94$, while participants in the reduced anxiety condition reported a significant decrease in anxiety following the mood induction, $t(192) = 8.99$, $p < .001$, $d = .31$. Similarly, the interaction between mood induction condition and mood assessment point was significant in the ANOVA carried out on the transmission phase induction mood ratings, $F(1366) = 136.26$, $p < .001$, $\eta^2 = .27$. Again, participants in the elevated anxiety condition reported a significant increase in anxiety after receiving the mood induction, $t(176) = 6.86$, $p < .001$, $d = .48$, while participants in the reduced anxiety condition reported a significant decrease in anxiety following the mood induction, $t(192) = 10.33$, $p < .001$, $d = .44$. These results indicate that the mood induction procedure was successful in eliciting the desired shift in anxiety across the two mood induction conditions.

3.2. Survival of unambiguously negative and positive story events across multiple transmission episodes

The general variant of the Negative Survival Hypothesis predicts that negative information will have a survival advantage over positive information across repeated social transmission episodes. The intergenerational variant of this hypothesis predicts that the survival of negative story events, relative to positive story events, will increase across social transmission episodes. To test each variant of the Negative Survival Hypothesis, the stories produced by participants at each position in each chain were separated into the underlying events. A coder, blind to participants' experimental condition, assessed each participant's story reproduction and indicated if each described event in the reproduction was present in the original story. This determined the number of unambiguously positive and unambiguously negative original story events that survived across the transmission chain. Using the same scoring approach as Eriksson and Coultas (2014), an event was considered to be present if the basic gist was the same as an event in the original story. A second independent coder, also blind to participants' experimental conditions, coded a random selection of 20 chains (22%) using the same procedure. Inter-rater reliability was confirmed by the high Krippendorff's alpha, $\alpha = .96$. The first coder's assessment of each story reproduction was used in the final analysis.

Fig. 2 shows the pattern of survival for positive and negative events across each chain position. It indicates that a greater proportion of unambiguously negative events than unambiguously positive events survived at each chain position. This was confirmed by a binary logistic mixed-effects model. The analysis was carried out following methods outlined by Finch, Bolin, and Kelley (2014), using the lme4 software package (Bates, Maechler, Bolker, & Walker, 2015) in R version, 3.2.2 (R Core Team, 2015). All predictor variables were centered prior to analysis. As fixed effects, we entered event Valence (positive, negative) and Chain Position (1–4) with interaction, plus Item Position. Item Position was included to control for any influence of item position on the transmission of positive and negative events. Item position scores ranged from story event position 3 to story even position 53. Following Barr, Levy, Scheepers, and Tily (2013) a maximal random effects structure was specified. This included random intercepts for Chain and Item, as well as a by-Chain random slope for the effect of Valence.[4]

The best fitting model was one that specified event Valence and Chain Position as fixed effects without interaction (see Table 1). This model was compared to a model that included an interaction term for chain position and event valence. Model comparison confirmed that allowing position and valence to interact did not improve model fit, $\chi^2(1) = .86$, $p = .35$. A reduced model was tested which excluded chain position as a predictor. Model comparison confirmed that including chain position as a predictor provided a significantly better fit than the reduced model, $\chi^2(1) = 250.99$, $p < .001$. Finally, a reduced model, which excluded event valence as a predictor was tested. Again, model comparison confirmed that including event valence as a predictor provided a significantly better fit than the reduced model, $\chi^2(1) = 5.58$, $p < .05$. Our findings support the general variant of the Negative Survival Hypothesis; unambiguously negative story events survived better across transmission episodes than unambiguously positive story events.

[4] See Supplementary Materials 2 for model specification.

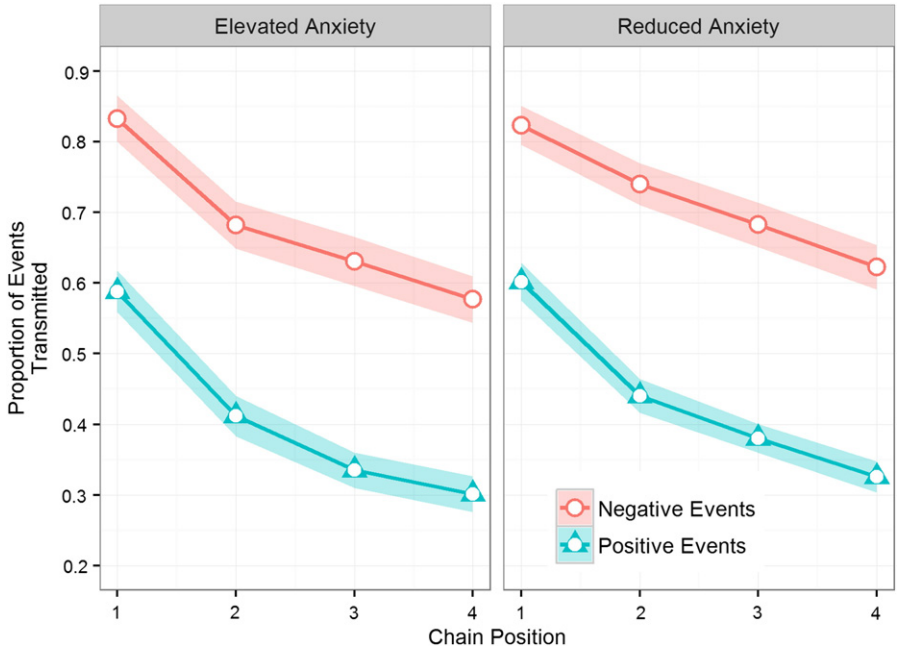

Fig. 2. Mean proportion of unambiguously positive and negative story events that survived across each chain position. Shaded areas reflect the standard error of the means.

The Anxiety-Linked Negative Transmission Hypothesis predicts that the preferential survival of negative events will be disproportionately great when participants are in an anxious mood state. If correct, the mood induction condition will predict the survival of story events. To test this, a further model was tested which included the mood induction condition as a fixed effect, along with event Valence and Chain Position and allowed for the interaction of all three predictors. The inclusion of the mood induction condition as a factor did not significantly improve the fit of the model over the initial model, $\chi^2(5) = 3.64$, $p = .60$. Thus, the Anxiety-Linked Negative Transmission Hypothesis was not supported.

3.3. The resolution of ambiguity across multiple transmission episodes

The general variant of the Negative Resolution of Ambiguity Hypothesis predicts that negative resolutions of ambiguous story events will be more common than positive resolutions. The intergenerational variant of this hypothesis predicts that as ambiguous story events are disambiguated, negative resolutions will become progressively more frequent than positive resolutions of ambiguity across successive social transmission episodes. To test each variant of the Negative Resolution of Ambiguity Hypothesis, a coder, naïve to the experimental conditions, judged if the originally ambiguous story events had survived as ambiguous or had been resolved in either a negative or positive manner. Again, a second coder coded a random selection of 20 chains (22%) using the same procedure. Inter-rater reliability was high: judgments concerning the number of ambiguous events that survived as ambiguous, $\alpha = .82$; the number of negative resolutions that occurred, $\alpha = .81$; and the number of positive resolutions that occurred, $\alpha = .89$. Coder one's assessment of the ambiguous story events was used in the analysis.

Table 1
Results of the best fitting model for the survival of unambiguous story events (Valence and Chain Position as fixed effects without interaction, controlling for Item Position).

Predictor	Coefficient	*SE*	z
(Intercept)	0.45	0.33	1.35
Valence	1.79	0.69	2.57*
Chain Position	−0.55	0.03	−17.48**
Item Position Model fit:	−0.01	0.02	−0.54
AIC	5790.50		
BIC	5864.60		
Log-likelihood	−2884.30		

Note:
* $p < .05$.
** $p < .001$.

The cumulative proportions of the originally ambiguous events that remained ambiguous, and that were resolved (negative or positive resolutions combined); or were omitted in each participant's retelling are shown in Fig. 3. Across successive transmission episodes very few ambiguous events remained ambiguous; ambiguous statements were either lost or participants resolved the ambiguity.

Fig. 4 shows the pattern of resolutions of ambiguity that occurred across successive transmission episodes and reveals that negative resolutions became increasingly more frequent, relative to positive resolutions, across successive chain positions. This finding was confirmed by analyzing the cumulative proportions of positive and negative resolutions using a linear mixed-effects model[5] (same fixed effects and random effects structure used earlier; see Supplementary Materials 2). The analysis was carried out following the methods outlined by Finch et al. (2014), using the nlme software package (Pinheiro, Bates, DebRoy, Sarkar, & R Core Team, 2015) in R version, 3.2.2 (R Core Team, 2015). The best fitting model specified event resolution Valence and Chain Position as fixed effects with interaction (see Table 2). This model was compared to a main effects only model, which specified resolution Valence and Chain Position as fixed effects without interaction. Model comparisons confirmed that allowing event resolution Valence and Chain Position to interact significantly improved model fit, $\chi^2(1) = 40.13$, $p < .001$.

To examine the interaction between resolution Valence and Chain Position, pairwise comparisons were conducted for each position in the chain by comparing a model in which resolution valence was included as a predictor against a null model. These comparisons revealed that at chain position one, the proportion of negative and positive resolutions of ambiguity was similar, $\chi^2(1) = .27$, $p = .60$. However, at later chain positions there were more negative resolutions than positive resolutions: at chain position two, $\chi^2(1) = 8.39$, $p < .01$, three, $\chi^2(1) = 12.46$, $p < .01$ and four, $\chi^2(1) = 12.80$, $p < .01$. These findings

[5] As each ambiguous item could be transmitted in three different ways (survive as ambiguous. resolved in a negative manner, resolved in a positive manner) it was not possible to model the transmission of these statements using a binary logistic model.

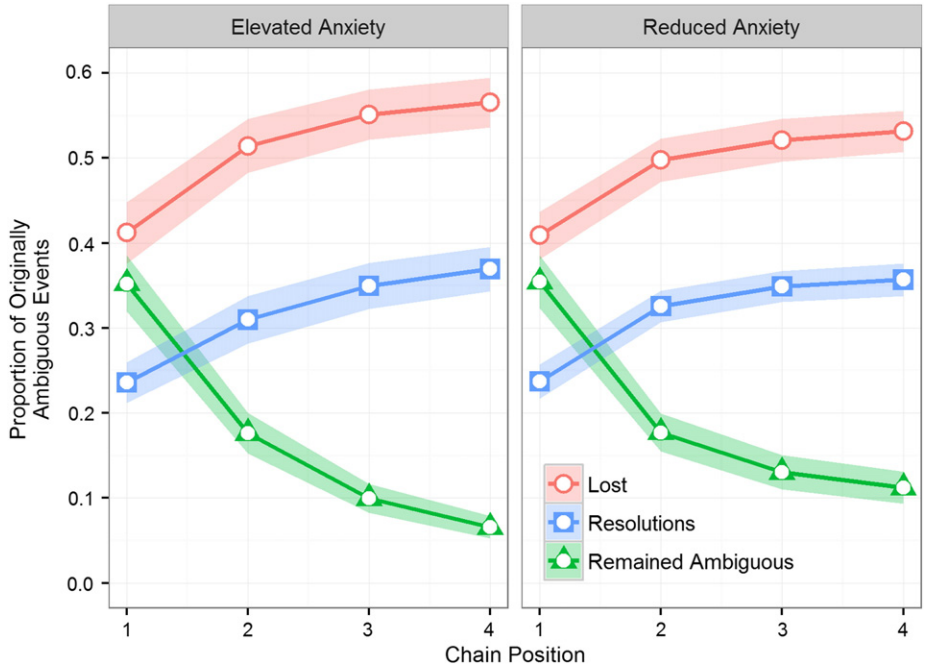

Fig. 3. Mean proportion of ambiguous story events that survived, were lost and were resolved (positive and negative resolutions combined). Shaded areas reflect the standard error of the means.

support the intergenerational variant of the Negative Resolution of Ambiguity Hypothesis; negative resolutions of ambiguity became increasingly more common than positive resolutions across successive social transmission episodes.

The Anxiety-Linked Negative Transmission Hypothesis predicts that increasingly negative resolutions of ambiguity will be disproportionately great when participants are in an anxious mood state. If correct, the mood induction condition will significantly predict the number of resolutions of ambiguity observed across successive chain positions. To test this, a further model was tested which included the mood induction condition as a fixed effect, along with resolution valence and chain position, and allowed for the interaction of all three predictors. The inclusion of mood induction as a fixed effect did not significantly improve model fit, $\chi^2(4) = 2.25$, $p = .69$. This finding suggests that anxiety did not influence the degree to which negative resolutions of originally ambiguous story events became progressively more likely across successive transmission episodes. Hence, our findings concerning the disambiguation of the originally ambiguous story elements supports the Negative Resolution of Ambiguity Hypothesis, but not the Anxiety-Linked Negative Transmission Hypothesis.

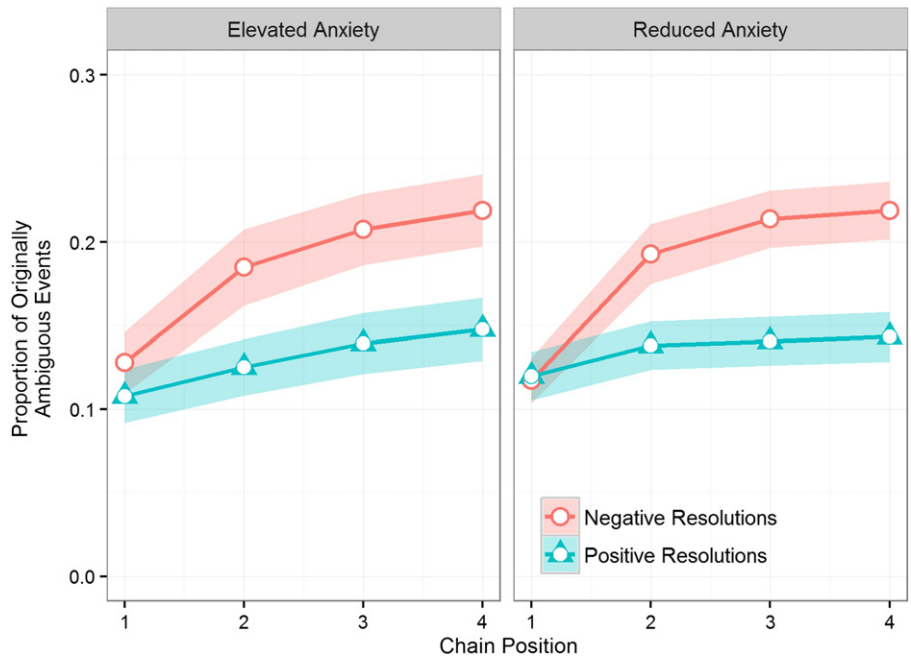

Fig. 4. Mean proportion of originally ambiguous story events that were resolved positively and negatively. Shaded areas reflect the standard error of the means.

Table 2
Results of the best fitting model for the resolution of originally ambiguous story events (resolution Valence and Chain Position as fixed effects with interaction).

Predictor	Coefficient	*SE*	*t*
(Intercept)	0.16	0.01	21.60***
Valence	0.05	0.02	2.98**
Chain Position	0.02	0.00	12.70***
Valence* Chain Position Model fit:	0.02	0.00	6.43***
AIC	−1783.38		
BIC	−1746.57		
Log-likelihood	889.69		

Note:
* $p < .05$.
** $p < .01$.
*** $p < .001$.

4. Discussion

The present study tested three hypotheses related to the social transmission of emotionally valenced information. It found that across successive social transmission episodes the original story information was lost, as is typical of serial reproduction studies (Bartlett, 1932; Mesoudi & Whiten, 2008). The Negative Survival Hypothesis predicted that unambiguously negative information would survive better than unambiguously positive information across multiple transmission episodes. Two variants of this hypothesis were tested. The general variant predicted that negatively-valenced information, compared to positively-valenced information, will exhibit enhanced survival across multiple transmission episodes. The intergenerational variant of the Negative Survival Hypothesis predicted that negatively-valenced information would become increasingly common, relative to positively-valenced information, across transmission episodes. The general variant of the Negative Survival Hypothesis was supported. Participants produced a greater number of negative story events, relative to positive story events, at each chain position. This finding supports Eriksson and Coultas' (2014) observation that stories higher in disgust content survived better than those lower in disgust, while also demonstrating that this pattern does not simply reflect a transmission preference for emotional information in general. By providing the first direct comparison of the social transmission of negative and positive information, the current study demonstrates a preference for the transmission of negatively-valenced information over positively-valenced information across transmission episodes.

This study also tested the Negative Resolution of Ambiguity Hypothesis. Again, two variants of this hypothesis were tested. The general variant predicted that negative resolutions of ambiguity will occur more often than positive resolutions of ambiguity. The intergenerational variant predicted that negative resolutions of ambiguity would become increasingly more frequent, relative to positive resolutions, across chain positions. Originally ambiguous story events tended to be either lost or resolved, with very few ambiguous elements surviving in their original ambiguous form across transmission episodes. When these story elements were resolved participants tended to resolve them negatively rather than positively, and this disparity grew across transmission episodes. This pattern of results supports the intergenerational variant of the Negative Resolution of Ambiguity Hypothesis. To our knowledge this is the first study to examine the resolution of ambiguous information across multiple social transmission episodes, and clearly demonstrates a bias favoring the negative resolution of emotionally ambiguous information.

Finally, we tested the Anxiety-Linked Negative Transmission Hypothesis. This hypothesis predicted that the enhanced survival of unambiguously negative information and the preferential negative resolution of ambiguous information across transmission episodes, would be disproportionately pronounced when state anxiety was elevated. This hypothesis was not supported; the social transmission of negative information, relative to positive information, did not differ as a function of whether participants received the elevated state anxiety induction or the reduced state anxiety induction. While the Anxiety-Linked Negative Transmission Hypothesis was not supported, this does not exclude the possibility that anxiety may affect the social transmission of negative information. Although the mood induction procedure used in the current study elicited the desired shift in anxious mood state, this does not conclusively refute the validity of the Anxiety-Linked Negative Transmission Hypothesis. It is possible that the shift in mood state elicited by the first induction (encoding phase) may not have endured for the length of time taken by participants to read the full transcript, and/or the second induction (transmission phase) may not have endured for the length of time taken to reproduce the story. Analysis of participants' VAMS revealed that the shift in anxious mood state produced by the encoding phase induction had dissipated by the time participants received the transmission phase induction (see Fig. 1). Hence, a more enduring state anxiety mood induction procedure may enhance the social transmission of negative information, as predicted by the Anxiety-Linked Negative Transmission Hypothesis.

4.1. Mechanisms driving the preferential transmission of negative information

Our findings support the general variant of the Negative Survival Hypothesis and the intergenerational variant of the Negative Resolution of Ambiguity Hypothesis. Consistent with both hypotheses, we observed a preference for the transmission of negative over positive information across transmission episodes. This raises the question of whether each of these effects are driven by independent biases, or whether they are driven by the same underlying processing bias. If these effects represent a general negativity bias, we would expect the number of unambiguously negative story events that survived in participants' retellings of the story to be positively correlated with the number of negative resolutions of ambiguity that were observed. Post hoc tests support this, $r = .20$, $p < .001$. Similarly, the number of unambiguously positive story events that survived in participants' retellings was positively associated with the number of positive resolutions of ambiguity, $r = .38$, $p < .001$. These correlations suggest a general negativity bias in the social transmission of information.

Such a general negativity bias may be expressed though two complimentary processes of cultural evolution: cultural selection and cultural attraction (for a review, see Acerbi & Mesoudi, 2015). The preferential survival of unambiguously negative information may be the result of a preservative mechanism in which cultural evolution arises from the selective transmission of different variants; in this case, the preferential transmission of negative story events relative to positive story events (i.e., cultural selection). The preferential negative resolution of ambiguity may be the result of a reconstructive mechanism in which individuals transform the material to be transmitted; in this case, ambiguous information is transformed in a manner that favors a negative interpretation over a positive interpretation (i.e., cultural attraction). The use of ambiguous materials in social transmission studies provides researchers with a method to explore cultural attraction. A key benefit of the ambiguous materials used in the current study is that they not only lend themselves to transformation, they also constrain the number of potential resolutions (positively or negatively). By contrast, in Bartlett's (1932) study, there were an indefinite number of potential resolutions of the ambiguous material, making it difficult to determine the pull of particular cultural attractors. Studies of cultural evolution have typically explored either cultural selection (selective transmission of competing variants) or cultural attraction (transformation of existing variants) but rarely examine both processes concurrently. To our knowledge, the current study is the first to present evidence consistent with both processes operating during social transmission.

It is possible that the proposed general negativity bias is driven by something other than emotional tone. One alternative explanation is

that it is driven by arousal. For example, Berger (2011) contends that information that elicits emotions that stimulate the autonomic nervous system (e.g. surprise, disgust, amusement) will be socially shared more often than information that does not elicit the same level of arousal (e.g. sadness). It is possible that the negative story events used in the current study were more arousing than the positive story events, as well as having a less pleasant emotional tone. However, an arousal-based account cannot adequately explain the negative resolution of the ambiguous story events in the present study. For ambiguous story elements, the ambiguity has to be resolved before the associated arousal is experienced. A second alterative explanation of the proposed general negativity bias is suggested by Stubbersfield, Tehrani, and Flynn (2015), who found that information pertinent to our survival is transmitted with greater fidelity than information that lacks such survival information. It may be that the materials used in the current study differ in their relevance to our survival, as well as differing in their in emotional tone. Future research should aim to determine if the observed general negativity bias is driven by its less pleasant emotional tone, or by some other property of its content, such as its relevance to survival.

4.2. Future directions

In the current study, we did not find evidence that state anxiety amplifies the selective transmission of negatively-valenced information. Hence, the appropriate conclusion for now is that state anxiety does not directly influence the biased social transmission of emotional information. However, it is possible that a more robust mood induction procedure may reveal the predicted anxiety-linked effect. Additionally, it is possible that the impact of state anxiety could be moderated by individual differences in the disposition to experience state anxiety, a personality dimension commonly referred to as trait anxiety. There is considerable evidence from the cognition and emotion literature that an attentional bias favoring negative information is interactively determined by state and trait anxiety. For example, using a modified version of the Stroop color naming task MacLeod and Rutherford (1992) found that elevated state anxiety increased selective attention to negative information only in high trait anxious participants. Hence, it is possible that elevated state anxiety may amplify the transmission of negative information only among high trait anxious people. Although they did not measure trait anxiety, Fessler et al. (2014) argued for the importance of trait-linked variables in emotional information processing. They found that the tendency to perceive the world as a dangerous place was positively associated with dispositional credulity regarding hazards but not benefits. They argue that this "…suggests that individuals who believe the world to be dangerous may constitute important nodes in cultural transmission processes, as congruence between their priors and information concerning hazards may lead them to be particularly prone to differentially retain and propagate hazard information." (Fessler et al., 2014, p. 5). This is compatible with the possibility that high trait anxious individuals may be more likely to transmit negative information than low trait anxious individuals when experiencing high state anxiety. Future research should explore this possibility by comparing the impact of state anxiety induction on high and low trait anxious participants during the social transmission of emotionally-valenced information.

Another useful direction for further research would be to examine whether the preferential transmission of negative information depends on the nature of the relationship between interlocutors. Peters, Kashima, and Clark (2009) found that people are more willing to communicate social anecdotes with a close friend than with a stranger. In particular, participants were more willing to communicate anecdotes that aroused surprise and sadness with an intimate audience, but not with a stranger. Given that the participants in the current study were unacquainted, it is possible that the observed negativity bias may be stronger among participants who have an existing relationship, such as friends or family members.

In the current study participants were not informed that adjacent members of their transmission chain received the same mood induction procedure they received. Hence, they had no basis to infer the emotional state of those they received the message from, or those they transmitted the message to. However, in many real world settings, interlocutors are aware of each other's emotional state. For example, following international news events that capture the attention of the public, such as the 9/11 attacks, or the disappearance of Malaysian Airlines flight MH370, social transmission occurs in a context in which the emotional state of the public is generally shared. It is possible that this knowledge will influence the manner in which emotional information is transmitted. Research has shown that people tailor their message based on prior knowledge of their audience (Rogers, Fay, & Maybery, 2013). Future research could explore whether knowledge of the audience's emotional state influences the social transmission of emotional information by contrasting social transmission that occurs under conditions in which the participants can infer the emotional state of those with whom they are interacting, with conditions in which participants' emotional state is unknown, as was the case in the current study.

Taken together, our findings suggest that social transmission is characterized by the preferential social transmission of negatively-valenced information. In the present study this was demonstrated using textual transmission of information. Given the ubiquity of text-based communication, through social media platforms such as Facebook and Twitter, the presently observed negativity bias is of considerable social significance. A recent report from the Australian Bureau of Statistics found that 83% of the population are internet users with two-thirds of these using the internet for social networking (Australian Bureau of Statistics, 2014). Additionally there is evidence that text messaging has overtaken voice calls as the preferred method of communication via mobile phone (Walsh, White, & Young, 2010). To determine the pervasiveness of the observed negativity bias, future research might explore whether a similar effect exists when participants communicate orally. Nevertheless, even if future research reveals that the observed negativity bias is specific to textual communication, this bias is likely to exert an increasing impact on cultural evolution in the coming years as our reliance on textual forms of social communication continues to expand.

5. Conclusion

The present study provides the first direct comparison of the survival of negative information and positive information across multiple social transmission episodes. Additionally, it is the first serial reproduction experiment to assess the resolution of ambiguous emotional information across multiple social transmission episodes. In both cases a clear preference for the transmission of negatively-valenced information over positively-valenced information was identified. The observed association between the survival of unambiguously negative information and the negative resolution of ambiguous information suggests a general negativity bias that favors the social transmission of negative information. There was no evidence that elevated state anxiety amplified the transmission of negative information, though it is possible that a more robust mood induction procedure will reveal an anxiety-linked amplification of these effects. The finding of a general negativity bias that influences the transmission of information is of considerable social importance. Identifying the biases that influence social transmission can help us understand why negatively-valenced information tends to dominate news headlines, making it sometimes seem like the sky is falling.

Supplementary materials

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.evolhumbehav.2016.07.004.

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