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

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Abstract

The principle aim of the current program of research was to determine if there is a general tendency for people to preferentially communicate negative information during social transmission. The cultural evolution literature highlights the role that cognitive processing biases play in shaping cultural change and there is now a substantial body of work documenting the interpersonal consequences of a range of intrapersonal processing biases. Given the extensive evidence that people preferentially process negative, over positive information, it was argued that there may be a commensurate negativity bias in the social transmission of information.

The studies presented in this thesis explored two complementary processes that contribute to the proposed negative transmission bias. Firstly, this thesis tested whether there was evidence of a content bias characterised by the selective transmission of negative information, over positive information. Secondly, by examining the social transmission of ambiguous information, this thesis tested whether there was evidence of guided variation involving the transformation of information in a negative, as opposed to a positive, manner. In exploring both processes, the studies presented in this thesis found convergent evidence of a negativity bias in the social transmission of information.

A related research question that was under investigation throughout this thesis was whether elevated anxiety (trait and/or state) may be associated with a disproportionate tendency to transmit negative information, relative to people with low levels of anxiety. There was no evidence that elevated levels of trait or state anxiety influenced the social transmission of emotional information. Despite this, in exploring whether there are individual differences in expression of transmission biases the current thesis makes a novel contribution to the cultural evolution literature, which has to date, focused predominantly

on understanding the tendencies shared by people, that contribute to cultural change. In exploring whether there are individual differences in the social transmission of information the current thesis extends this body of work. The theoretical and applied implications of these research findings are discussed in detail. Avenues for future research that stem from this are considered, with particular focus on the value of exploring the conditions that may amplify or attenuate the expression of established transmission biases.

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Author Contributions

The author played a significant role in all aspects of the studies reported within this thesis. This included experimental design and development, participant recruitment and testing, data entry, data analysis and interpretation, and the preparation and revision of the published manuscript reported in Chapter 6. This manuscript was written in collaboration with the author's supervisors, Professor Colin MacLeod and Dr Nicolas Fay.

Table of Contents

Chapter One	1
General Introduction to the Research Program	1
Evidence of negativity processing biases	8
Evidence of a negativity bias in the social transmission of information	12
Individual differences in the social transmission of information	14
Anxiety-linked negative processing biases	17
Anxiety and the social transmission of information	23
Overview of the current research program	24
References	27
Chapter Two	37
Study One	37
The interpretation of ambiguity by people without elevated anxiety vulnerability	37
Methodological considerations when assessing the interpretation of ambiguity	41
Overview and design	46
Method	47
Participants	47
Materials	48
Questionnaire measures.	48

Experimental scenarios.	48
Experimental hardware.	50
Experimental tasks	51
Encoding task.	51
Rehearsal prevention task.	51
Similarity judgement task.	52
Procedure	53
Results	53
Valence ratings of ambiguous scenarios	54
Similarity ratings of test sentences	57
Target sentences.	57
Foil sentences.	62
Discussion	63
Are biases in the interpretation of ambiguity context specific?	65
Anxiety-linked negative interpretation biases in non-clinical samples	67
Conclusion	67
References	69
Chapter Three	73
Study Two	73
Guided variation	74

Exploring guided variation using ambiguous scenarios	78
The current study	79
Overview and design	80
Method	81
Participants	81
Materials	83
Questionnaire measures.	83
Experimental scenarios.	83
Experimental hardware.	83
Experimental tasks	84
Transmission phase.	84
Rehearsal prevention task.	84
Similarity judgement task.	84
Procedure	85
Results	85
Valence ratings of ambiguous scenarios	86
Transmitters' valence ratings.	88
Receivers' valence ratings.	90
Similarity ratings of negative and non-negative meanings of the ambiguous scenarios	92

Similarity ratings of target test sentences.	92
Is there evidence of a response bias in the similarity judgement task?	102
Discussion	104
Is there evidence of a negative transformation bias in the current study?	106
Conclusion	107
References	108
Chapter Four	111
Study Three	111
Content biases in the social transmission of information	111
Methodological considerations for examining the preferential transmission of emotional information	114
Overview and design	116
Method	117
Participants	117
Materials	118
Questionnaire measures.	118
Experimental story.	118
Procedure	119
Results	120
Discussion	123

Conclusion	126
References	128
Chapter Five	131
Study Four	131
The role of state anxiety in the social transmission of information	131
Beyond rumours	134
The role of state and trait anxiety in determining negativity biases	134
The current study	136
Overview and design	137
Method	138
Participants	138
Materials	139
Experimental story.	139
State anxiety induction videos.	141
Mood ratings.	142
Experimental hardware.	143
Experimental phases	143
State anxiety induction phase.	143
Encoding phase.	144
Transmission phase.	144

Procedure	144
Results	145
State anxiety induction	145
Transmission of unambiguously negative and positive story events	148
Resolution of originally ambiguous story events	152
Discussion	155
Evidence of a negative content bias in social transmission	156
Guided variation did not contribute to the resolution of ambiguity	157
The role of elevated state anxiety in the social transmission of valenced information	158
Elevated trait anxiety is not associated with enhanced transmission of negative information	159
Conclusion	160
References	162
Chapter Six	165
Study Five	165
Abstract	166
Social transmission in the laboratory	168
The social transmission of emotionally valenced information	170
The impact of anxiety on the transmission of emotional information	173

The current study	174
Overview and design	175
Method	175
Participants	175
Materials	176
Experimental story.	176
Anxiety manipulation videos.	177
Mood ratings.	179
Procedure	179
Results	180
Mood manipulation	181
Survival of unambiguously negative and positive story events across multiple transmission episodes	183
The resolution of ambiguity across multiple transmission episodes	186
Discussion	191
Mechanisms driving the preferential transmission of negative information	194
Future directions	196
Conclusion	199
References	200
Chapter Seven	207

General Discussion	207
Evidence of a negative content bias	208
Reconstruction or preservation?	209
Content biases are not memory biases.	210
Evidence of a negativity bias in the transformation in ambiguity	211
Serial reproduction experiments can reveal the cumulative effects of subtle biases.	213
The impact of anxiety on the social transmission of information	215
The role of state anxiety in the social transmission of emotional information.	217
Arousal stimulates the social sharing of information.	218
State anxiety induction procedures.	219
Future directions	220
Conclusion	222
References	224
Appendices	232
1. Description of the model comparisons that were conducting during analysis of foil test sentences in Study 2.	232
2. Material for Study Three	234
3. Material for Studies Four and Five	236

Chapter One

General Introduction to the Research Program

We spend much of our day to day lives communicating with other people, sharing anecdotes, debating current affairs and forming plans, amongst other things. A feature of this communication is that we often pass on information that was told to us by others. The transfer of information from one person to another, referred to here as social transmission, is rarely a faithful reproduction of the information that was received. Rather it is a reconstructive process, during which certain details are transformed or lost, but the gist of the message remains (Bartlett, 1932). This imperfect replication, coupled with the differential survival of informational elements across successive transmission episodes, represents the two cornerstones of cultural evolution.

While cultural stability relies on the faithful transmission of knowledge (Tan & Fay, 2011) the corpus of knowledge, beliefs and norms that define a culture, not only accumulates but changes over time as a result of the dynamic nature of social transmission (Henrich & McElreath, 2003; Mesoudi & Whiten, 2008). 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 (Berger, 2014; Stubbersfield, Tehrani, & Flynn, 2015). Viral messages on social media platforms are perhaps the most modern expression of social transmission and there is a burgeoning interest in the ways in which social media can drive cultural change (Acerbi, 2016; Berger & Milkman, 2012).

Drawing on the relatively disparate fields of anthropology, evolutionary biology, sociology, psychology and computer science, the study of cultural evolution has, in recent

decades, enjoyed a period of rapid growth. Indicative of this growth is the creation of The Cultural Evolution Society in 2016, with the aim of unifying the study of cultural evolution across these disciplines. Despite recent interest in this area, the study of cultural evolution can trace its roots back to Darwin (for a review, see Mesoudi, 2016). Indeed, the guiding theoretical tenets of biological evolution are readily applied to the study of cultural change. These are:

1. In a given population there are a range of exemplars that vary in their characteristics (variation);
2. These variants differ in the rate at which they are transmitted (differential fitness); and
3. Variants are passed from one member to another (inheritance).

A modern-day example of these principles is the phenomenon of viral content on social media. For any given topic, there are a vast array of tweets, Instagram images, memes and Facebook posts that are created and shared. However, some enjoy a far greater rate of transmission than others. For example, following the Paris terror attacks in 2016 the general sense of shock, disbelief and sadness was expressed worldwide through social media. One post in particular was shared, arguably more than any other: the Eiffel Tower peace symbol. Among the thousands of posts generated in the aftermath of the event, this variant perhaps captured the sentiment of many, better than any other and 'went viral'.

Despite the obvious parallels between biological and cultural evolution, it should be noted that not all the processes involved in biological evolution have equivalents in cultural evolution. For example, in cultural evolution inheritance is not restricted to vertical transmission from parent to child. Rather, transmission also occurs between peers from the same generation (horizontal transmission) and from older members (e.g. grandparents) to

children. The greater number of opportunities for the transmission of information means that cultural evolution can occur more rapidly than biological evolution.

Early work in the area of cultural evolution focussed primarily on the use of mathematical models to explore the population-level consequences of different modes of information transmission. For example, Cavalli-Sforza and Feldman (1981) constructed models that compared vertical information transmission (parent-child) with horizontal transmission (peer-peer) and found that vertical transmission leads to the slowest rate of change. Extending this work, Boyd and Richerson (1985) constructed models of social transmission that included scenarios in which agents preferentially copied from other members of the population (models). The inclusion of model-based biases in social transmission added an element of realism that drew on known (though to that point, poorly understood) psychological phenomenon. For example, by preferentially copying from prestigious members of the population, Boyd and Richerson explored the population-level consequences of an individual-level affinity for certain models, based on traits that often have little relevance to the behaviour or information being replicated. This sort of model-based prestige bias explains why celebrity endorsement is such a powerful marketing tool. Mathematical modelling of this bias revealed that when the specific traits that are considered prestigious are allowed to vary from person to person, social transmission can lead to a process that is analogous to runaway sexual selection, which has been used to explain the evolution of exaggerated male traits such as the expansive and colourful (but largely impractical) tails of male peacocks. Such a process can explain why sometimes seemingly maladaptive traits are valued in various cultures (e.g. many trends in fashion run counter to our general health and wellbeing, such as wearing high-heels, smoking, tanning etc.)

As well as exploring the characteristics of the model that can influence the social transmission of information, Boyd and Richerson (1985) hypothesised that certain properties of information itself can influence the rate at which it is transmitted, with such patterns of selective transmission being moderated by people's cognitive processing tendencies. It is this area of interest that has inspired the current program of research. Boyd and Richerson highlighted two ways in which the properties of the information can interact with patterns of selective cognitive processing to bias transmission. The first, which has received greater empirical attention in the intervening years, was referred to as a 'direct content bias' (more recently just 'content bias') and involves the preferential transmission of certain types of information (or cultural variants) over others during social transmission. In the years since Boyd and Richerson first described this phenomenon, mathematical modelling and naturalistic research exploring content biases has been complemented by laboratory based experiments. These efforts have identified a number content biases, including biases for stereotype-consistent information (Kashima, 2000; Lyons & Kashima, 2003, 2006), social information (Mesoudi, Whiten, & Dunbar, 2006) and survival information (Stubbersfield et al., 2015). For example, Mesoudi, Whiten & Dunbar (2006) used a "transmission chain experiment" to show that social information is transmitted with greater fidelity than non-social information.

Originally pioneered by Bartlett (1932), a transmission chain or serial reproduction experiment typically involves participants being exposed to novel information, for example, a short story. The participant reads the story and, after a delay, retells 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 during social transmission, which are lost and which are transformed. In the study by Mesoudi, Whiten and Dunbar (2006), participants were provided with four passages to read and then retell, by writing the information on a piece of paper. Two of the passages contained social information and two contained non-social information. For one of the social passages the information was considered 'gossip' and described a salacious affair between a student and professor. The other social passage described less intense social interactions that were not considered to be gossip-like. Analysis of participants' retellings of these passages revealed that the passages containing social information were retold with greater accuracy than the non-social passages, suggesting a content bias favouring the transmission of social over non-social information. There was also no difference in recall accuracy for the two types of social passages (gossip vs. non-gossip), suggesting that the bias for social information is not dependent on the intensity of the interactions described. The transmission advantage for social information has been supported in other serial reproduction experiments (Stubbersfield, Tehrani, & Flynn, 2015), in a study examining the influence of collaboration on recall (Reysen, Talbert, Dominko, Jones, & Kelley, 2011) and in an open diffusion experiment involving children in which social and non-social information was introduced to one child during a conversation with a teacher and was then allowed to naturally disperse through the peer group (McGuigan & Cubillo, 2013).

The selective transmission of certain cultural variants over others, although now well documented, is not the only method by which an individual's cognitive processing tendencies can influence the social transmission of information. The second, is the notion of 'guided variation' (Boyd & Richerson, 1985). Guided variation describes the transformation of a cultural variant in some non-random manner, as a result of an individuals' underlying cognitive processing tendencies. Consider, for example, that you are told about an event by a

friend or family member. In describing the event to you, certain elements were not explained clearly and as such, remain ambiguous. The following description captures this sort of ambiguity well, “Walking down the concourse, Sarah saw a young man take an old women's bag”. This description could be interpreted to mean that the young man was stealing the women's bag (negative interpretation) or that the young man helped the old woman carry her bag (positive interpretation). Bartlett's (1932) early studies on remembering revealed that when such ambiguity is encountered, it is frequently transformed to fit with the individuals' cultural understanding of objects and events. For example, ‘something black’ that came out of a man's mouth in the Native American story script that was used by Bartlett, was disambiguated as his ‘soul’ in later retellings of the story by his mostly British participants. In this way, the variant that was inherited by participants in the study was transformed in a manner that was guided by their cognitive processing tendencies. Boyd and Richerson explain that the transformation of information in this manner often occurs outside of an individual's conscious awareness.

Laboratory studies have shown that over multiple transmission episodes the cultural variants themselves come to resemble the cognitive bias that shaped them. Using a serial reproduction experiment, Kalish, Griffiths and Lewandowsky (2007) explored the influence of a documented preference for learning positive linear functions, on the form of variants across multiple transmission episodes. In their study, participants were randomly allocated to one of eight, nine-person transmission chains, with each participant completing a training phase and a transmission phase. During the training phase, the first participants in each chain (generation one) were given a set of data points, consisting of a value for x , which was a randomly selected value between 1 and 100; and a value for y , which was determined by the condition to which they had been allocated. There were four different conditions used in the

experiment, each reflecting a different underlying function that determined the relationship between x and y . These were: (1) positive linear; (2) negative linear; (3) non-linear, U-shaped and; (4) random pairings of x and y . During the transmission phase, participants were provided with a randomly selected value for x and were required to predict the value of y , based upon the function they had learned during the training phase. Participants in generations two to nine of each transmission chain, completed the experiment in the same manner. However, the data used for x and y in the training phase for these participants was the output that was generated during the transmission phase by the preceding participant in their chain. The authors found that, regardless of the function that had been learned by first generation participants, the output generated by later generations came to resemble a positive linear function. This finding supports the notion of guided variation, with the inherited variant being transformed in a manner that was consistent with the inductive bias of the participants. Additional support for guided variation comes from other transmission chain studies that have observed transformation in colour-naming conventions across successive transmission episodes (Xu, Dowman, & Griffiths, 2013) and the emergence of compositionality in artificial languages (Kirby, Cornish, & Smith, 2008).

As described here, content biases and guided variation are two complementary processes that contribute to the evolution of culture. Boyd and Richerson (1985) highlight that the processes should not be considered mutually exclusive. They explain that the same cognitive processing that operates to influence selection among different variants during social transmission can serve to guide the transformation of these variants, a view that is shared by Acerbi & Mesoudi (2015). However, there is value in distinguishing between these two processes. Importantly, the environmental conditions that give rise to content biases and guided variation differ. Whereas content biases depend on variation in the population (and

are stronger with an increasing number of variants from which to choose), guided variation can occur in the absence of any variation in the population as it results from the transformation of existing traits by individuals (Mesoudi, 2011).

The current program of research will explore whether a well-documented cognitive processing bias which favours the negative processing of information influences social transmission through (i) a content bias characterised by the selective transmission of negative information over positive information and; (ii) guided variation involving the transformation of information in a negative, as opposed to a positive, manner. The section that follows will review the existing literature demonstrating this negative processing bias across a wide range of domains and will argue that such a bias is likely to influence social transmission in a manner that shapes cultural evolution.

Evidence of negativity processing biases

A large body of research indicates that humans, like animals, exhibit a processing advantage for negative information (over positive information) (for a review, see Baumeister, Bratslavsky, Finkenauer, & Vohs, 2001). From an evolutionary standpoint being oriented toward negative information is intuitive. The early detection and processing of negative information enables us to constrain approach and avoidance behaviour to enhance our chances of survival (Rozin & Royzman, 2001). For instance, evidence from animal studies suggests that learning in response to negative events occurs much more rapidly than learning in response to positive events (Garcia, Hankins, & Rusiniak, 1974). There is also emerging evidence of emotional contagion in canines for negative emotional stimuli but not positive

(Huber, Barber, Faragó, Müller, & Huber, 2017) and some evidence of an attentional bias toward negative emotional expression in chimpanzees (Kano & Tomonaga, 2010).

The experimental evidence for such a bias in humans is extensive and covers a broad range of domains, including attention (Dijksterhuis & Aarts, 2003), memory (Inaba, Nomura, & Ohira, 2005), impression formation (Peeters & Czapinski, 1990), decision-making (Tversky & Kahneman, 1991) and learning (Fazio, Eiser, & Shook, 2004). For instance, people are faster to detect negative information than positive information. Using a lexical decision task, Dijksterhuis & Aarts (2003) assessed the ability of participants to detect negative and positive words that were presented outside conscious awareness (subliminally). In the first of three experiments, participants were presented with a row of Xs on a computer screen. In each trial, the Xs were briefly replaced with either a negative word, a positive word, or they were simply removed, leaving a blank screen. Participants were asked to indicate whether a word had been presented. They were informed that due to the short presentation duration of the words (13.3ms) they may not perceive a change in the onscreen array but should make a best guess. Despite indicating in post-experiment interviews that they did not notice a change in the onscreen presentation, participants were more likely to report that a word had been presented when a negative word had been shown than when a positive word had been shown. This suggests an enhanced ability to detect negative, relative to positive information. The experiments that followed revealed that participants were also able to more accurately identify the affective tone of negative words (presented in the same manner) than positive words, despite not having encoded the semantic content of the words presented. These findings suggest that people are faster to detect negative information than positive information.

Negative information also exerts a greater influence on impression formation than positive information (for a review, see Peeters & Czapinski, 1990). For instance, Fiske (1980) provided participants with images of people performing a range of positive and negative behaviours that varied in their extremity and asked them to rate how likeable they found the person depicted. For example, one low extremity scenario depicted the target walking past a woman who was holding up a petition on a clipboard. In the high extremity version of this scenario, the target aggressively shoves the clipboard away. The study found that negative behaviours had a greater impact on likeability ratings than positive behaviours and this effect was enhanced when the behaviour depicted was more extreme. Consistent with this, there is considerable evidence that negative product reviews have a greater impact on product sales than positive reviews (Chen & Lurie, 2013).

Infants also exhibit a negativity bias (for a review, see Vaish, Grossmann, & Woodward, 2008). For example, a neurodevelopmental study that measured event-related potentials (ERPs) in response to adult displays of negative, neutral and positive affect found that infants' responses to negative cues were significantly elevated compared to responses to neutral and positive cues, indicating a greater allocation of attention to negative information than positive (Carver & Vaccaro, 2007). Other studies have found that, like adults, infants are more likely to attribute agency (the ability to carry out goal-directed action) in the context of negative outcomes than positive outcomes (Hamlin & Baron, 2014) and show greater emotional contagion in response to negative (as opposed to positive) emotional expression (Mumme & Fernald, 2003). The presence of a negativity bias in very young children and in non-human animals (see above) suggests that a processing advantage for negative information may serve important evolutionary and survival functions because it enables us to avoid potential threat (Rozin & Royzman, 2001).

An alternative explanation for the existence of negative processing biases is that negative events are much rarer than positive events and so information regarding negative events is preferentially processed as it tends to stand out more (Rozin & Royzman, 2001). Furthermore, it has been suggested that the rarity of negative events makes them more diagnostic than positive information and should therefore be weighted more heavily (Skowronski & Carlston, 1989). Consistent with this, there is evidence that negative information is considered more veracious than positive information (Hilbig, 2009, 2012). If the frequency-diagnosticsity account holds true, then positive information should be preferentially processed in circumstances in which it is rarer than negative information. Indeed, there is some evidence of this. For example, when forming an impression of someone based upon their ability, positive information indicting high ability is weighted more heavily than negative information indicating low ability (Mende-Siedlecki, Baron, & Todorov, 2013). Such evidence can be explained by the rarity of instances of truly exceptional ability, relative to incidences of poor ability, resulting in positive information being preferentially processed in this case. This evidence lends support for the frequency-diagnosticsity account of negativity biases. However, as Rozin & Royzan argue, frequency is unlikely to be the only determinant of the full range of negativity biases. In many instances there is clearly a greater cost associated with failing to recognise a potential threat than failing to recognise a potential benefit and the evidence of negativity biases in very young children and in non-human animals point to their adaptive value.

As described previously in this chapter, there is considerable evidence that cognitive processing tendencies influence the social transmission of information. Given the breadth of the evidence, reviewed here, suggesting that negative information is preferentially processed (over positive information), it is predicted that this negativity bias will extend to the social

transmission of information. Specifically, it is predicted that a bias which favours the processing of negative information will result in (i) a content bias characterised by the selective transmission of negative information (over positive information) and; (ii) guided variation involving the transformation of information in a negative manner. The current program of research will test both these possibilities by examining the social transmission of valenced information.

Evidence of a negativity bias in the social transmission of information

There is evidence suggestive of a negativity bias in the social transmission of information. For instance, negatively-valenced rumours are more likely to be socially transmitted than positively-valenced rumours (Walker & Blaine, 1991). Walker and Blaine planted an equal number of negatively- and positively-valenced rumours among a cohort of college students, by writing them on postcards and sending them to the students. The postcards were deliberately addressed to another person, so as to seem as if they had been misaddressed by mistake. One week later, a sample of students were asked to report which, if any, rumours they had heard in the preceding week. It was found that students were more likely to report having heard a negative rumour than a positive rumour. Although this finding is consistent with a bias that favours the transmission of negative information over positive information, the uncontrolled nature of the experiment makes it difficult to draw firm conclusions. For example, it may be that the students who initially received the rumours retold them to people not sampled in the study (e.g. family members). In that case, the finding that students reported hearing more negative rumours than positive may be an artefact of the sample used, rather than evidence of a genuine negative transmission bias.

Other evidence suggestive of a negative transmission bias was found by Fessler, Pisor and Navarrete (2014) who examined the content of a selection of frequently circulated urban legends. Analysis of the content of these legends revealed that they contained three times more negative information than positive information. Whilst this finding is consistent with a bias which favours negative informational elements, the evidence is indirect, as the methodological approach used does not examine the social transmission process itself. Furthermore, it is unclear whether the positive-negative asymmetry observed by Fessler, Pisor and Navarrete is due to a content bias involving the selective transmission of negative over positive informational elements, or guided variation involving the transformation of informational elements in a negative manner during social transmission (or a combination of the two).

One study which has examined the social transmission of negative information in a more direct manner was conducted by Eriksson and Coultas (2014), who argue that social transmission occurs across three distinct phases, referred to as: choose-to-receive; encode-and-retrieve and; choose-to-transmit phases. In a series of three studies, the authors examined the transmission of urban legends that differed in their level of disgust content. They found that participants were more likely to select legends to read (choose-to-receive) that were high in disgust content, retold high disgust legends with greater fidelity to the original script (encode-and-retrieve) and were more likely to transmit high disgust legends (choose-to-transmit). The positive effect of disgust on the choose-to-transmit phase remained, even after controlling for the influence of how surprising, plausible and interesting the legends were. These findings are consistent with the possibility that a bias may operate during transmission that favours negatively-valenced information. However, Eriksson and Coultas did not include positive information in their studies. Hence, the observed preferential transmission of legends that

were high in disgust content could be attributed to a preference for emotional information in general, rather than negative information specifically. The current program of research will address this issue by directly comparing the social transmission of positive and negative information to determine if, as predicted, negative information is preferentially transmitted over positive information.

Although Eriksson and Coultas (2014) specifically examined the transmission of disgust information, we take a broader view. In the current thesis, we explore the social transmission of negatively-valenced information that is likely to elicit a range of negative emotions (i.e. disgust, fear, embarrassment, sadness etc.) Hence, we intend that the term “negativity-valenced” refers to any event or situation that is likely to be experienced as aversive and unpleasant. By our definition, negatively-valenced events include events or circumstances that are detrimental to an individual’s inclusive fitness. However, this is not a prerequisite. For example, a visit to the dentist that involves a root canal is an aversive experience but one that is likely to have an overall positive effect of an individual’s health and wellbeing. By our definition, this example would be classified as negative event given the experience itself is likely to be experienced as aversive.

Individual differences in the social transmission of information

As described previously in this review, a key feature of the study of cultural evolution is an interest in the consequences of individual-level processes, at the level of the population (Acerbi, 2016). That is, cultural evolution researchers seek to reveal how *intrapersonal* processes may influence *interpersonal* processes that drive cultural change. The current program of research is motivated by a similar interest in understanding how individual-level

psychological processes might influence interpersonal processes. Specifically, this thesis explores whether, consistent with evidence of negative cognitive processing biases, there is a general tendency for negatively-valenced information to be preferentially transmitted during social transmission, compared to positively-valenced information.

Despite a dedicated interest in the link between intrapersonal and interpersonal processes, to date, the study of cultural evolution has tended to focus on the biases that are shared by individuals. This focus perhaps stems from an assumption that culture represents the aggregate of individual-level biases (as discussed in Boyd & Richerson, 1985). However, the current thesis seeks to go beyond an understanding of shared transmission biases to examine whether there are individual differences in the expression of the proposed negativity bias.

There are likely to be a range of personal factors which could influence the tendency to transmit negative information to other people. For instance, Pezzo and Beckstead (2006) found that an individual's belief in a rumour was positively associated with the rate at which it was transmitted, suggesting that credulity plays an important role in social transmission. However, in exploring the social transmission of negative information, it is critical to consider how individual differences in emotional disposition may influence transmission.

Despite limited existing research designed to evaluate the role that individual differences in emotional disposition may play in the social transmission of information, there is some evidence which suggests that elevated dispositional anxiety may be associated with greater transmission of negative information. For instance, Fessler, Pisor and Navarrete (2014) found evidence of a general tendency for people to be more credulous towards information concerning hazards, than information concerning benefits. This finding is consistent with the negativity bias literature reviewed in this chapter. In a subsequent study, they assessed the

degree to which this negatively-biased credulity was related to an individual's perception of danger in their environment. They found that an increased perception of danger was associated with greater negatively-biased credulity. Although the authors acknowledge that they did not directly assess the social transmission of information, they argue that:

...differences (in the perception of danger) may influence the social dynamics of information transmission, as individuals characterized by high levels of negatively-biased credulity may act as important nodes in a network, accepting and broadcasting an above-average number of beliefs about hazards. (Fessler et al., 2017, p. e95167)

Consistent with this, Moussaïd, Brighton and Gaissmaier (2015) found that the amplification of risk during social transmission was associated with an individual's level of concern about a widely used but controversial antibacterial agent (triclosan) in a diffusion experiment. Their study adopted a modified version of a serial reproduction experiment. Like a typical serial reproduction experiment, the first participant in each chain was provided with some information to communicate to the next person in the chain, in this case information concerning the risks and benefits of triclosan. The second person then communicates this information to the next person in the chain and so on. The key difference in this study design was that the social transmission itself took the form of open, unstructured conversations in which the recipient of the information could ask questions, offer opinion and so on. The content of the discussions was coded to determine the valence of the information that was communicated. It was found that there was an overall tendency for participants in the study to amplify negative information about the drug and attenuate positive information, consistent with the proposed negative transmission bias. However, this tendency varied as a function of

the participants self-reported concern about triclosan. Specifically, it was found that participants who reported high levels of concern about triclosan were more likely to amplify the negative features of the drug and attenuate positive information, whereas those reporting low levels of concern about triclosan showed the opposite pattern. The results of this study highlight the importance of considering individual differences in the expression of social transmission biases.

Although Fessler et al (2014) and Moussaïd et al (2015) did not directly measure anxiety, elevated risk perception is a defining characteristic of anxiety. Hence, it is plausible that anxiety may be associated with a greater tendency to transmit negative information during social transmission. Although it is likely that individual variation in sensitivity to other negative emotions (e.g. disgust, sadness) may also modulate the proposed negative transmission bias, there is extensive evidence from the cognitive bias literature that elevated anxiety vulnerability is associated with a range of processing biases which favour negative information (for a review, see Mathews & MacLeod, 2005). The section that follows will review this literature and will argue that an anxiety-linked negative transmission bias is commensurate with predictions derived from the dominant explanatory models in anxiety research.

Anxiety-linked negative processing biases

Elevated anxiety vulnerability is associated with a range of processing biases characterised by a facilitated orientation to, and persistent preoccupation with negative information (for a review, see Mathews & MacLeod, 2005). These effects are evident in non-clinical populations, where elevated anxiety vulnerability is indicated by higher levels of trait

anxiety and in clinical populations where it is indicated by the presence of an anxiety disorder. A consistent finding is that individuals with elevated anxiety vulnerability demonstrate increased vigilance towards negative information (for a meta-analysis of this literature, see Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van Ijzendoorn, 2007).

This pattern of attentional selectivity has been observed using a range of experimental methodologies including visual-search tasks (Byrne & Eysenck, 1995), the emotional Stroop task (MacLeod & Hagan, 1992; MacLeod & Rutherford, 1992; Pury, 2002) and attentional probe ('dot-probe') tasks (MacLeod, Mathews, & Tata, 1986). For example, in a standard attentional probe task, participants are briefly presented with stimulus pairs that differ in emotional valence (i.e. one negative and one neutral). Following this, a small visual probe is presented in the locus of one of the stimuli shown previously. The participant is required to quickly discriminate the identity of this probe, and the time taken to respond is recorded. An attentional bias toward negative information is demonstrated by faster discrimination latencies for probes that appear in the location previously occupied by the negative stimuli, relative to probes that appear in the location previously occupied by the neutral stimuli. MacLeod, Mathews and Tata (1986) found that clinically anxious participants showed this biased pattern of response latencies, suggestive of an attentional vigilance toward negative information. In contrast, non-anxious control participants demonstrated the opposite pattern of response latencies, suggesting an attentional avoidance of negative stimuli.

More recently, researchers have extended this work to reveal that the observed attentional vigilance for negative information is comprised of two distinct components: the facilitated engagement of attention with negative information and the impaired disengagement of attention from negative information. Rudaizky, Basanovic & MacLeod (2013) adapted the attentional probe paradigm described above to enable the independent

assessment of attentional engagement and disengagement. For each trial in their study, participants were initially told where to fixate their attention: either to the left or right of the screen. An initial probe then briefly appeared in this location. Following this, participants were presented with stimulus pairs (as in a standard attentional probe task) consisting of an abstract image and a representational image that was either negatively or non-negatively valenced. After the images had been presented, a second probe appeared in the locus of either the abstract image or the valenced image. Participants were required quickly judge whether the probe matched the identity of the probe presented previously. Trials in which the location of the representational image was distal to the location of the initial probe, provided a measure of selective attentional engagement with this image, as a function of its emotional tone. In contrast, trials in which the representational image was proximal to the location of the initial probe, provided a measure of attentional disengagement from this image, as a function of its emotional tone. The researchers obtained a pattern of probe detection latencies indicating that high trait anxious participants demonstrated both facilitated attentional engagement with negative information and inhibited attentional disengagement from negative information. Furthermore, they found that the measures of attentional engagement and disengagement were unrelated to each other and made independent contributions to trait anxiety scores in a regression analysis. These findings highlight that heightened anxiety vulnerability is characterised by an attentional bias which favours the processing of negative information.

Elevated anxiety vulnerability is also associated with a disproportionate tendency to interpret ambiguous information in a negative manner (Eysenck, Mogg, May, Richards, & Mathews, 1991; A. Richards, 2004). Studies that have explored anxiety-linked negative interpretive bias have employed a range of ambiguous stimuli that are amenable to alternative interpretations that differ in emotional valence. For example, studies have used

ambiguous words (i.e. homophones; homographs) (Mathews, Richards, & Eysenck, 1989; A. Richards & French, 1992), ambiguous sentences (Eysenck et al., 1991) and even ambiguous faces (A. Richards et al., 2002) in a variety of tasks designed to reveal the interpretation that is encoded by participants. In one such task, clinically anxious and non-anxious control participants were told to write down auditorily presented words, that included homophones with negative and non-negative meanings (e.g. dye/die). It was found that the clinically anxious participants wrote down the negative variant of the homophone more frequently than non-anxious control participants (Mathews et al., 1989). This suggests that clinically anxious participants demonstrated a greater tendency to encode the negative variant of the homophones, relative to the non-anxious participants. A criticism of this experimental approach is that it is vulnerable to demand effects, in which the participant demonstrates a particular pattern of responding that they believe to be expected of them by the experimenter (cf. Hirsch, Meeten, Krahé, & Reeder, 2016). Furthermore, it's possible that participants in this study may have apprehended both meanings of the ambiguous homophone but were restricted to writing down only one of these. Thus, the finding that clinically anxious participants were more likely to write down the negative variant may reflect a response bias, rather than a genuine anxiety-linked interpretive bias.

An alternative approach that overcomes these issues, was used by Richards and French (1992) who developed a priming task to assess the interpretation of ambiguity by participants who differed in their level of trait anxiety. In their study, participants were required to make lexical decisions regarding words that were consistent with either the negative or non-negative meaning of an ambiguous homograph prime (e.g. 'hit' which could refer to an attack (negative) or a song (non-negative)). In a typical priming task, participants tend to respond faster on trials in which the word following the prime is semantically related.

Richards and French found that high trait anxious participants showed a relative speeding to respond when making lexical decisions about words that were consistent with the negative meaning (as opposed to the non-negative meaning) of the ambiguous homograph prime. The low trait anxious participants did not show this pattern of biased responding, suggesting that the high trait anxious participants (but not the low trait anxious participants) tended to interpret the ambiguity in a negative manner.

This anxiety-linked negative interpretation bias has been replicated in studies comparing groups of participants who differ in their level of state anxiety (Blanchette & Richards, 2003; Calvo & Castillo, 1997), in children (Hadwin, Frost, French, & Richards, 1997; Waters, Craske, Bergman, & Treanor, 2008) and in studies of specific anxiety disorders including social phobia (Amir, Foa, & Coles, 1998; Stopa & Clark, 2000), and panic disorder (Clark et al., 1997; J. C. Richards, Austin, & Alvarenga, 2001). The tendency to resolve ambiguity in a negative manner is a key feature of cognitive models of anxiety (e.g. Beck & Clark, 1997; Mathews & Mackintosh, 1998) and is believed to play a crucial role its development and maintenance. Consistent with this, there is considerable evidence that a negative interpretation bias contributes to elevated anxious mood in response to a stressor (for a review, see Hirsch et al., 2016). For instance, Wilson, MacLeod, Mathews & Rutherford (2006) adopted a training procedure originally developed by Grey and Mathews (2000) to induce either a negative or benign (non-negative) interpretation bias in a sample of undergraduate students who were homogenous with respect to trait anxiety. To encourage participants to interpret ambiguity in the desired direction, participants were initially presented with homographs that had either a negative or non-negative meaning (as in A. Richards & French, 1992). Following this, a word fragment appeared, which could be completed to yield a word related to the negative meaning of the homograph (for the negative

interpretation condition) or the non-negative meaning (for the benign interpretation condition). In this way, participants were encouraged, over more than 120 trials, to resolve the ambiguity in either a negative or benign manner, depending on their training condition. A subsequent assessment phase confirmed that the interpretation training procedure was successful in inducing the intended interpretation bias. Following this, participants were shown a video stressor, consisting of four video-clips that depicted real-life rescue operations, chosen for their capacity to elicit a negative affective response in participants. Anxiety reactivity was measured by administering visual analogue mood scales (VAMS) immediately preceding presentation of the video stressor, and again after the videos had been viewed. It was found that participants who were trained to interpret ambiguity in a negative manner experienced a significant increase in anxious mood after watching the video stressor. In contrast, participants who were trained to interpret ambiguity in a benign manner did not experience any significant elevation in anxious mood in response to this same stressor. These findings suggest that the tendency to interpret ambiguity in a negative manner plays a causal role in anxiety reactivity.

The findings that (i) it is possible to induce differential patterns of interpretation and (ii) that such training can subsequently influence anxiety reactivity, have been replicated in a number of studies, including those that have used ambiguous scenarios instead of homographs during training (Murphy, Hirsch, Mathews, Smith, & Clark, 2007). Other studies have explored the durability of these training effects and found that following a single-session of interpretative bias training (a form of cognitive bias modification often referred to as CBM-I) the desired attenuation of negative interpretations of ambiguity for high trait anxious participants was still present 24 hours later (Yiend, Mackintosh, & Mathews, 2005). Multiple-session CBM-I may be even more effective with one-study finding that the change in

interpretation endured for at least one week and there was a concomitant reduction in trait anxiety scores (Mathews, Ridgeway, Cook, & Yiend, 2007). Encouragingly, CBM-I appears to have clinical utility. For example, participants with generalised anxiety disorder reported a reduction in worry following CBM-I, and this therapeutic effect was found to be mediated by the change in interpretive bias (Hayes, Hirsch, Krebs, & Mathews, 2010). Consistent with this, a meta-analysis found that CBM-I is effective in reducing anxiety reactivity to a stressor (Hallion & Ruscio, 2011). These findings highlight the important role that the interpretation of ambiguity has in determining anxious symptomatology.

Anxiety and the social transmission of information

Whilst the dominant explanatory models of anxiety differ in the relative importance that is assigned to attention, memory, interpretation and behaviour in the development and maintenance of anxiety, what is common to all, is a prioritisation of the processing of negative information (cf. Beck & Clark, 1997; Mathews & Mackintosh, 1998). Indeed, the evidence reviewed in the preceding section supports the assertion that negative processing biases are a reliable feature of elevated anxiety vulnerability and play a crucial role in its development and maintenance. Despite a concerted research effort to elucidate the *intrapersonal* cognitive processing biases associated with elevated anxiety vulnerability, what is yet to be explored is whether there are concomitant *interpersonal* biases in the social transmission of information. The current program of research seeks to close this gap in our understanding of the *interpersonal* consequences of elevated anxiety vulnerability. Specifically, this thesis will seek to test whether anxiety modulates the social transmission of valenced information.

Overview of the current research program

The studies that comprise the current program of research were designed to test two hypotheses regarding the social transmission of information. The first is that there is a general negativity bias in the social transmission of information. Consistent with the cultural evolution literature, we predict that a bias which favours the processing of negative information will result in (i) a content bias characterised by the selective transmission of negative information over positive information and; (ii) guided variation involving the transformation of information in a negative, as opposed to a positive, manner. The second hypothesis is that anxiety will modulate this proposed negative transmission bias, such that elevated anxiety vulnerability will be associated with a greater tendency to transmit negative information, relative to low levels of anxiety vulnerability.

Prior to exploring the social transmission of information, the current thesis will address a related question, which may inform our interpretation of the subsequent studies designed to address the two hypotheses outlined above. Specifically, the first study presented in this thesis will test whether there is a general negativity bias in interpretation of ambiguous information. As outlined in this chapter there is considerable evidence that elevated anxiety vulnerability is associated with a disproportionate tendency to interpret ambiguity in a negative manner (cf. A. Richards, 2004). However, studies in this area have not directly assessed whether there is a general tendency for people to interpret ambiguity negatively, regardless of their disposition to experience anxiety. If subsequent studies in this thesis do find evidence that people tend to transform ambiguity in a negative manner during social transmission, it would be useful to understand the role that general patterns of interpretation may play in its expression. This first study in the thesis, presented in Chapter Two, will employ the methodology used by Eysenck et al (1991) who found that clinically anxious participants

showed a greater tendency to interpret ambiguous sentences (with candidate negative and non-negative meanings) in a negative manner, relative to non-anxious control participants.

The four studies that follow in the current program of research will all examine the social transmission of valenced information by undergraduate participants who vary in their level of trait anxiety. Study Two (Chapter Three) modifies the methodology used by Eysenck et al (1991) to examine the social transmission of the ambiguous sentences used in Study One. This provides a test of the prediction that a bias which favours the processing of negative information will result in guided variation involving the disproportionate transformation of information in a negative manner. The study participants include high and low trait anxious participants to test the prediction that trait anxiety will modulate the transformation of ambiguity during social transmission.

The subsequent studies presented in the thesis adopt a less constrained approach to examine the social transmission of information. In Study Two (Chapter Four), participants who differ in their level of trait anxiety are asked to read, and later retell a short story that contains unambiguously negative and positive information. This approach seeks to test the prediction that a bias which favours the processing of negative information will result in a content bias characterised by the preferential transmission of negative, over positive information. Whether trait anxiety modulates the transmission of valenced information in this study will also be assessed by contrasting the story retellings generated by high and low trait anxious participants.

Following this, Study Four (Chapter Five) will expand on the methodology used in Study 3 to examine the social transmission of a story that contains unambiguously negative and positive information, as well as ambiguous information that permits negative and positive interpretations. This enables us to test for the presence of a negative content bias and

guided variation in a negative manner, in a single study. Whether trait anxiety modulates these effects will be examined by contrasting the social transmission of high and low trait anxious participants. Additionally, this study will test whether elevated state anxiety is associated with greater transmission of negative information by randomly allocating participants to receive one of two mood manipulations designed to either elevate or reduce state anxiety.

The final study presented in this thesis (Study Five, Chapter Six) will extend the methodology used in Study Four to explore the social transmission of valenced information across four-person transmission chains. The same materials used in Study Four are used here. However, this study will randomly allocate each chain (rather than each individual) to receive either an elevated or reduced state anxiety induction. In this way, we are able to contrast the serial transmission of valenced information by chains of participants who differ in their current level of anxious mood. A version of this study appears in *Evolution and Human Behavior* and the manuscript is included in this thesis. Finally, the findings of the studies presented in this thesis and the conclusions drawn from these will be discussed. The implications of this research for our understanding of cultural evolution, cognition emotion will be considered along with potential avenues for future research that stem from this work.

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Chapter Two

Study One

There is considerable evidence that humans exhibit a range of cognitive processing biases that favour negative information (over positive information) (cf. Baumeister, Bratslavsky, Finkenauer, & Vohs, 2001; Rozin & Royzman, 2001). This negativity bias has been documented in studies that have explored patterns of information processing across a variety of domains, including attention, memory and decision-making (see Chapter One for a review of this literature). What is missing from this body of work is a thorough examination of whether or not there is a general tendency for people to form negative representations of ambiguity. The current study aims to address this issue by examining the interpretation of ambiguous scenarios by a sample undergraduate students. Furthermore, this study will test whether, consistent with findings reported in the anxiety literature, elevated-anxiety vulnerability modulates patterns of interpretation in this sample. The section that follows will review the anxiety-linked negative interpretation bias literature with specific reference to the patterns of interpretation demonstrated by participants without elevated levels of anxiety vulnerability, typically used as comparison groups in these studies.

The interpretation of ambiguity by people without elevated anxiety vulnerability

The existing literature regarding anxiety-linked biases in interpretation has focused on the differential patterns of interpretation that are revealed when participants with elevated anxiety-vulnerability are compared to those without elevated anxiety vulnerability. As described in Chapter One, a consistent finding is that elevated anxiety vulnerability is associated with a disproportionate tendency to interpret ambiguity in a negative manner,

relative to people without such heightened anxiety vulnerability (cf. Richards, 2004). Furthermore, the tendency to interpret ambiguity in a disproportionately negative manner has been shown to play a causal role in anxiety reactivity (e.g. Wilson, MacLeod, Mathews, & Rutherford, 2006). Despite the vigour with which researchers have explored anxiety-linked negative interpretation bias, comparatively little attention has been given to understanding general patterns of interpretation.

It has been claimed that most people will tend toward benign representations of ambiguity, thereby “viewing the world through rose-coloured glasses” (Mathews, 2012). This type of benign interpretation bias has been argued to serve a protective function, particularly in the domain of social relationships where it may bolster self-esteem and safeguard against social withdrawal (Fay, Page, Serfaty, Tai, & Winkler, 2008). Whereas people with elevated social anxiety tend to interpret ambiguous social cues (e.g. a yawn from a conversational partner) as indicative of their poor social performance (e.g. they are boring), it is assumed that people without elevated levels of social anxiety will tend toward more benign interpretations (e.g. the conversational partner is tired) (Rapee & Heimberg, 1997). However, a careful examination of the manner in which ambiguity is interpreted by participants who do not exhibit heightened anxiety vulnerability does not strongly support this argument. Whilst a number of studies have found evidence consistent with a general tendency toward benign interpretations of ambiguity in people with low levels of anxiety vulnerability (Eysenck, Mogg, May, Richards, & Mathews, 1991; MacLeod & Cohen, 1993), others have found that such people display unbiased patterns of interpretation, in which both negative and non-negative meanings are equally likely to be imposed on ambiguity (Grey & Mathews, 2000; Richards & French, 1992). For instance, Hirsch and Mathews (1997) provided participants who reported either a high or low level of anxiety about job interviews with descriptions of

interviews to read on a computer screen. The experimenters adopted a self-paced reading paradigm in which each subsequent line of text was revealed after the participant pressed a key. At various stages throughout the experiment the text shown described an event that was emotionally ambiguous. At these points, participants were presented with a target word that was semantically related to either a negative or non-negative interpretation of this preceding ambiguity, and they were required to make a lexical decision regarding this target word. Lexical decision latencies displayed by participants with elevated job interview anxiety did not differ for target words related to each interpretation (negative or the non-negative) of the preceding emotionally ambiguous information. In contrast, participants with low levels of job interview anxiety displayed faster lexical decision latencies on target words related to the non-negative, as opposed to the negative, interpretation of this preceding ambiguity. These findings suggest that people with low levels of anxiety vulnerability may tend to interpret ambiguity in a non-negative manner.

However, contradictory evidence suggests that low levels of anxiety may instead be associated with unbiased patterns of interpretation, in which both negative and non-negative interpretations are equally likely. In a much cited study, Richards and French (1992) developed a priming task to assess the interpretations imposed on ambiguous homograph prime words by participants who differed in their level of trait anxiety (see Chapter One for a detailed description of this study). Whilst high trait anxious participants showed speeding to process target words consistent with the negative meaning of the ambiguous homograph prime, low trait anxious participants did not show any difference in their speed to process these two categories of target words. These findings suggest that low trait anxious participants are unbiased in their interpretation of the ambiguous primes. Similar findings were obtained by Grey and Mathews (2000) who conducted a series of experiments to test whether it is

possible to induce a negative interpretation bias in participants. As part of the experimental series, pre-existing patterns of interpretation demonstrated by a group of participants who did not receive any training (and were not selected on the basis of their anxiety status) were assessed to establish a baseline with which to compare results from training conditions. It was found that this unselected group of participants did not differ in their speed to complete word fragments consistent with either the negative or non-negative meanings of the ambiguous homographs. These findings are consistent with the position that people without elevated levels of anxiety vulnerability tend to be unbiased in their interpretation of ambiguity.

Finally, at least one study has found evidence consistent with a general tendency to impose negative interpretations on ambiguous information, irrespective of a person's level of anxiety vulnerability. Mathews, Richards and Eysenck (1989) compared the interpretation of ambiguous homophones by high and low trait anxious participants, using a simple spelling task. Consistent with an anxiety-linked negative interpretation bias, anxious participants (with a diagnosis of Generalised Anxiety Disorder) demonstrated a greater tendency to write down the negative meaning of the ambiguous homophones, relative to non-anxious control participants. However, non-anxious controls also demonstrated a bias favouring negative interpretations of ambiguity, writing down the negative meaning of the ambiguous homophone in 69.9% of cases (compared to 77.1% for the anxious group). This finding suggests that participants in this study showed a general tendency to impose negative meanings on the ambiguous homophones, irrespective of their level of anxiety vulnerability.

The studies reviewed here are clearly inconclusive with regard to general patterns of interpretation shown by people, irrespective of their level of anxiety vulnerability. It is possible that the contradictory findings reported by studies that have explored the interpretation of ambiguity are due in part to variation in the participant samples that were

tested (people with low levels of trait anxiety vs. those unselected on the basis of anxiety), the experimental stimuli used (e.g. single-words vs. ambiguous scenarios) and the methodologies employed (e.g. priming tasks vs. self-report). The current program of research aims to determine if there is a negativity bias in the social transmission of information, and whether such a bias is modulated by anxiety. As noted in Chapter One, one process that may give rise to biased transmission is guided variation, which involves the transformation of information in a non-random manner as a result of an individual's underlying cognitive processing tendencies (Boyd & Richerson, 1985). In the studies presented in this thesis, the process of guided variation will be explored by examining the social transmission of ambiguous scenarios which permit emotionally discrepant interpretations. Given these aims, the current study will investigate how these types of ambiguous scenarios are interpreted by the cohort of undergraduate students recruited to participate in these studies. The section that follows will briefly review some important methodological considerations before describing the experimental approach that will be adopted in the current study.

Methodological considerations when assessing the interpretation of ambiguity

As mentioned previously in this chapter, the interpretation of ambiguity has been explored predominantly with reference to anxiety-linked differences in the manner in which ambiguity is interpreted. However, early studies suffered from two key limitations. Firstly, several studies that found evidence of an anxiety-linked negative interpretation bias used stimuli that lack strong ecological validity. For example, a number of the studies, including those described above (e.g. Mathews et al., 1989; Richards & French, 1992), presented participants of differing levels of anxiety vulnerability with ambiguous words (i.e.

homographs/homophones) that have negative and non-negative meanings. Despite the utility of ambiguous homophones and homographs in experimental settings, we rarely communicate single words to others without some context. A better approach is to employ stimuli that describe situations that might be encountered in everyday life.

Secondly, several studies in this area have failed to exclude the possibility that their findings may be explained by a response bias, rather than a genuine interpretive bias. For example, in the study by Mathews, Richard & Eysenck (1989) described above, the finding that participants (both clinically anxious and non-anxious) showed a greater tendency to write down the negative variant of the ambiguous homographs than the non-negative variant might not reflect a negative interpretation bias characterized by a tendency to encode the negative meaning of the homograph. Instead, it is possible that participants may have encoded both the negative and non-negative meanings of the ambiguous homograph but were restricted to writing down just one of these options. In that case, the tendency for participants to write down more negative variants than non-negative variants might reflect a general preference for selecting negative response options, rather than a genuine negative interpretation bias.

A study which addressed both these limitations was conducted by Eysenck, Mogg, May, Richards and Mathews (1991). In their experiment, the representations of ambiguous scenarios that were formed by clinically anxious participants (with a diagnosis of Generalised Anxiety Disorder) and a control group (with no known history of psychiatric disorder) were assessed using a task that was also able to detect whether participants demonstrated a response bias. The experiment involved an initial encoding task, during which participants were presented (via headphones) with spoken descriptions of ambiguous scenarios permitted negative and non-negative interpretations, interspersed with unambiguous filler scenarios. For half of the ambiguous scenarios, the negative interpretations were related to social harm

(e.g. rejection or embarrassment) and for the other half, the negative interpretations were related to physical harm (e.g. injury). This was done to ensure that the types of potential negative interpretations were related to the range of concerns commonly reported by people with elevated anxiety vulnerability. For example, the ambiguous scenario “*Your boss calls you to their office to discuss the quality of your recent work*” permits the negative interpretation that your boss feels that your work has been substandard (socially relevant negative interpretation) or the non-negative interpretation that your boss feels your work has been excellent. In contrast, the ambiguous scenario “*The doctor measured little Emma’s growth*” permits the negative interpretation that the doctor examined Emma’s cancerous growth (physically relevant negative interpretation) or the non-negative interpretation that the doctor measured Emma’s height (non-negative interpretation). Eysenck et al. recognised the possibility that some participants may be more likely to show a negative interpretive bias for ambiguous materials in which negative interpretations related to social harm, whereas others may be more likely to show such interpretive bias for materials in which negative interpretations are related to physical harm.

To determine which meaning (negative or non-negative) was imposed on the ambiguity by participants, the researchers used two complementary measures to infer interpretation. Firstly, after each scenario was presented to participants, they were required to indicate the perceived valence of the situation described using a rating scale that ranged from ‘*very unpleasant*’ (1) to ‘*very pleasant*’ (9). Ratings closer to 1 suggest that the participant imposed the negative interpretation on the ambiguous scenarios. After all scenarios had been presented and participants had completed an intervening distractor task that prevented verbatim memory of the ambiguous sentences (the Mill Hill Vocabulary Scale – Synonyms section; Raven, 1958), the participants completed a similarity judgement task, which provided

the second measure of interpretation. To determine which meaning (negative or non-negative) of the originally ambiguous scenarios was encoded by participants, the similarity judgement task assessed participants' recognition of the test sentences which described the candidate negative and non-negative meanings of these ambiguous scenarios (or described negative or non-negative information unrelated to these alternative interpretations). Thus, during this similarity judgement task, for each ambiguous scenario presented earlier, participants were given four test sentences. These were the candidate negative and non-negative interpretations of the ambiguous scenario (targets), along with negative and non-negative foil sentences that were not possible interpretations of the ambiguous scenarios. Participants used a rating scale that ranged from '*very similar in meaning*' (1) to '*very different in meaning*' (4) to indicate how similar each test sentence was to the situation described in the ambiguous scenario they had previously heard at the beginning of the experiment. Higher similarity ratings for one type of target sentence (negative or non-negative) relative to the other, suggested that participants may have encoded that meaning. The inclusion of the foil sentences enabled the researchers to determine if participants showed a response bias, characterized by a general tendency to endorse either negative or non-negative response options, regardless of whether the option reflected a possible interpretation of the ambiguous scenario. If no evidence of such a response bias is found when analysing participants' similarity ratings of the foil sentences, this permits the conclusion that any difference in participants' endorsement of the negative and non-negative targets reflects a genuine difference in the representations that were formed.

Eysenck et al. (1991) found that clinically anxious participants rated the ambiguous scenarios as more negative than the control group during the encoding task, suggesting a greater tendency for clinically anxious participants to interpret these scenarios negatively,

relative to the control group. Analysis of data from the similarity judgement task supported this conclusion. It was found that the non-anxious control group were more likely to endorse the non-negative targets than the negative targets, suggesting a tendency for non-anxious participants to interpret the originally ambiguous scenarios in a benign manner, consistent with the study by Hirsch and Mathews (1997), described above. In contrast, clinically anxious participants were equally likely to endorse both the negative and non-negative targets, indicating a greater tendency to interpret the ambiguous scenarios negatively, relative to the control group. However, there was evidence that both the non-anxious control group and the clinically anxious group demonstrated a response bias which favoured non-negative response options. That this effect was not modulated by anxiety, permits the conclusion that clinically anxious participants in this study demonstrated a genuine anxiety-linked negative interpretation bias characterised by a disproportionate tendency to encode the negative meaning of the ambiguous scenarios, relative to non-anxious controls. However, the finding that non-anxious control participants endorsed more non-negative targets than negative targets could reflect either a genuine tendency to favour benign interpretations of ambiguity or a general preference for non-negative response options (or a combination of the two). As the focus of the study by Eysenck et al. was on exploring anxiety-linked differences in interpretation the question of whether the non-anxious control participants demonstrated a genuine tendency to favour benign interpretations of ambiguity was not explored further. The current study will seek to resolve this issue.

The use of both the valence ratings (obtained during the encoding task) and the similarity ratings (obtained during the similarity judgement task) to provide converging evidence of an anxiety-linked negative interpretation bias is a key advantage of the experimental protocol developed by Eysenck et al. (1991). Considered in isolation, the

tendency for clinically anxious participants to rate the ambiguous scenarios as more negative than control participants during the encoding task might reflect either an anxiety-linked negative interpretation bias, or simply a heightened tendency for the clinically anxious participants to find all events more negative than the control participants, regardless of the how they resolved the ambiguity communicated with the scenarios. The similarity judgement task is not subject to this same limitation as it doesn't require participants to rate their affective experience. Instead it requires that participants indicate how similar the candidate negative and non-negative interpretations are to the originally ambiguous scenarios they were presented with. As a result of these methodological strengths, the current study will employ this approach to determine the manner in which a sample of undergraduate students (from the cohort of participants recruited to participate in subsequent studies in this thesis) interpret ambiguous scenarios that permit a negative or non-negative interpretation. The current study will also test whether anxiety modulates the interpretation of these ambiguous scenarios in this sample by comparing the pattern of interpretation demonstrated by low and high trait anxious participants.

Overview and design

The design of the current study followed the protocol used in the study by Eysenck et al (1991), described above. Participants in this study completed the same encoding task used by Eysenck et al., during which participants indicated the perceived valence of the ambiguous scenarios that were presented (via headphones). This provided the first measure of the interpretation (negative or non-negative) of the originally ambiguous scenarios. Participants in the current study then completed a short task designed to prevent verbatim memory of the

ambiguous scenarios that had been presented. Following the rehearsal prevention task participants completed the same similarity judgement task used by Eysenck et al. As described earlier, this task enables the detection of a potential response bias favouring either negative or non-negative response options. If this possibility is excluded, then the pattern of endorsement of the negative and non-negative candidate interpretations of the ambiguous scenarios can be interpreted as a genuine reflection of the meaning that was encoded by high and low trait anxious participants in this study.

Method

Participants

Participants in this study were 31 low trait anxious (19 male; 12 female) and 32 high trait anxious (13 male; 19 female) undergraduate psychology students from the University of Western Australia. A large sample of candidate participants (N=1,179) was screened using the State-Trait Anxiety Inventory, Trait Version, Form Y (STAI-T; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983), an established and widely used measure of trait anxiety. Low trait anxious participants were recruited from those scoring in the lower quartile of this distribution, while high trait anxious participants were recruited from those scoring in the upper quartile of the STAI-T distribution, (< 34 and > 47 score on STAI-T, respectively). Eligibility for inclusion required that participants were able to speak English fluently by the age of 6.

It was important to verify that whilst the two participant groups differed in their level of trait anxiety, they did not differ with regards to age and gender. The age of participants ranged from 17 to 22 years with an average of 18.35 years (SD=1.25). A *t*-test confirmed that

the age of participants in the low and high trait anxiety groups did not differ statistically, $t(61)=.77, p=.444$. There was also no statistical difference between low and high trait anxiety groups with regards to gender ratio, $\chi^2(1)=2.69, p=.101$.

Materials

Questionnaire measures. The 20 item State-Trait Anxiety Inventory, Trait Version, Form Y (STAI-T; Spielberger et al., 1983) was used to identify low and high trait anxious participants at the screening session carried out prior to testing. The STAI-T is a frequently used measure of trait anxiety that requires participants to rate how they often they ‘generally’ feel each one of 20 anxiety-related symptoms, using a four-point scale ranging from ‘*Almost Never*’ (1) to ‘*Almost Always*’ (4). Scores range from 20-80, with higher scores indicating a greater level of trait anxiety. Test-retest reliability and internal consistency for the STAI-T is high (Barnes, Harp, & Jung, 2002) and the scale has established concurrent and construct validity (Groth-Marnat, 2009).

Experimental scenarios. There were 32 experimental scenarios created for use in this study. Each was ambiguous in meaning, permitting a negative and non-negative interpretation. As in Eysenck et al. (1991) for half of the scenarios the candidate negative interpretations were related to social threat and for the other half of the scenarios the candidate negative interpretations were related to physical harm. This was done to allow for the possibility that participants may show greater evidence of an interpretive bias for one type of material. For example, the ambiguous scenario “*As you check your exam results online you find it hard to believe what you see.*” permits the non-negative interpretation that you are pleasantly surprised with your performance or the negative interpretation that you performed poorly on

the exam (socially relevant negative interpretation). In contrast, *"You are at the beach and you see someone waving in the sea"* is an ambiguous scenario that permits the non-negative interpretation that someone is waving hello or the negative interpretation that someone is signaling for help in the surf (physically relevant negative interpretation). There is evidence that young adults tend to worry more about social relationships than physical health (Lindesay et al., 2006) so it's plausible that for the undergraduate student sample in the current study, differential patterns of interpretation may be found for these types of materials.

A short title was created to accompany each scenario and was used to prompt participants' memory of the scenario during the similarity judgement task. Each title was 2-4 words long, and was created such that it did not influence the interpretation of the accompanying scenario. For example, the title *"At the beach"* was created for the ambiguous scenario *"You are at the beach and you see someone waving in the sea."* All scenarios were audio recorded by the same Australian female speaker experimenter.

For each of the 32 experimental scenarios, four test sentences were prepared for use in the similarity judgement phase of the experiment. These were structurally similar to the original scenario and all four sentences began with the same context-setting words. Two of these test sentences were the candidate negative and non-negative interpretations of the original scenario (target sentences). For the remaining two test sentences, one was negative and one was non-negative in emotional tone, but neither was a potential interpretation of the original scenario (foil sentences). An example of an experimental scenario and the four associated test sentences created for use in the recognition memory test, is presented below:

Title: "At the beach"

Scenario: "You are at the beach and you see someone waving in the sea."

Negative Target Test Sentence: "From the beach, you can see someone in the sea signaling they are in trouble."

Non-negative Target Test Sentence: "From the beach, you can see a friend waving hello to you from the sea."

Negative Foil Test Sentence: "From the beach, you can see someone in the sea colliding with a surfer."

Non-negative Foil Test Sentence: "From the beach, you can see someone in the sea talking with a surfer."

A set of 16 unambiguous filler scenarios, and a practice scenario (with accompanying titles) were also created for use in the experiment to obscure the focus on the ambiguity of the experimental scenarios. Responses recorded by participants in relation to the filler scenarios were not analysed.

It was important that the test sentences associated with the experimental scenarios had the intended emotional valence. This was verified by having 5 independent judges indicate how pleasant they found the scenario described by each test sentence 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 test sentences was -1.16 (SD=.80), which was significantly lower than zero, $t(63)=11.60$, $p<.001$, confirming their negative valence. The mean rating for the non-negative test sentences was .90 (SD=.91), which was significantly higher than zero, $t(63)=7.97$, $p<.001$, confirming their non-negative valence.

Experimental hardware. The experiment was delivered using a tablet computer (iPad) with headphones provided for the auditory presentation of stimuli. Responses were made by touching the relevant option on the screen.

Experimental tasks

Encoding task. During the encoding task participants were first presented with the title for the current scenario on the screen. Following this, the scenario was presented via headphones. Participants were instructed to imagine themselves experiencing the scenario described and to indicate how '*pleasant*' they would find this situation if they were to experience it. Responses were recorded on a 9-point scale from '*Very unpleasant*' (-4) to '*Very pleasant*' (4), with a score of '0' representing neutral valence. Participants were presented with the practice scenario first, followed by the 32 experimental scenarios, randomly interspersed with the filler scenarios. The valence ratings provide the first measure of interpretation. Negative valence ratings indicate that the participant encoded the ambiguous scenario in a negative manner.

Rehearsal prevention task. Participants were told the rehearsal prevention task was a short 'literacy test' used to assess their English language competency, and participants were asked to work through this task as quickly as possible, whilst being as accurate as possible. During the task, participants were presented with a series of words on the screen, one after the other. One letter in each word had been replaced, so that the word was no longer spelled correctly. Participants were required to indicate which letter this was. After making their selection, the program progressed to a new word. The words were all between five and nine letters long and were selected randomly from a database of common English words¹. The letter to be replaced and the letter which appeared in its place were both selected at random. The task continued for two minutes.

¹ Available from <http://icon.shef.ac.uk/Moby/>

Similarity judgement task. During the similarity judgement task, participants were presented (on screen) with the title of the scenario, followed by the four test sentences associated with the scenario. Participants were instructed to rate each test sentence for similarity to the meaning of the original scenario, previously presented via headphones. The four test sentences for each scenario were presented in random order, with the similarity scale presented underneath each. The scale included the following response options: *very similar* (1), *fairly similar* (2), *fairly dissimilar* (3) and *very dissimilar* (4). Participants rated each sentence in turn and were told that they could use each response option more than once. This allowed for the possibility that participants might have encoded both candidate interpretations of the experimental scenarios (negative and non-negative). Participants were presented with the test sentence set created for the practice scenario first, followed by the test sentence sets created for the 32 experimental scenarios, interspersed with those created for the filler scenarios, presented in the same random order as was used to present these scenarios during the encoding task.

The similarity ratings of the target sentences provide the second measure of interpretation in the current study. As in Eysenck et al (1991), the target sentence (negative or non-negative) that was rated as most similar to the original was assumed to be the meaning that was encoded. Ratings obtained from low and high trait anxious participants will be compared to determine if trait anxiety modulates the interpretation of the ambiguous scenarios in this study. Ratings of foil sentences provide an indication of response bias. A response bias will be indicated by participants tending to rate one type of foil sentence (negative or non-negative) as more similar to the originally ambiguous scenario than the other. If no evidence of a response bias is found in the current study, then the pattern of similarity ratings obtained for the negative and non-negative target sentences can be

interpreted as a genuine reflection of the manner in which the ambiguous scenarios were encoded by participants in this study.

Procedure

All participants were tested individually. Participants were informed that the experiment examined how emotion may interact with how we process verbal information and that further information about the goals of the study would be provided at the end of the session. Participants were then seated at a table in front of a tablet computer (iPad). Next, participants completed the encoding task, the rehearsal prevention task and the similarity judgement task in turn. Once the similarity judgement task had been completed the experimenter debriefed the participants and the session ended.

Results

As described previously, two measures obtained in the current study provide an indication of the representations that were formed of the ambiguous scenarios (negative or non-negative). Participants' valence ratings of the ambiguous scenarios, obtained during the encoding task, provide the first indication of the representations formed. Participants' similarity ratings of the target test sentences (negative and non-negative) provide the second indication of the representations formed. Finally, participants' similarity ratings of the foil test sentences, obtained during the similarity judgement task provide an indication of response bias. If no evidence of a response bias is found, then any difference in participants' similarity ratings of the negative and non-negative target test sentences can be attributed to the

differential tendency to impose negative and non-negative interpretations on the ambiguous scenarios.

Valence ratings and similarity ratings were analysed using linear mixed-effects modelling using the lme4 software package (Bates, Maechler, Bolker, & Walker, 2015) in R version, 3.2.2 (R Core Team, 2015). Linear mixed-effects modelling was used as it enables variation due to individual participants and individual test items to be modelled explicitly as random effects, thereby reducing the likelihood of Type 1 errors. As recommended by Barr, Levy, Scheepers, and Tily (2013) all models included the maximal random effects structure justified by the experimental design. In instances where models with the maximal random effects structure did not converge on a solution, the random effects structure was simplified by removing a random slope (or slopes).

Valence ratings of ambiguous scenarios

Analysis of participants' valence ratings of the ambiguous scenarios provide the first indication of interpretation that was obtained in the current study. As mentioned previously, negative ratings suggest that participants encoded the negative (as opposed to the non-negative) meaning of the ambiguous scenarios. The average valence ratings for the low and high trait anxious groups are presented in Table 1.

Table 1

Mean (SD) valence ratings for low and high trait anxious participants.

Scenario Type	Low Trait Anxiety	High Trait Anxiety
Social	-.59 (.69)	-1.02 (.95)
Physical	-1.57 (.67)	-1.51 (1.00)

The initial model tested for the participants' valence ratings specified Scenario Type (socially relevant or physically relevant) and Trait Anxiety Group (low or high trait anxiety) as fixed effects, with interaction (see Table 2). A maximal random effects structure was specified, which included random intercepts for Participant and Item, as well as a by-Participant random slope for the effect of Scenario Type and a by-Item random slope for the effect of Trait Anxiety Group. This model was compared to a model that specified Scenario Type and Trait Anxiety Group as fixed effects without interaction, preserving the same random effects structure. Model comparisons confirmed that allowing Scenario Type and Trait Anxiety Group to interact significantly improved model fit, $\chi^2(1)=5.08, p=.024$. The nature of this interaction is shown in Figure 1 and reveals that high trait anxious participants rated the social type scenarios more negatively than the low trait anxious participants. In contrast, high and low trait anxious participants did not differ in their ratings of the physical type scenarios. These findings suggest that high trait anxious participants were disproportionately likely to form negative representations of the socially relevant ambiguous scenarios, relative to low trait anxious participants. However, this same anxiety-linked bias was not found for the physically relevant ambiguous scenarios.

As mentioned previously in this chapter, the valence ratings of the ambiguous scenarios provide an indication of the affective tone that was perceived by participants during the encoding task. To confirm the meaning (negative or non-negative) that was encoded by participants in the current study, the data obtained from the similarity judgement task will be analysed next.

Table 2

Results of the maximal (and best-fitting) model for the valence ratings of experimental scenarios (Scenario Type and Anxiety Group as fixed effects with interaction).

Predictor	Coefficient	SE	<i>t</i>
(Intercept)	-1.53	.27	5.74***
Scenario Type (Social)	.53	.34	1.59
Trait Anxiety Group (Low Anxiety)	-.04	.22	.20
Scenario Type* Trait Anxiety Group	.45	.20	2.31*
Model fit:			
AIC	8000.1		
BIC	8061.7		
Log-likelihood	-3989.1		

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

Figure 1. Mean valence ratings for physically and socially relevant ambiguous scenarios during the encoding task. Error bars represent standard error of the means.

Similarity ratings of test sentences

The similarity ratings obtained during the similarity judgement task were analysed to provide the second indication of interpretation in this study. As described previously, ratings closer to 4 indicate that the participant found the test sentence similar to the originally ambiguous scenario. The average similarity ratings for the high and low trait anxious participant groups, for each type of test sentence are shown in Table 3.

Table 3

Mean (SD) similarity ratings of test sentences for low and high trait anxious participants.

Test Sentence Type	Low Trait Anxiety	High Trait Anxiety
<i>Physical Scenarios</i>		
Negative Targets	3.20 (.92)	3.33 (.89)
Non-negative Targets	2.77 (1.00)	2.77 (1.07)
Negative Foils	1.71 (.87)	1.80 (.92)
Non-negative Foils	1.59 (.80)	1.69 (.88)
<i>Social Scenarios</i>		
Negative Targets	2.94 (.93)	3.14 (.91)
Non-negative Targets	3.13 (.85)	2.92 (1.00)
Negative Foils	1.51 (.79)	1.66 (.89)
Non-negative Foils	1.59 (.85)	1.65 (.86)

Target sentences. To determine the manner in which participants interpreted the ambiguous scenarios in the current study, participants' similarity ratings of the target test sentences were analysed. The model for the target test sentences included Scenario Type (physical or social), Valence of the target (negative or non-negative) and Trait Anxiety Group (high and low trait anxiety) as fixed effects, with interaction (see Table 4). A random effects structure was specified, which included a random intercept for Participant, as well as a by-Participant random slopes for the effects of Scenario Type and Valence and the interaction of

these effects. A random intercept for Item was also included, as well as a by-Item random slope for the effect of Valence². This model was compared to a model that excluded the three-way interaction between the fixed effects, retaining all lower order two-way interactions. Model comparisons confirmed that allowing the three fixed effects to interact significantly improved model fit, $\chi^2(1)=5.33$, $p=.021$. To decompose the three-way interaction between Scenario Type, Valence and Trait Anxiety Group, separate models were tested for the similarity ratings of the target test sentences for the socially and physically relevant ambiguous scenarios.

Table 4

Results of the maximal model for the similarity ratings of the target test sentences (Scenario Type, Valence and Anxiety Group as fixed effects with interaction).

Predictor	Coefficient	SE	<i>t</i>
(Intercept)	3.33	.10	34.68***
Scenario Type (Social)	-.19	.11	1.63
Valence (Non-negative)	-.56	.15	3.64***
Trait Anxiety Group (Low Anxiety)	-.13	.10	1.36
Scenario Type * Valence	.34	.19	1.76
Scenario Type * Trait Anxiety Group	-.06	.09	.71
Valence * Anxiety Group	.13	.13	1.04
Scenario Type * Valence * Trait Anxiety Group	.27	.11	2.36*
Model fit:			
AIC	10312.3		
BIC	10451.0		
Log-likelihood	-5134.2		

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

² The initial model tested specified a maximal random effects structure that also included by-Item random slopes for the effects of Trait Anxiety Group and the interaction of Trait Anxiety Group and Valence. However, models with this more complex random effects structure did not converge on a solution and so the random effects structure was simplified by excluding the by-Item random slopes involving Trait Anxiety Group.

Socially relevant ambiguous scenarios – target sentences. The model for the target test sentences of the socially relevant scenarios specified Valence of the target and Trait Anxiety Group as fixed effects, with interaction. A random effects structure was specified, which included a random intercept for Participant and Item, as well as by-Participant and by-Item random slopes for the effect of Valence³ (see Table 5). This model was compared to a model that excluded the interaction between Valence and Trait Anxiety Group. Model comparisons confirmed that allowing Valence and Trait Anxiety Group to interact significantly improved model fit, $\chi^2(1)=11.36$, $p<.001$. Figure 2 reveals that the nature of this interaction is such that low trait anxious participants rated the non-negative targets as more similar to the originally ambiguous scenarios than the negative targets, suggesting a tendency to interpret these scenarios in a benign manner. In contrast, high trait anxious participants rated the negative targets as more similar to the originally ambiguous scenarios than the non-negative targets, suggesting a tendency to interpret these scenarios negatively.

³ The initial model tested, specified a maximal random effects structure that also included by-Item random slopes for the effects of Trait Anxiety Group and the interaction of Trait Anxiety Group and Valence. This model did not converge on a solution and so the random effects structure was simplified by excluding the by-Item random slopes involving Trait Anxiety Group.

Figure 2. Mean similarity ratings for physically and socially relevant targets of the ambiguous scenarios. Error bars represent standard error of the mean.

Table 5

Results of the maximal model for the similarity ratings of the socially relevant target test sentences (Valence and Anxiety Group as fixed effects with interaction).

Predictor	Coefficient	SE	t
(Intercept)	3.14	.11	28.21***
Valence (Non-negative)	-.22	.15	1.44
Trait Anxiety Group (Low Anxiety)	-.19	.11	1.78
Valence * Trait Anxiety Group	.40	.11	3.53***
Model fit:			
AIC	5007.6		
BIC	5069.3		
Log-likelihood	-2492.8		

Note. *** $p < .001$

Physically relevant ambiguous scenarios – target sentences. The initial model tested for the target test sentences of the physically relevant scenarios specified Valence of the target and Trait Anxiety Group as fixed effects, with interaction (see Table 6). The same random effects structure specified for the socially relevant targets (above) was used here. This model was compared to a model which excluded the interaction between Valence and Trait Anxiety Group. Model comparisons confirmed that excluding the interaction between Valence and Trait Anxiety Group did not significantly impact model fit, $\chi^2(1)=1.06$, $p=.303$. Next, the fixed effect of Trait Anxiety Group was tested by comparing a model with this as the only fixed effect to the null model, with no fixed effects. Model comparisons confirmed that excluding Trait Anxiety Group did not significantly impact model fit, $\chi^2(1)=.93$, $p=.335$. Finally, the fixed effect of Valence was tested by comparing a model with this as the only fixed effect to the null model. Model comparisons confirmed that including Valence as a fixed effect significantly improved model fit, $\chi^2(1)=10.26$, $p=.001$. As shown in Figure 2, both high and low trait anxious participants rated the negative targets as more similar to the physically relevant ambiguous scenarios than the non-negative targets. This suggests that both groups of participants tended to form negative representations of the physically relevant ambiguous scenarios. Furthermore, anxiety did not modulate this effect. Hence there is evidence of a general negative interpretation bias for the physically relevant ambiguous scenarios and no evidence of an anxiety-linked negative interpretation bias for these materials.

Table 6

Results of the maximal model for the similarity ratings of the physically relevant target test sentences (Valence and Anxiety Group as fixed effects with interaction).

Predictor	Coefficient	SE	<i>t</i>
(Intercept)	3.33	.09	39.07***
Valence (Non-negative)	-.56	.15	3.76***
Anxiety Group (Low Anxiety)	-.13	.10	1.36
Valence * Anxiety Group	.13	.13	1.04
Model fit:			
AIC	5366.2		
BIC	5427.9		
Log-likelihood	-2672.1		

Note. *** $p < .001$

Foil sentences. To determine if participants in this study demonstrated a response bias in the current study, participants' similarity ratings of the foil test sentences were analysed. Evidence of a response bias would be higher similarity ratings for one type of foil statement (negative or non-negative) over the other. The initial model tested for the foils included Scenario Type (socially relevant or physically relevant), Valence of the foil (negative or non-negative) and Trait Anxiety Group (high or low trait anxiety) as fixed effects, with interaction. A random effects structure was specified that included a random intercept for Participant, as well as by-Participant random slopes for the effects of Scenario Type and Valence and the interaction of these effects. A random intercept for Item was also included, as well as a by-Item random slope for the effect of Valence⁴. There were no main effects or interaction effects

⁴ The initial model tested, specified a maximal random effects structure that also included by-Item random slopes for the effect of Trait Anxiety Group and the interaction of Trait Anxiety Group and Valence. However, models with this more complex random effects structure did not converge on a solution and so the random effects structure was simplified by excluding the by-Item random slopes involving Trait Anxiety Group.

found (see Table 7). This model was compared to the null model which excluded the fixed effects. Model comparisons confirmed that the initial full model did not provide a significantly better fit than the null model, $\chi^2(14)=11.17$, $p=.673$. Hence, there was no statistical evidence of a response bias for the low or high trait anxious participants in the current study. As a result, the pattern of results obtained for the similarity ratings of the targets (described above) can be attributed to a difference in their tendency to impose negative and non-negative interpretations on the ambiguous scenarios.

Table 7

Results of the maximal model for the similarity ratings of the foil test sentences (Scenario Type, Valence and Anxiety Group as fixed effects with interaction).

Predictor	Coefficient	SE	t
(Intercept)	1.80	.12	15.26***
Scenario Type (Social)	-.14	.13	1.08
Valence (Non-negative)	-.11	.08	1.35
Anxiety Group (Low Anxiety)	-.09	.11	.81
Scenario Type * Valence	.10	.11	.89
Scenario Type * Anxiety Group	-.06	.07	.84
Valence * Anxiety Group	.01	.06	.18
Scenario Type * Valence * Anxiety Group	.09	.09	1.09
Model fit:			
AIC	8777.6		
BIC	8916.3		
Log-likelihood	-4366.8		

Note. *** $p<.001$

Discussion

The primary aim of the current study was to determine the manner in which a sample of undergraduate students (from the cohort of participants recruited to participate in subsequent studies presented in this thesis) interpret ambiguous scenarios that permit a negative or non-negative interpretation. A secondary aim was to determine if anxiety

modulates the interpretation of these ambiguous scenarios in this sample by comparing the patterns of interpretation demonstrated by low and high trait anxious participants. As in Eysenck et al., (1991) two types of ambiguous scenarios were employed in the current study (socially relevant and physically relevant scenarios) as it was thought that participants may be more likely to show an interpretive bias for scenarios related to the primary area of concern. The results of the current study indicate that this was indeed the case.

Analysis of participants' similarity ratings of the targets of the physically relevant ambiguous scenarios revealed that low and high trait anxious participants rated the negative candidate interpretations as more similar to the originally ambiguous scenarios than the non-negative candidate interpretations. This indicates a tendency to interpret ambiguous scenarios in a negative (as opposed to the non-negative) manner. There was no evidence that participants exhibited a response bias favouring either negative or non-negative response options. Hence, the pattern of results obtained for the targets can be interpreted as a genuine reflection of the manner in which these scenarios were interpreted. Additionally, there was no evidence that the low and high trait anxious participants differed in their endorsement of the negative and non-negative meanings of these scenarios. Hence, anxiety was not found to modulate the interpretation of the physically relevant ambiguous materials used in the current study.

In contrast, analysis of participants' similarity ratings of the targets of the socially relevant ambiguous scenarios revealed that low trait anxious participants tended to rate the non-negative candidate interpretations as more similar to the originally ambiguous scenarios than the negative candidate interpretations, indicating that they tended to interpret the ambiguous scenarios in a non-negative manner. The high trait anxious participants showed the opposite pattern of similarity ratings. Specifically, high trait anxious participants tended

to rate the negative candidate interpretations as more similar to the originally ambiguous scenarios than the non-negative candidate interpretations, indicating that they tended to interpret the ambiguous scenarios in a negative manner. Again, there was no evidence that participants exhibited a response bias favouring either negative or non-negative response options. Hence, the pattern of results obtained for the targets can be interpreted as a genuine reflection of the manner in which these scenarios were interpreted.

Taken together, these findings suggest that there was a general tendency for participants to interpret the physically relevant ambiguous scenarios in a negative manner, irrespective of their level of trait anxiety. In contrast, it was found that low trait anxious participants tended to interpret the socially relevant ambiguous scenarios in a non-negative manner, whereas high trait anxious participants tended to interpret these same scenarios in a negative manner.

Are biases in the interpretation of ambiguity context specific?

The current study found evidence of a general negativity bias in the interpretation of the physically relevant ambiguous scenarios but not the socially relevant ambiguous scenarios. This finding is partially consistent with Eysenck et al. (1991) who found that both clinically anxious and non-anxious control participants in their study rated the physically relevant ambiguous scenarios more negatively than the socially relevant ambiguous scenarios during the encoding task. However, in their study the data obtained for the two types of ambiguous scenarios during the similarity judgement task were pooled when comparing ratings by the clinically anxious and non-anxious control groups. The pattern of similarity ratings specific to each type of ambiguous scenario was only examined within the clinically

anxious participant group to determine whether the observed anxiety-linked negative interpretation bias was specific to the participants' primary area of concern (it wasn't). Hence, it is unclear whether non-anxious participants in their study may have interpreted the physically relevant and socially relevant ambiguous scenarios differently, as was the case here.

As noted in the introduction to this chapter, it has been claimed that, at least in relation to social relationships, people without elevated levels of anxiety vulnerability may tend toward benign interpretations of ambiguity (Mathews, 2012). It has been argued that favouring non-negative interpretations of ambiguity may serve a protective function, safeguarding against potential harm to self-esteem and increasing the likelihood that an individual may take advantage of positive opportunities as they arise (Fay et al., 2008). The same argument cannot be made in relation to ambiguous situations that carry the potential for physical harm. A tendency to favour non-negative interpretations in this case could mean that sources of potential threat are not recognised and responded to, leaving the individual vulnerable to harm. Hence, the tendency to favour either negative or non-negative interpretations of ambiguity may be context specific. The evidence obtained in the current study suggests that this may indeed be the case. Low trait anxious participants in the current study showed a clear tendency to favour negative interpretations of physically relevant ambiguous scenarios. However, this same tendency to favour negative interpretations of ambiguity was not found for the socially relevant ambiguous scenarios.

Anxiety-linked negative interpretation biases in non-clinical samples

The current study found evidence that anxiety modulated the interpretation of the socially relevant ambiguous scenarios but not the physically relevant ambiguous scenarios. One possible explanation for this is that the high trait anxious participants in the current study may have tended to worry more about social concerns, than physical concerns. This would be consistent with existing evidence that young adults tend to worry more about social relationships than physical health (Lindesay et al., 2006). Hence, it's possible that the observed anxiety-linked negative interpretation bias may have been specific to their area of primary concern. Although Eysenck et al., (1991) did not find evidence of this kind of specificity in their study, their elevated anxiety participants were clinically anxious individuals who had been diagnosed with Generalized Anxiety Disorder. In contrast, the elevated anxiety participants in our study were drawn from a non-clinical sample of undergraduate students who reported experiencing elevated anxiety vulnerability. It's possible that at sub-clinical levels, anxiety-linked negative interpretation bias is specific to the individual's primary area of concern but in more severe, clinical presentations, the tendency to favour negative interpretations of ambiguity generalizes to other domains.

Conclusion

The current study found evidence of a general tendency to interpret the physically relevant ambiguous scenarios in a negative manner, irrespective of an individual's level of trait anxiety. This same general pattern of negative interpretation was not evident for the socially relevant ambiguous scenarios, suggesting that the tendency to form negative representations of ambiguity may depend on content of the scenario described. The current

study also explored whether there was evidence of an anxiety-linked negative interpretation bias for a sample of undergraduate students, drawn from the cohort that will be recruited to participate in subsequent studies presented in this thesis. There was evidence that participants with elevated trait anxiety were disproportionately likely to encode the negative meaning of the socially relevant scenarios, relative to participants with low levels of trait anxiety. However, this same effect of trait anxiety was not found for the physically relevant scenarios.

As outlined in Chapter One, the primary aim of the current program of research is to test whether there is a negativity bias in the social transmission of information. In this context, understanding general patterns of interpretation when faced with ambiguity provides a useful foundation with which to explore the social transmission of this sort of information. The next study presented in this thesis will test whether a negative transmission bias is evident when these same scenarios are orally transmitted from one participant (the transmitter) to another (the receiver). If these materials are subject to guided variation during social transmission, then we can predict that the ambiguous scenarios will tend to be transformed in a manner consistent with the transmitters' own interpretation. By adapting the experimental methodology employed in the current study, Study Two will determine the representations of the ambiguous scenarios (negative or non-negative) that are encoded by receivers and explore whether meanings encoded can be wholly, or partially accounted for by the meanings that were encoded by the transmitter. Study Two will also explore whether anxiety modulates the social transmission of these scenarios by recruiting both low and high trait anxious transmitters. The receivers paired with the two groups of transmitters will be homogenous with respect to trait anxiety. This will enable us to determine if there is an anxiety-linked bias in the social transmission of the ambiguous scenarios.

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Chapter Three

Study Two

As described in Chapter One, guided variation is the process by which cultural variants are transformed in a non-random manner during social transmission, as a result of an individual's cognitive processing biases (Boyd & Richerson, 1985). Given the extensive evidence that people tend to favour the processing of negative information (cf. Baumeister, Bratslavsky, Finkenauer, & Vohs, 2001) it is argued here that, through guided variation, people may be likely to transform ambiguity (that permits emotionally discrepant interpretations) in a disproportionately negative manner during social transmission. As a precursor to exploring this issue, Study One (see Chapter Two) examined the way in which this type of ambiguity was encoded by a sample of undergraduate students (drawn from the cohort recruited to participate in the subsequent studies presented in this thesis). Despite extensive evidence from the anxiety literature that elevated anxiety vulnerability is associated with a disproportionate tendency to encode negative (as opposed to non-negative) meanings of ambiguity (cf. Richards, 2004), existing evidence regarding general patterns of interpretation shown by people without elevated anxiety vulnerability has been inconsistent. Study One sought to clarify this issue. As a secondary issue, whether anxiety modulated the interpretation of ambiguity in this sample was also explored by comparing the patterns of interpretation shown by low and high trait anxious participants.

Study One found that there was a negativity bias in the interpretation of ambiguous scenarios that permit negative interpretations related to physical harm. The low and high trait anxious participants demonstrated a general tendency to tend to interpret these scenarios in a negative manner. In contrast, it was found that low trait anxious participants tended to interpret the socially relevant ambiguous scenarios in a non-negative manner,

whereas high trait anxious participants tended to interpret these same scenarios in a negative manner.

Having established the manner in which these ambiguous scenarios tend to be encoded, the primary aim of the current study is to test whether a negative transmission bias is evident when these same scenarios are orally transmitted from one participant (the transmitter) to another (the receiver). Given the evidence that the physically relevant ambiguous scenarios tend to be encoded in a negative manner (irrespective of the individuals' level of trait anxiety), it might be expected that transmitters will be likely to transform the originally ambiguous scenarios in a manner that conveys the negative meaning to the receiver. This would be consistent with Bartlett's (1932) early studies on remembering, which found that ambiguous elements in a Native American story script were transformed in a manner that was consistent with the participants' cultural understanding of objects and events (see Chapter One for a more detailed discussion of this study). More broadly, this would be consistent with Boyd and Richerson's (1985) description of guided variation. Prior to describing the current study in more detail, the literature surrounding this mechanism of cultural evolution will be revisited, with reference to points of contention that are subject to ongoing debate. Additionally, it will be argued that ambiguous scenarios (of the type used in Study One) offer a unique opportunity to explore guided variation as it relates to the social transmission of emotionally valenced information.

Guided variation

Despite the obvious parallels between biological evolution and cultural evolution, the social transmission of information is much more prone to mutation than the replication

of genes (Henrich & McElreath, 2003). As will be apparent to any participant in the childhood game Chinese Whispers, the retelling of information tends to be error-prone, leading to the transformation of the original variant. In some cases, this transformation is random, resulting from either the imperfect reception or replication of the message. For instance, the mishearing of the word 'bank' as 'tank'. This type of random transformation is akin to genetic mutation. However, unlike genetic mutation, the social transmission of information is also subject to non-random transformation. Boyd and Richerson (1985) argue that some cultural variants will be transformed during social transmission as a result of the cognitive processing biases of the transmitter. This process of guided variation has no obvious parallels in biological evolution, where high fidelity replication is a feature.

As noted in Chapter One, the transformation of cultural variants has been documented in a number of studies (e.g. Kalish, Griffiths, & Lewandowsky, 2007; Xu, Dowman, & Griffiths, 2013). For instance, drawing on Bartlett's (1932) method of serial reproduction, Mesoudi and Whiten (2004) explored the communicative consequences of a cognitive processing bias which favours high-level descriptions of event information over low-level action descriptions. In their study, narratives that described an event, such as going to a restaurant (high-level event description), were transmitted along chains of four people. The original story script for each narrative was composed entirely of low-level actions descriptions (e.g. 'open the menu', 'decide on food', 'tell waitress the order'). Analysis of participants' retellings of these narratives revealed that across multiple transmission episodes the number of low-level descriptions decreased, whilst medium- and high- level descriptions spontaneously emerged. That there were no medium- or high-level event descriptions present in the original script clearly points to the transformation of information during social transmission.

Boyd and Richersen (1985) argue that the same cognitive processes that give rise to the transformation of information during social transmission, can drive selection among different variants. By this logic, if the well-documented negative processing biases (described in detail in Chapter One) influence the social transmission of information, then this may result in both the transformation of some variants in a more negative manner, and the preferential transmission of negative (over non-negative) variants. Despite this feature of cultural evolution being posited by Boyd and Richersen over three decades ago, research in this area has tended to focus on one, or the other process. For instance, there is now considerable evidence that people preferentially transmit information that is consistent with pre-existing stereotypes, over information that is stereotype-inconsistent (Kashima, 2000; Lyons & Kashima, 2003, 2006). Studies in this area have typically employed experimental designs involving the serial reproduction of a narrative that contains equal amounts of each type of information. Analysis of participants' story reproductions has revealed that a greater number of stereotype-consistent story elements from the original story script feature in participants' retellings, than stereotype-inconsistent elements. This evidence is consistent with a selection bias (also known as a content bias) which favours the preferential transmission of certain variants over others. However, whether there is also a tendency to transform existing variants in a manner which is congruous with this stereotype-consistency bias has not received the same empirical attention. Across the studies presented in this thesis both these processes of cultural evolution will be explored in the context of the social transmission of emotional information.

At this juncture, it is appropriate to acknowledge the ongoing debate in the field of cultural evolution regarding the role played by transformative and preservative (or selection-based) processes. Whilst theorists such as Boyd & Richersen (1985) propose that

guided variation (transformation) and content biases (selection) are two complementary processes of cultural evolution, proponents of ‘cultural attraction’ argue that these two processes cannot be uncoupled (Claidière & Sperber, 2007; Sperber, 1996). In their view, all social transmission involves the reconstruction and transformation of cultural variants. They argue that the sort of high fidelity replication seen in biological evolution is not possible in social transmission. As a result, the evidence that certain variants (such as the stereotype-consistent story elements explored by Lyons and Kashima (2003, 2006)) are seemingly *replicated* in transmission actually reflects the fact that certain elements are more likely to be *reconstructed* than others. In this way, what appears to be replication, is actually transformation that results in a very specific variant. This is not a distinction on which this thesis will dwell. The interested reader can review Acerbi and Mesoudi’s (2015) discussion of the two theoretical standpoints. However, one point of relevance to the current program of research is made particularly well in their paper: often the perception of whether cultural change is the result of *transformation* or *selection* rests on the level of granularity of the analysis. Consider again, Lyons and Kashima’s studies of stereotype-consistency bias. To my mind, the finding that more stereotype-consistent information survives in social transmission, when equal amounts of this and stereotype-inconsistent information were available in the original story script, is evidence of the preferential selection of certain variants over others. However, this conclusion rests on the viewpoint that the unit of analysis is not the narrative as a whole but rather the clauses of which it consists. Some of these clauses contain stereotype-consistent information, whilst others contain stereotype-inconsistent information. If the unit of analysis is instead the narrative itself, then it can be argued that the story script was transformed. As should be evident from the discussion of these processes here (and in Chapter One), the current thesis adheres to Boyd and

Richersen's description of guided variation (referred to by Acerbi and Mesoudi as '*narrow cultural attraction*') and conceptualizes transformation and selection as two distinct but complementary processes which contribute to cultural change.

Exploring guided variation using ambiguous scenarios

As described in Chapter Two, the anxiety bias literature has fruitfully employed ambiguous materials to explore patterns of interpretation, consistently finding that elevated anxiety vulnerability is associated with a tendency to favour negative representations of ambiguity, relative to people with low levels of anxiety vulnerability (e.g. Eysenck, Mogg, May, Richards, & Mathews, 1991; Richards & French, 1992). The use of ambiguous materials that permit emotionally discrepant interpretations has obvious empirical utility. However, their use has been largely restricted to studies that explore the *reception* of information. In contrast, the current study will employ these same materials to examine the *transmission* of information.

As noted earlier in this chapter, Study One found that the physically relevant ambiguous scenarios used in that study tended to be interpreted in a negative manner by low and high trait anxious participants. In contrast, it was found that low trait anxious participants tended to interpret the socially relevant ambiguous scenarios in a non-negative manner, whereas high trait anxious participants tended to interpret these same scenarios in a negative manner. The obvious variation in which these materials tend to be encoded suggests that they might be particularly amenable to transformation during social transmission. People may be likely to convey the representation that was formed of the scenario described, rather than preserving the ambiguity in the scenario. Hence, the same

materials used in Study One will be employed in the current study to examine the social transmission of information that is amendable to both negative and non-negative interpretation.

The current study

The primary aim of the current study is to determine if there is a tendency for people to transform the ambiguous scenarios used in Study One in a negative (as opposed to non-negative) manner during social transmission. Given the evidence from Study One of a negativity bias in the interpretation of the physically relevant ambiguous scenarios but not the socially relevant ambiguous scenarios, it is plausible that a negative *transformation* bias might be most evident for the physically relevant scenarios. In contrast, Study One found that high trait anxious participants tended to interpret the socially relevant ambiguous scenarios in a negative manner, whereas low trait anxious participants interpreted these same scenarios in a non-negative manner. Hence, it is likely that a negative transformation bias may only be evident for these scenarios for high trait anxious participants. To test these possibilities, the current study adapts the experimental methodology employed in Study One, to determine the representations that are formed by receivers who were told about these scenarios by low and high trait anxious transmitters. In this study, a negative transformation bias may be evidenced in two ways. Firstly, evidence of a negative transformation bias will be receivers recording more negative valence ratings of the originally ambiguous scenarios, than the transmitters during the valence ratings task. Secondly, a negative transformation bias will be evidenced by receivers showing a disproportionate tendency to rate the negative candidate interpretations of the ambiguous

scenarios as more similar to the original statement than the non-negative candidate interpretations, relative to the transmitters.

Overview and design

The current study adapts the experimental approach used in Study One to include the social transmission of the same ambiguous scenarios employed in that study. During the experiment, the ambiguous scenarios will be presented (via headphones) to participants (transmitters) who differ in their level of trait anxiety (low or high). The ambiguous scenarios will be randomly interspersed with filler scenarios to obscure the focus on these experimental scenarios. After each scenario is presented, transmitters will orally communicate the scenario to a receiver, who is low with respect to trait anxiety. The same two measures, used in Study One to indicate the representations that were formed of the ambiguous scenarios, will be obtained from both the transmitters and the receivers in the current study. Firstly, after the transmitter has communicated each scenario to the receiver, both participants will provide a rating indicating the perceived valence of the scenario. These valence ratings will provide the first indication of the representations that were formed of the ambiguous scenarios (negative or non-negative). Next, participants will complete the same rehearsal prevention task described in Study One (designed to prevent verbatim memory of the scenarios), followed by the similarity judgement task. As described in Study One, the similarity judgment task provides an indication of the meaning (negative or non-negative) that was encoded by participants. In addition, the task enables the detection of a potential response bias, characterised by a general preference for endorsing either negative or non-negative response options. If this possibility is excluded, then the

pattern of endorsement of the negative and non-negative candidate interpretations of the ambiguous scenarios can be interpreted as a genuine reflection of the meaning that was encoded by participants in this study.

Method

Participants

In the current study, it was necessary to recruit a group of participants who report low levels of anxiety vulnerability and a second group of participants who report elevated anxiety vulnerability, to act as transmitters. It was also necessary to recruit receivers, to whom the transmitters would communicate the ambiguous scenarios. To ensure that the assessment of the representation (negative or non-negative) that was formed by receivers is not confounded with their own level of trait anxiety, it was necessary to ensure the receivers were homogenous with respect to trait anxiety. Recruiting receivers who do not differ in their level of trait anxiety ensures that any difference in the representations formed by the receivers paired with low trait anxious transmitters and those paired with high trait anxious transmitters can be attributed to the trait anxiety status of the transmitter. Hence, transmitters in this study were 25 low trait anxious participants (7 male; 18 female) and 33 high trait anxious participants (9 male; 24 female). The receivers in this study were 58 low trait anxious participants (21 male; 37 female). The result was 25 dyads whose transmitters were low trait anxious (low trait anxiety dyads) and 33 dyads whose transmitters were high trait anxious (high trait anxiety dyads).

To recruit participants of low and high trait anxiety status the same approach that was used in Study One was adopted here. A large sample of candidate participants

($N=1,096$) was screened using the State-Trait Anxiety Inventory, Trait Version, Form Y (STAI-T; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983), a measure of trait anxiety. Low trait anxious participants were recruited from those scoring in the lower quartile of the STAI-T distribution, while high trait anxious participants were recruited from those scoring in the upper quartile of this distribution (in the present study this was scores <34 and >48 , respectively). Eligibility for inclusion required that participants reported being able to speak English fluently by the age of 6. All participants were undergraduate psychology students from the University of Western Australia.

It was necessary to verify that the two groups of transmitters differed in their level of trait anxiety but not in age or gender. A t -test comparing the STAI-T scores of the low and high trait anxious transmitters confirmed that their trait anxiety scores significantly differed, $t(56)=22.37, p<.001$. The age of the transmitters ranged from 17 to 44 years with an average of 20.21 years ($SD=5.31$). A t -test confirmed that the age of the low and high trait anxious transmitters did not significantly differ, $t(33.19)=1.24, p=.224$. There was also no statistically significant difference between the low and high trait anxious transmitters with regards to gender ratio, $\chi^2(1)=.004, p=.951$.

It was also necessary to verify that receivers paired with low and high trait anxious transmitters did not differ in their level of trait anxiety, age or gender. A t -test comparing the STAI-T scores of the receivers paired with low and high trait anxious transmitters confirmed that their trait anxiety scores did not significantly differ, $t(56)=1.09, p=.280$. The age of the receivers ranged from 16 to 54 years with an average of 19.45 years ($SD=6.17$). A t -test confirmed that the age of the receivers paired with low and high trait anxious transmitters did not significantly differ, $t(56)=.63, p=.530$. There was also no statistically

significant difference between the receivers paired with low and high trait anxious transmitters with regards to gender ratio, $\chi^2(1)=.27, p=.600$.

Materials

Questionnaire measures. The 20 item State-Trait Anxiety Inventory, Trait Version, Form Y (STAI-T; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) was used to identify low and high trait anxious participants at the screening session carried out prior to testing. This measure is described in detail in Chapter Two.

Experimental scenarios. The materials used in the present study were the same 32 ambiguous scenarios used in Study One. For half of the scenarios the candidate negative interpretations were related to physical harm and for the other half of the scenarios the candidate negative interpretations were related to social threat. As described in detail in Chapter Two, each scenario permitted a negative and non-negative interpretation and was accompanied by a short title. For each scenario, the four associated test sentences prepared for use in the similarity judgement phase of the experiment were also used. These included the candidate negative and non-negative interpretations of the scenarios (targets) along with negative and non-negative foil sentences that were not possible interpretations of the scenarios. These scenarios were randomly interspersed with 32 filler scenarios that were used to obscure the focus on the experimental scenarios.

Experimental hardware. Both the transmitters and receivers were provided with a tablet computer (iPad) which delivered the experiment. The transmitters were also provided with headphones for the auditory presentation of the ambiguous scenarios. Responses (by transmitters and receivers) were made by touching the relevant option on the screen.

Experimental tasks

Transmission phase. During the transmission phase, the transmitters and receivers completed the encoding task that was used in Study One. However, the presentation of the stimulus materials differed for transmitters and receivers. Specifically, the transmitters were presented, via headphones, with the same ambiguous scenarios that had been audio recorded by a female experimenter and were used in Study One. After each scenario had been presented, the transmitter orally communicated this scenario to the receiver. Next, both participants provided a rating indicating the perceived valence of the scenario using a 9-point scale from ‘*Very unpleasant*’ (-4) to ‘*Very pleasant*’ (4). The practice scenario was presented first, followed by the 32 ambiguous scenarios, randomly interspersed with the filler scenarios. The valence ratings provide the first measure of interpretation. Negative valence ratings indicate that participant encoded the ambiguous scenario in a negative manner.

Rehearsal prevention task. The rehearsal prevention task was the same as that used in Study One and was included to prevent verbatim memory of the scenarios that were presented to transmitters via headphones (see Chapter Two for details). The transmitters and receivers completed this task concurrently.

Similarity judgement task. The similarity judgement task was the same as that used in Study One and was completed by transmitters and receivers concurrently. For each scenario presented to the transmitter via headphones (and communicated by the transmitter to the receiver), participants rated the four test sentences for similarity to the original scenario. The rating scale included the following response options: *very similar* (1), *fairly similar* (2), *fairly dissimilar* (3) and *very dissimilar* (4). Two of the test sentences described the candidate negative and non-negative interpretations of the originally ambiguous scenarios

(targets). The other two test sentences were negative and non-negative in meaning but were not possible interpretations of the original scenarios (foils) (see Chapter Two for details).

Procedure

The transmitter and receiver were seated opposite each other across a table (approximately 1.5m in diameter), in front of a tablet computer (iPad). Responses were made by touching the relevant option on the screen. Both participants were informed that the experiment examined how emotion may interact with how we process verbal information and that further information about the goals of the study would be provided at the end of the session. The transmitter and receiver then completed the transmission phase, the rehearsal prevention task and the similarity judgement task (described above) in turn. Once the similarity judgement task had been completed, the experimenter debriefed the participants and the session ended.

Results

The primary issue investigated in the current study is whether there is a tendency for people to transform ambiguity in a negative (as opposed to non-negative manner) during social transmission. To address this research question, the same two measures of interpretation obtained in Study One, were obtained here from transmitters and receivers to provide an indication of the representations that were formed of the originally ambiguous scenarios. Participants' valence ratings of the ambiguous scenarios (obtained during the encoding task) provide the first indication of the representations formed. Next, participants' similarity ratings of the target test sentences (negative and non-negative), obtained during

the similarity judgement task provide the second indication of the representations formed. Finally, participants' similarity ratings of the foil test sentences provide an indication of response bias, characterised by a tendency to endorse either negative or non-negative response options. If no evidence of a response bias is found, then any difference in participants' similarity ratings of the negative and non-negative target test sentences can be interpreted as a genuine reflection of the representations that were formed of the ambiguous scenarios by participants.

As in Study One, valence ratings and similarity ratings were analysed using linear mixed-effects modelling using the lme4 software package (Bates, Maechler, Bolker, & Walker, 2015) in R version, 3.2.2 (R Core Team, 2015). As recommended by Barr, Levy, Scheepers, and Tily (2013) all models included the maximal random effects structure justified by the experimental design. In instances where models with the maximal random effects structure did not converge on a solution, the random effects structure was simplified by removing a random slope (or slopes).

Valence ratings of ambiguous scenarios

Valence ratings were analysed to provide the first indication of the representations that were formed of the originally ambiguous scenarios by transmitters and receivers. As mentioned previously, negative ratings suggest that participants encoded the negative (as opposed to the non-negative) meaning of the ambiguous scenarios. Average valence ratings for the transmitters and receivers, for each type of ambiguous scenario (physically relevant and socially relevant) are shown in Table 1.

Table 2

Mean (SD) valence ratings of the ambiguous scenarios for transmitters and receivers from high and low trait anxiety dyads.

Scenario Type	Low Trait Anxiety Dyad		High Trait Anxiety Dyad	
	Transmitter	Receiver	Transmitter	Receiver
Physically relevant	-1.72 (.74)	-1.80 (.57)	-1.85 (.70)	-1.85 (.68)
Socially relevant	-.86 (.65)	-.77 (.80)	-1.32 (.74)	-.85 (.57)

The initial model tested for participants' valence ratings specified Role (transmitter or receiver) Dyad Type (low or high trait anxiety transmitter) and Scenario Type (physical or social) as fixed effects, with interaction. A random effects structure was specified, which included random intercepts for Dyad and Item, as well as a by-Dyad random slope for the effect of Scenario Type and a by-Item random slope for the effect of Role⁵ (see Table 2). This model was compared to a model which excluded the three-way interaction between Role, Dyad Type and Scenario Type. Model comparisons confirmed that including the three-way interaction between the fixed effects marginally improved model fit, $\chi^2(1)=3.20$, $p=.074$. To decompose this three-way interaction separate models were conducted for the transmitters and the receivers.

⁵ The initial model tested also specified by-Item random slopes for the effect of Dyad Type and the interaction of Dyad Type and Role. However, models with this more complex random effects structure did not converge on a solution and so the random effects structure was simplified by removing the by-Item random slopes involving Dyad Type.

Table 2

Results of the maximal model for participants' valence ratings of originally ambiguous scenarios (Role Scenario Type and Dyad Type as fixed effects with interaction).

Predictor	Coefficient	SE	<i>t</i>
(Intercept)	-1.85	.26	7.04***
Role (Transmitter)	.003	.12	.02
Dyad Type (Low Trait Anxiety Transmitter)	.14	.15	.88
Scenario Type (Socially Relevant)	1.00	.36	2.77**
Role*Dyad Type	-.02	.16	.10
Role*Scenario Type	-.49	.17	2.93**
Dyad Type*Scenario Type	.07	.17	.40
Role*Dyad Type*Scenario Type	.40	.23	1.79 (<i>p</i> =.074)
Model fit:			
AIC	14525.1		
BIC	14618.3		
Log-likelihood	-7247.6		

Note. ****p*<.001, ***p*<.01, **p*<.05

Transmitters' valence ratings. The initial model tested for the transmitters' valence ratings specified Dyad Type (low or high trait anxiety transmitter) and Scenario Type (physical or social) as fixed effects, with interaction. The maximal random effects structure was specified, which included random intercepts for Dyad and Item, as well as a by-Dyad random slope for the effect of Scenario Type and a by-Item random slope for the effect of Dyad Type (see Table 3). This model was compared to a model that excluded the interaction between Dyad Type and Scenario Type. Model comparisons confirmed that including the interaction between the fixed effects provided a significantly better model fit, $\chi^2(1)=7.54$, *p*=.006. As shown in Figure 1, the low and high trait anxious transmitters did not differ in their valence ratings of the physically relevant ambiguous scenarios. In contrast, the high trait anxious transmitters tended to rate the socially relevant ambiguous scenarios more negatively than the low trait anxious transmitters. These findings replicate the pattern of

results obtained for participants in Study One and suggest that anxiety modulated the interpretation of the socially relevant ambiguous scenarios but not the physically relevant ambiguous scenarios.

Table 3

Results of the maximal model for transmitters' valence ratings of originally ambiguous scenarios (Dyad Type and Scenario Type as fixed effects with interaction).

Predictor	Coefficient	SE	t
(Intercept)	-1.85	.26	7.13***
Dyad Type (Low Trait Anxiety Transmitter)	.12	.19	.63
Scenario Type (Socially Relevant)	.51	.34	1.52
Dyad Type*Scenario Type	.47	.17	2.84**
Model fit:			
AIC	7248.3		
BIC	7309.0		
Log-likelihood	-3613.1		

Note. *** $p < .001$, ** $p < .01$

Figure 1. Mean valence ratings of the ambiguous scenarios by low and high trait anxiety dyads. Error bars represent standard error of the mean.

Receivers' valence ratings. The initial model tested for the receivers' valence ratings specified Dyad Type (low or high trait anxiety transmitter) and Scenario Type (physical or social) as fixed effects, with interaction. Again, the maximal random effects structure was specified, which included random intercepts for Dyad and Item, as well as a by-Dyad random slope for the effect of Scenario Type and a by-Item random slope for the effect of Dyad Type (see Table 4). This model was compared to a model that excluded the interaction between Dyad Type and Scenario Type. Model comparisons confirmed that including the interaction between the fixed effects did not significantly improve model fit, $\chi^2(1)=.13$, $p=.724$. Next, the fixed effect of Dyad Type was tested by comparing a model with this as the only fixed effect, to the null model without any fixed effects. Model comparisons confirmed

that including Dyad Type as a fixed effect did not significantly improve model fit, $\chi^2(1)=1.29$, $p=.256$. Finally, the fixed effect of Scenario Type was tested by comparing a model with this as the only fixed effect, to the null model without any fixed effects. Model comparisons confirmed that including Scenario Type as a fixed effect provided a significantly better model fit than the null model, $\chi^2(1)=7.41$, $p=.007$. This confirms that receivers rated the physically relevant ambiguous scenarios more negatively than the socially relevant ambiguous scenarios (see Figure 1). There was no evidence that receivers' valence ratings were influenced by the trait anxiety status of the transmitter who communicated the ambiguous scenarios to them.

As noted in Chapter Two, the valence ratings of the ambiguous scenarios provide an indication of the affective tone that was perceived by participants during the encoding task. To confirm the meaning (negative or non-negative) that was encoded by participants in the current study, the data obtained from the similarity judgement task will be analysed next.

Table 4

Results of the maximal model for receivers' valence ratings of originally ambiguous scenarios (Dyad Type and Scenario Type as fixed effects with interaction).

Predictor	Coefficient	SE	t
(Intercept)	-1.85	.26	7.00***
Dyad Type (Low Trait Anxiety Transmitter)	.14	.18	.80
Scenario Type (Socially Relevant)	1.00	.36	2.81**
Dyad Type*Scenario Type	.07	.19	.35
Model fit:			
AIC	7273.1		
BIC	7333.7		
Log-likelihood	-3625.5		

Note. *** $p<.001$, ** $p<.01$

Similarity ratings of negative and non-negative meanings of the ambiguous scenarios

Similarity ratings obtained from the transmitters and receivers during the similarity judgement task provide the second indication of the representations that were formed of the originally ambiguous scenarios. The average ratings of the target and foil test sentences by transmitters and receivers are shown in Table 5. Participants' similarity ratings of the target test sentences will be analysed first, to provide an indication of the meaning of (negative or non-negative) that was encoded. Following this, participants' similarity ratings of the foil test sentences will be analysed to determine if there was evidence of a response bias in the current study.

Table 5

Mean (SD) similarity ratings of target and foil test sentences for participants from the two groups of dyads.

Test Sentence Type	High Trait Anxiety Dyad		Low Trait Anxiety Dyad	
	Transmitter	Receiver	Transmitter	Receiver
Physically Relevant Scenarios				
Negative Targets	3.45 (.31)	3.31 (.39)	3.24 (.42)	3.21 (.41)
Non-negative Targets	2.69 (.47)	2.64 (.49)	2.65 (.42)	2.48 (.42)
Negative Foils	1.76 (.41)	1.72 (.46)	1.51 (.33)	1.52 (.31)
Non-negative Foils	1.59 (.35)	1.54 (.40)	1.41 (.31)	1.44 (.30)
Socially Relevant Scenarios				
Negative Targets	3.32 (.33)	3.09 (.40)	2.96 (.47)	3.02 (.33)
Non-negative Targets	2.96 (.51)	3.00 (.37)	3.00 (.43)	2.86 (.40)
Negative Foils	1.60 (.46)	1.55 (.42)	1.34 (.32)	1.37 (.25)
Non-negative Foils	1.53 (.32)	1.59 (.40)	1.36 (.29)	1.40 (.29)

Similarity ratings of target test sentences. The initial model tested for the participants' similarity ratings of the target test sentences specified Role (transmitter or receiver), Dyad Type (high or low trait anxiety dyad), Scenario Type (physically relevant or

socially relevant) and Valence of the target (negative or non-negative) as fixed effects with interaction. A random effects structure was specified, which included random intercepts for Dyad and Item. A by-Dyad random slope for the effect of Valence was also specified, along with by-Item random slopes for the effects of Role and Valence and the interaction of these effects⁶. The results of this model can be found in Table 6. This model was compared to a model that excluded the four-way interaction between Role, Scenario Type, Dyad Type and Valence of the foil, retaining all lower order interactions. Model comparisons confirmed that including the four-way interaction between Role, Scenario Type, Dyad Type and Valence of the foil did not significantly improve model fit, $\chi^2(1)=2.30, p=.130$. Next, this reduced model (excluding the four-way interaction between the predictors) was compared to a model which excluded the three-way interaction between Role, Dyad Type and Valence. Model comparisons confirmed that including this three-way interaction significantly improved model fit, $\chi^2(1)=21.08, p<.001$. To determine the nature of this three-way interaction, separate models were conducted for transmitters and receivers.

⁶ The initial model tested, specified the maximal random effects structure that also included by-Dyad random slopes for the effect of Scenario Type and the interaction of Scenario Type and Valence. Additionally, by-Item random slopes for the effect of Dyad Type, and the interaction of Dyad Type, Role and Valence were also included. However, this model did not converge on a solution and so the random effects structure was simplified by removing the by-Dyad random slopes involving Scenario Type and the by-Item random slopes involving Dyad Type.

Table 6

Results of the maximal model for the participants' similarity ratings of the target test sentences (Role, Dyad Type, Scenario Type and Valence of the target as fixed effects with interaction).

Predictor	Coefficient	SE	t
(Intercept)	3.31	.09	37.53***
Role (Transmitter)	.14	.05	2.66**
Dyad Type (Low Trait Anxiety Transmitter)	-.09	.08	1.16
Scenario Type (Social)	-.22	.11	1.92
Valence of the target (Non-negative)	-.67	.14	4.71***
Role*Dyad Type	-.11	.08	1.45
Role*Scenario Type	.09	.07	1.27
Dyad Type*Scenario Type	.03	.08	.44
Role*Valence	-.08	.07	1.12
Scenario Type*Valence	-.07	.10	.73
Dyad Type*Valence	.58	.19	3.02**
Role*Dyad Type*Scenario Type	-.19	.11	1.74
Role*Dyad Type*Valence	.24	.11	2.18*
Role*Scenario Type*Valence	-.18	.10	1.78
Dyad Type*Scenario Type*Valence	-.01	.11	.07
Role*Dyad Type*Scenario Type*Valence	.24	.16	1.52
Model fit:			
AIC	18505.2		
BIC	18712.4		
Log-likelihood	-9222.6		

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

Similarity ratings of targets by transmitters. The initial model tested for the similarity ratings of the target test sentences by transmitters, specified Dyad Type (low or high trait anxious transmitter), Scenario Type (physically relevant or socially relevant) and Valence of the target (negative or non-negative) as fixed effects, with interaction. A random effects structure was specified, which included random intercepts for Dyad and Item, as well as by-Dyad random slopes for the effects of Scenario Type and Valence and the interaction of these effects. Additionally, a by-Item random slope for the effect of Valence

was specified⁷. The results of this model can be found in Table 7. This model was compared to a model that excluded the three-way interaction between Dyad Type, Scenario Type and Valence. Model comparisons confirmed that including the three-way interaction marginally improved model fit, $\chi^2(1)=3.00, p=.083$. To decompose the three-way interaction, separate models were tested for target test sentences of the physically relevant and socially relevant ambiguous scenarios.

Table 7

Results of the maximal model for the transmitters' similarity ratings of the target test sentences (Dyad Type, Scenario Type and Valence of the target as fixed effects with interaction).

Predictor	Coefficient	SE	t
(Intercept)	3.45	.10	34.70***
Dyad Type (Low Trait Anxiety Transmitter)	-.20	.10	2.15*
Scenario Type (Social)	-.13	.12	1.06
Valence (Non-negative)	-.76	.16	4.70***
Dyad Type*Scenario Type	-.16	.08	1.89
Dyad Type*Valence	.17	.13	1.27
Scenario Type*Valence	.40	.21	1.91
Dyad Type*Scenario Type*Valence	.23	.13	1.75 ($p=.083$)
Model fit:			
AIC	9033.6		
BIC	9170.3		
Log-likelihood	-4494.8		

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

⁷ The initial model tested, specified a maximal random effects structure that also included by-Item random slopes for the effect of Dyad Type and the interaction of Dyad Type and Valence. However, this model did not converge on a solution and so the random effects structure was simplified by removing the by-Item random slopes involving Dyad Type.

The initial model tested for the transmitters' similarity ratings of the physically relevant targets specified Dyad Type and Valence as fixed effects with interaction. The maximal random effects structure was specified, which included random intercepts for Dyad and Item, as well as by-Dyad and by-Item random slopes for the effect of Valence (see Table 8). The initial model was compared to a model that excluded the interaction between Dyad Type and Valence. Model comparisons confirmed that including the interaction between the fixed effects did not significantly improve model fit, $\chi^2(1)=1.55$, $p=.214$. Next, the fixed effect of Valence was tested by comparing a model with Valence as the only fixed effect with the null model, without any fixed effects. Model comparisons confirmed that including Valence as a fixed effect provided a significantly better model fit than the null model, $\chi^2(1)=14.17$, $p<.001$. As shown in Figure 2, transmitters rated the negative targets of the ambiguous scenarios as more similar to the original than the non-negative targets. This suggests that transmitters (low and high trait anxious) tended to interpret the physically relevant ambiguous scenarios in a negative manner, replicating the pattern of results obtained for participants in Study One.

Finally, the fixed effect of Dyad Type was tested by comparing a model with Valence as the only fixed effect with the null model, without any fixed effects. Model comparisons confirmed that including Dyad Type as a fixed effect provided a marginally better model fit than the null model, $\chi^2(1)=3.07$, $p<.080$. High trait anxious transmitters tended to rate the targets (negative and non-negative) as more similar to the originally ambiguous scenarios than the low trait anxious transmitters.

Table 8

Results of the maximal model for the transmitters' similarity ratings of the target test sentences of the physically relevant ambiguous scenarios (Dyad Type and Valence of the target as fixed effects with interaction).

Predictor	Coefficient	SE	t
(Intercept)	3.45	.08	44.43***
Dyad Type (Low Trait Anxiety Transmitter)	-.20	.09	2.18 ⁸
Valence (Non-negative)	-.76	.16	4.75***
Dyad Type*Valence	.16	.13	.44
Model fit:			
AIC	4661.2		
BIC	4721.9		
Log-likelihood	-2319.6		

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

Figure 2. Mean similarity ratings of the target test sentences by transmitters. Error bars represent standard error of the mean.

⁸ The initial model indicated that the effect of Dyad Type was significant at $p = .034$. Model comparisons confirmed that this effect was marginal at $p = .080$ as reported in text.

The initial model tested for the transmitters' similarity ratings of the socially relevant targets specified Dyad Type and Valence as fixed effects with interaction. The maximal random effects structure was specified, which included random intercepts for Dyad and Item, as well as by-Dyad and by-Item random slopes for the effect of Valence (see Table 9). The initial model was compared to a model that excluded the interaction between Dyad Type and Valence. Model comparisons confirmed that including the interaction between the fixed effects significantly improved model fit, $\chi^2(1)=9.15$, $p=.002$. As shown in Figure 2, the low trait anxious transmitters ratings of the negative and non-negative meanings of the socially relevant ambiguous scenarios did not differ. This suggests that low trait anxious transmitters did not consistently favour either the negative or non-negative meanings of these scenarios. In contrast, the high trait anxious transmitters rated the negative meanings of the socially relevant ambiguous scenarios as significantly more similar to the original than the non-negative meanings, suggesting a tendency to interpret the socially relevant scenarios in a negative manner. These findings replicate those obtained for the participants in Study One.

Table 9

Results of the maximal model for the transmitters' similarity ratings of the target test sentences of the socially relevant ambiguous scenarios (Dyad Type and Valence of the target as fixed effects with interaction).

Predictor	Coefficient	SE	t
(Intercept)	3.32	.12	27.76***
Dyad Type (Low Trait Anxiety Transmitter)	-.36	.10	3.46**
Valence (Non-negative)	-.36	.16	2.23*
Dyad Type*Valence	.39	.13	3.15**
Model fit:			
AIC	4448.4		
BIC	4509.1		
Log-likelihood	-2213.2		

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

Similarity ratings of targets by receivers. The initial model for the receivers' similarity ratings of the targets specified Dyad Type (low or high trait anxious transmitter), Scenario Type (physically relevant or socially relevant) and Valence of the target (negative or non-negative) as fixed effects, with interaction. The maximal random effects structure was specified, which included random intercepts for Dyad and Item. By-Dyad random slopes for the effect of Scenario Type and Valence and the interaction of these effects were specified. Additionally, by-Item random slopes for the effect of Dyad Type and Valence and the interaction of these effects were also specified. The results of this model can be found in Table 10. This model was compared to a model that excluded the three-way interaction between Dyad Type, Scenario Type and Valence. Model comparisons confirmed that including the three-way interaction did not significantly improve model fit, $\chi^2(1) = .002$, $p = .961$. Next, this reduced model (without the three-way interaction between the fixed effects) was compared to a model which excluded the two-way interaction between Dyad

Type and Scenario Type. Model comparisons confirmed that including this two-way interaction did not significantly improve model fit, $\chi^2(1)=.36$, $p=.546$. This reduced model was then compared to a model that excluded the two-way interaction between Dyad Type and Valence. Model comparisons confirmed that including this two-way interaction did not significantly improve model fit, $\chi^2(1)=.47$, $p=.491$. Finally, this reduced model was compared to a model that excluded the interaction between Scenario Type and Valence. Model comparisons confirmed that including this two-way interaction significantly improved model fit, $\chi^2(1)=8.31$, $p=.004$. Hence, the best-fitting model specified Dyad Type, Scenario Type and Valence as fixed effects and allowed for the interaction between Scenario Type and Valence. As shown in Figure 3, the receivers endorsed more negative meanings of the physically relevant ambiguous scenarios than non-negative meanings, $t(46)=4.71$, $p<.001$. In contrast, there was no statistically significant difference in receivers' similarity ratings of the negative and non-negative meanings of the socially relevant ambiguous scenarios, $t(46)=.85$, $p=.402$. This suggests that receivers tended to encode the negative meanings of the physically relevant ambiguous scenarios but did not consistently favour either the negative or non-negative meanings of the socially relevant ambiguous scenarios. Additionally, there was no evidence that the trait anxiety of the transmitter influenced the social transmission of the originally ambiguous scenarios.

Table 10

Results of the maximal model for the receivers' similarity ratings of the target test sentences (Dyad Type, Scenario Type and Valence of the target as fixed effects with interaction).

Predictor	Coefficient	SE	<i>t</i>
(Intercept)	3.31	.10	33.64***
Dyad Type (Low Trait Anxiety Transmitter)	-.09	.11	.88
Scenario Type (Social)	-.22	.11	1.92
Valence (Non-negative)	-.67	.16	4.29***
Dyad Type*Scenario Type	.04	.09	.39
Dyad Type*Valence	-.07	.17	.42
Scenario Type*Valence	.58	.19	3.02**
Dyad Type*Scenario Type*Valence	-.01	.16	.05
Model fit:			
AIC	9132.8		
BIC	9312.9		
Log-likelihood	-4537.4		

Note. *** $p < .001$, ** $p < .01$

Figure 3. Mean similarity ratings of the target test sentences by receivers. Error bars represent standard error of the mean.

Is there evidence of a response bias in the similarity judgement task? To

determine if participants in this study demonstrated a response bias, transmitters' and receivers' similarity ratings of the foil test sentences were analysed. The initial full model for participants' similarity ratings of the foil test sentences specified Role (transmitter or receiver), Scenario Type (physically relevant or socially relevant), Dyad Type (high or low trait anxiety dyad) and Valence of the foil (negative or non-negative) as fixed effects with interaction. A random effects structure was specified, which included random intercepts for Dyad and Item. A by-Dyad random slope for the effect of Valence was also specified, along with by-Item random slopes for the effects of Role, Dyad Type and Valence and the interaction of these effects⁹. The results of this model can be found in Table 11. This model was compared to a model that excluded the four-way interaction between Role, Scenario Type, Dyad Type and Valence of the foil, retaining all lower order interactions. Model comparisons confirmed that including the four-way interaction between Role, Scenario Type, Dyad Type and Valence of the foil did not significantly improve model fit, $\chi^2(1)=.95$, $p=.329$. Next, each of the three-way interactions between the fixed effects, and all lower order two-way interactions were excluded in turn. Model comparisons confirmed that removing these interactions did not significantly impact model fit¹⁰. Following this, each fixed effect was tested by comparing a model with the given fixed effect (as the only fixed effect) to the null model (without any fixed effects). Model comparisons confirmed that the model with

⁹ The initial model tested, specified the maximal random effects structure that also included by-Dyad random slopes for the effect of Scenario Type and the interaction of Scenario Type and Valence. Additionally, by-Item random slopes for the effect of Dyad Type and the interaction of Dyad Type, Role and Valence were also included. However, models with this more complex random effects structure did not converge on a solution and so the random effects structure was simplified by removing the by-Dyad random slopes involving Domain and the by-Item random slopes involving Dyad Type.

¹⁰ See Appendix 1 for details.

Role as the only fixed effect, did not provide a significantly better model fit than the null model, $\chi^2(1)=.01$, $p=.915$. Model comparisons confirmed that the model with Scenario Type as the only fixed effect, also did not provide a significantly better model fit than the null model, $\chi^2(1)=.11$, $p=.745$. Next, model comparisons confirmed that the model with Valence as the only fixed effect did not provide a significantly better fit than the null model, $\chi^2(1)=2.75$, $p=.097$. Finally, model comparisons confirmed that the model with Dyad Type as the only fixed effect provided a significantly better fit than the null model, $\chi^2(1)=7.31$, $p=.007$. Pairwise comparisons confirmed that high trait anxious transmitters and their receivers tended to rate all foil sentences as significantly more similar to the originally ambiguous scenarios than the low trait anxious transmitters and their receivers, $t(57)=2.85$, $p=.006$. As the effect of Dyad Type did not interact with Valence, it can be concluded that there was no statistical evidence that participants in this study demonstrated a response bias, favouring either negative or non-negative response options. Hence, the pattern of endorsement of the negative and non-negative candidate interpretations of the ambiguous scenarios (targets) can be interpreted as a genuine reflection of the representations that were formed of the scenarios by participants in this study.

Table 11

Results of the maximal model for the participants' similarity ratings of the foil test sentences (Dyad Type, Role and Valence of the foil as fixed effects with interaction).

Predictor	Coefficient	SE	<i>t</i>
(Intercept)	1.72	.11	15.72***
Role (Transmitter)	.03	.04	.78
Scenario Type (Social)	-.17	.14	1.19
Dyad Type (Low Trait Anxiety Transmitter)	-.19	.08	2.40**
Valence (Non-negative)	-.18	.08	2.32
Role*Scenario Type	.02	.06	.31
Role*Dyad Type	-.05	.06	.85
Scenario Type*Dyad Type	.01	.06	.23
Role*Valence	.01	.06	.20
Scenario Type*Valence	.22	.11	2.03
Dyad Type*Valence	.08	.07	1.23
Role*Scenario Type*Dyad Type	-.04	.09	.49
Role*Scenario Type*Valence	-.12	.08	1.47
Role*Dyad Type*Valence	-.01	.09	.13
Scenario Type*Dyad Type*Valence	-.10	.09	1.10
Role*Scenario Type*Dyad Type*Valence	.12	.12	.98
Model fit:			
AIC	14996.1		
BIC	15203.3		
Log-likelihood	-7468.1		

Note. *** $p < .001$, ** $p < .01$

Discussion

The primary issue investigated in the current study is whether there is tendency for people to transform ambiguity in a negative (as opposed to non-negative) manner during social transmission. To test this, the current study employed the ambiguous scenarios used in Study One in an experiment that involved the oral transmission of these scenarios from one participant (the transmitter) to another (the receiver). Given the evidence from Study One that the physically relevant ambiguous scenarios tend to be encoded in a negative

manner, irrespective of the participants' level of trait anxiety, it was predicted that low and high trait anxious transmitters in this study would be likely to transform the originally ambiguous scenarios in a manner that conveys the negative meaning to the receiver. In contrast, Study One found that high trait anxious participants tended to interpret the socially relevant ambiguous scenarios in a negative manner, whereas low trait anxious participants interpreted these same scenarios in a non-negative manner. Hence, it was predicted that a negative transformation bias may only be evident for these scenarios for high trait anxious transmitters.

It was found that the low and high trait anxious transmitters demonstrated a pattern of interpretation that was consistent with that found for participants in Study One. Specifically, there was evidence of a general tendency to interpret the physically relevant ambiguous scenarios in a negative manner (as opposed to a non-negative manner) irrespective of the transmitters' level of trait anxiety. In contrast, high trait anxious transmitters demonstrated a tendency to interpret the socially relevant ambiguous scenarios in a negative manner, whereas the low trait anxious transmitters did not consistently favour either negative or non-negative meanings of these scenarios.

The pattern of results obtained from the two groups of receivers in this study did not support the proposition that transmitters tended to transform the ambiguity in a negative manner. It was found that, the two groups of receivers (paired with low and high trait anxious transmitters) tended to encode the negative meaning of the physically relevant ambiguous scenarios. In contrast, it was found that the two groups of receivers did not consistently favour either negative or non-negative representations of the socially relevant ambiguous scenarios. Importantly, there was no evidence that the representations that

receivers formed of the ambiguous scenarios differed as a function of the trait anxiety status of the transmitter who communicated the scenarios to them.

Is there evidence of a negative transformation bias in the current study?

The current study found that despite evidence that high trait anxious transmitters tended to interpret the socially relevant ambiguous scenarios in a negative (as opposed to a non-negative manner), the receivers to whom they communicated these scenarios did not consistently favour either negative or non-negative meanings of the ambiguity. This suggests that transmitters in the current study may have communicated the scenarios in a manner that preserved the ambiguity. In light of this, the finding that low trait anxious transmitters and the receivers to whom they communicated the ambiguous scenarios demonstrated a similar pattern of interpretation would seem to reflect the fact that the transmitters and receivers were both low trait anxious. Hence, it is reasonable to expect that they share similar patterns of interpretation.

One possible explanation for these findings is that the experimental conditions created in the current study may have unintentionally constrained natural variation in what was communicated during the social transmission of the ambiguous scenarios. For instance, it's possible that the requirement for transmitters to communicate the ambiguous scenarios immediately after they were presented (via headphones) may have resulted in verbatim recital of these scenarios to the receivers. Verbatim recital would have constrained variation in what was said by transmitters and reduced the likelihood that the original variant was transformed. To allow for more variation in the communication of information by participants in future studies, it is necessary to design an experiment that encourages such

variation. One way to achieve this is to have participants communicate longer passages of text that cannot be recalled verbatim. Hence, the studies that follow in this thesis will employ social narratives, of sufficient length to prevent verbatim recall.

Conclusion

The findings of the current study suggest that transmitters may have communicated the scenarios in a manner that preserved the ambiguity. It's possible that the experimental conditions may have constrained natural variation in what was communicated to receivers, resulting in verbatim recital. To address these limitations, the studies that follow this thesis will employ less constrained experimental designs that involve the social transmission of social narratives. The output generated by participants in these studies will be captured to reveal whether the social transmission of emotional information involves the transformation of information (in the case of guided variation) as well as the preferential transmission of certain types of information over others (in the case of selection bias). The first study to employ this experimental approach (Study Three) will test whether negative information is preferentially transmitted over non-negative information during social transmission.

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Chapter Four

Study Three

As described in Chapter One, cultural evolution is driven not just by the *transformation* of cultural variants during social transmission but also the *selection* of certain variants over others (Boyd & Richerson, 1985). This second mechanism of cultural change has received arguably greater empirical attention in recent decades and the cultural evolution literature documents a growing catalogue of *selection* biases (also referred to as content biases) (Mesoudi & Whiten, 2008). It is argued here that there may be a content bias characterised by the preferential selection of negative information over positive information during social transmission. The section that follows will revisit the existing evidence of content biases in the cultural evolution literature, with specific reference to the preferential transmission of *emotional* information. Following this, important methodological considerations informed by this literature (and those arising from Study Two) will be discussed before describing the current study in detail.

Content biases in the social transmission of information

There is now considerable evidence that social transmission is biased, such that certain types of information are transmitted, over others. For instance, (as described in detail in Chapter One) there is evidence that people preferentially transmit social information over non-social information (Mesoudi, Whiten, & Dunbar, 2006). This evidence is consistent with the ‘social brain’ hypothesis which posits that humans (and other primates) evolved to be particularly adept at responding to complex social problems (Dunbar, 2003). Other investigators have documented a preference for transmitting stereotype-consistent

information over stereotype-inconsistent information, explaining one mechanism by which stereotypes are maintained in culture (Kashima, 2000; Lyons & Kashima, 2003, 2006; see Chapter Three for a detailed discussion of these studies). Content biases for information that is minimally counter-intuitive (Barrett & Nyhof, 2001) and information pertinent to our survival (Stubbersfield, Tehrani, & Flynn, 2015) have also been identified.

Of particular relevance to the current program of research, there is evidence that negative information may be preferentially transmitted during social transmission. For instance, Eriksson and Coultas (2014) examined the social transmission of stories that differed in their level of disgust content. In their study, stories that were either high or low in disgust content were passed along transmission chains of four people. Analysis of participants' retellings of the stories revealed that the high disgust stories were retold with greater fidelity to the original story script, than the low disgust stories. The preferential transmission of disgust information was explained by the authors in terms of a general preference for *emotional* information, rather than a specific preference for negative information. However other types of emotional information, including positive emotional information, were not examined. Given the extensive evidence that people exhibit negative cognitive processing biases (cf. Baumeister, Bratslavsky, Finkenauer, & Vohs, 2001; see Chapter One for a detailed discussion of this literature) it is plausible that any positive effect of emotion on the social transmission of information may be greater for negative emotional information than positive emotional information.

More recently, Stubbersfield, Flynn & Tehrani (2017) extended this work to examine the social transmission of four urban legends that elicited a range of emotions, in addition to disgust. The authors were primarily interested in whether the intensity of the elicited emotion had a positive effect on the social transmission of the legend. They found that

legends that evoked high levels of emotion were recalled with greater accuracy than those that evoked low levels of emotion, suggesting that emotional intensity does enhance transmission. Additionally, the effect of valence on the transmission of these stories was assessed by asking participants to indicate the specific emotions that were elicited (e.g. amusement, interest, disgust). The authors then grouped the stories into those that elicited negative or positive emotion (two stories of each valence). The analysis did not reveal any significant impact of valence on recall. However, examination of the content of these stories raises questions regarding the veracity of these groupings. For example, one 'positive' story used in the study described a woman's revenge on an ex-boyfriend by sewing a fish carcass into the seat of his car. The rotting fish smell then prevented him from finding a new girlfriend and he eventually had to sell the car. This story was found to evoke amusement and interest, which was thought to represent positive valence. However, it can be argued that revenge is hardly a positive emotional experience in that it inherently involves negative consequences for one party. Furthermore, this story clearly contains a level of disgust content, which is universally considered to be a negative emotion (Heath, Bell, & Sternberg, 2001). Although the findings of this study clearly point to a recall advantage for stories that evoke high levels of emotion (over lower levels of emotion), the conclusion that valence does not influence the social transmission of emotional information may be premature. As the authors note, certain emotions (e.g. interest and surprise) can occur in the context of both positive and negative emotion. Rather than focusing on the specific emotion that is elicited, a better approach to evaluating the influence of valence on social transmission is to directly measure the valence of the information to be transmitted. This, and other methodological considerations are addressed below.

Methodological considerations for examining the preferential transmission of emotional information

As described in Chapter Three, Study Two found that despite evidence that high trait anxious transmitters tended to interpret socially relevant ambiguous scenarios in a negative (as opposed to a non-negative manner), the receivers to whom they communicated these scenarios did not consistently favour either negative or non-negative meanings of the ambiguity. This suggests that the transmitters may have communicated the scenarios in a manner that preserved the ambiguity. One possible explanation for these findings is that the experimental conditions created in the current study may have unintentionally constrained natural variation in what was communicated during the social transmission of the ambiguous scenarios. Specifically, transmitters in Study Two were required to orally communicate the ambiguous scenarios to the receivers immediately after having heard them presented through headphones. An unintended consequence of this approach is that transmitters may have recited the scenarios verbatim. This would have reduced the likelihood that the original variant was transformed. To address this issue, the current study employs a less constrained experimental design that involves the social transmission of a social narrative. Capturing the output that is produced during social transmission can reveal which elements survive, which are lost, and which are transformed.

In the current study, a story script was created that was of sufficient length to prevent verbatim recall. To test whether there is a content bias characterised by the preferential transmission of negative (over positive) information, the story script included an equal number of negative and positive story events, that had been pre-rated to ensure that they were of the intended valence. Furthermore, the story events were matched for emotional intensity to control for the known influence of level of emotion on social

transmission (Stubbersfield et al., 2017). Analysis of the content of the participants' retellings will reveal the relative amounts of each type of information (negative and positive) that feature.

As noted above, Stubbersfield, Flynn & Tehrani (2017) did not find evidence that valence influenced the social transmission of emotional information. In their study participants were asked to "...read the material and then, on a new page, type what they remembered of this material." (p. 13). The instruction here clearly emphasized the recall of information. This is a feature of many experiments that explore the social transmission of information. However, there is evidence that some content biases may only emerge under conditions in which there is an intent to communicate to another person. For instance, Lyons and Kashima (2006) found that a bias favouring the communication of stereotype-consistent information over stereotype-inconsistent information only emerged under conditions that emphasised communicative intent. In a serial reproduction study, they found that when participants were asked to retell a story for another participant to read, they communicated more stereotype-consistent information than stereotype-inconsistent information. However, when the instructions asked participants to accurately recall the story from memory (with no mention that it would be read by another participant) no such bias emerged. This finding suggests that the proposed content bias for negative emotional information (over positive information) may also be specific to situations in which there is clear communicative intent. Hence, the current experimental conditions will encourage participants to *retell* the story script to an imagined friend or family member to emphasise communicative intent.

Overview and design

The primary aim of the current study was to determine whether there is a content bias characterised by the preferential transmission of negative (over positive) information. As described above, this was tested by examining the social transmission of a short story that contained an equal number of negative and positive story events. Participants first read the story and after a short delay, they recorded a video in which they orally retold the story to an imagined friend or family member. Participants' retellings were transcribed and then coded to determine the number of negative and positive story events that featured in the retellings. If evidence of a content bias for negative information is found in the current study, then participants' story retellings will feature a greater number of negative, than positive story events.

A secondary aim of the current study is to determine whether anxiety modulates the social transmission of emotional information, such that people with elevated anxiety vulnerability are disproportionately likely to transmit negative (over positive) information, relative to people with low levels of anxiety vulnerability. To test for this anxiety-linked negative transmission bias, the current study compares the social transmission of the story script by participants who report low levels of trait anxiety and those who report high levels of trait anxiety. If evidence of an anxiety-linked negative transmission bias is found in the current study, then the story retellings generated by high trait anxious participants will feature a greater number of negative story events than positive story events, relative to the retellings generated by low trait anxious participants.

Method

Participants

As described earlier in this chapter, the current study aims to determine whether there is a content bias characterised by the preferential transmission of negative (over positive) information. A secondary aim is to determine whether anxiety modulates the social transmission of emotional information. To address these aims it was necessary to recruit a group of participants who report low levels of anxiety vulnerability and a second group of participants who report elevated anxiety vulnerability. Hence, participants in this study were 16 low trait anxious participants (10 male; 6 female) and 15 high trait anxious participants (5 male; 10 female). To recruit participants of low and high trait anxiety status the same approach that was used in the preceding studies presented in this thesis was adopted here. A large sample of candidate participants ($N=644$) was screened using the State-Trait Anxiety Inventory, Trait Version, Form Y (STAI-T; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983), a measure of trait anxiety. Low trait anxious participants were recruited from those scoring in the lower quartile of this distribution, while high trait anxious participants were recruited from those scoring in the upper quartile of the STAI-T distribution (in the present study this was scores < 34 and > 47 on STAI-T, respectively). Eligibility for inclusion required that participants reported being able to speak English fluently by the age of 6. All participants were undergraduate psychology students from the University of Western Australia.

It was necessary to verify that the two groups of participants differed in trait anxiety status but not in age or gender. A t -test comparing the STAI-T scores of the two participant groups confirmed that their trait anxiety level significantly differed, $t(29)=17.59$, $p<.001$. The

age of the participants ranged from 17 to 21 years with an average of 18.68 years ($SD=1.17$). A t -test confirmed that the age of the low and high trait anxious participants did not significantly differ, $t(29)=.56$, $p=.580$. There was no significant difference between low and high trait anxious participants with regards to gender ratio, $\chi^2(1)=2.64$, $p=.104$.

Materials

Questionnaire measures. Trait Anxiety: The 20 item State-Trait Anxiety Inventory, Trait Version, Form Y (STAI-T; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) was used to screen candidate participants for trait anxiety status, prior to recruiting the groups of low and high trait anxious participants. The STAI-T is described in detail in the Method section of Study One (see Chapter Two).

Experimental story. A story was created for use in the present study that described a young girl's first day at university. The story consisted of 43 clauses that collectively described a sequence of events that happened throughout the day. There were eight emotionally negative events and eight emotionally positive events included in the script. Each event was described using a single clause. For example, "*The audience laughed at her when she messed up the words*" described a negative event used in the story, and "*As they left the party her friend told Julie how wonderful she looked in her new dress*" described a positive event used in the story. The thirty-three remaining clauses were emotionally neutral fillers (e.g. "*There was a really old movie on*"), and these served to connect the negative and positive story events. The negative and positive story events were distributed throughout the story, from the seventh statement to the 39th statement¹¹.

¹¹ See Appendix 3 for the original story script.

To verify that the negative and positive events were of the intended emotional valence, descriptions of these events were rated by four independent judges. The judges indicated how pleasant they found each described event, using a 7-point scale that ranged from '*Very unpleasant*' (-3) to '*Very pleasant*' (3), with a score of zero representing neutral valence. Scores were then averaged across judges to provide an indication of the perceived valence of the event. Average scores for negative events ranged from -1.50 to -2.50 with a mean rating of -2.06 (SD=.40), which was significantly lower than zero, $t(7)=14.76$, $p<.001$, confirming their negative valence. Average scores for the positive events ranged from 1.75 to 3.00 with a mean rating of 2.22 (SD=.43), which was significantly higher than zero, $t(7)=14.54$, $p<.001$, confirming their positive valence. The absolute mean ratings of the positive and negative events did not significantly differ, $t(14)=.76$, $p=.463$, confirming that, while these events differed in terms of emotional valence, their emotional intensity was equivalent. To verify that the fillers were not overly negative or positive in valence, descriptions of these clauses were also rated in the same manner as the negative and positive events. Scores for the fillers ranged from -1.25 to 1.50 with a mean rating of .31 (SD=.80), which did not significantly differ from zero, $t(26)=1.98$, $p=.059$, confirming their neutral emotional tone.

Procedure

All participants were tested individually. They were informed that the experiment examined how emotion may interact with how we produce verbal information and that further information about the goals of the study would be provided at the end of the session. Participants were then given the story, printed on a sheet of A4 paper. They were given five minutes to read the story as many times as they wished. After five minutes had elapsed, the

sheet on which the story was printed was removed, and participants were left alone in the experimental testing room for a period of two minutes. This delay was designed to further prevent verbatim recall of the original story script. Following this short delay, participants were given a pen and piece of paper and were told they could write up to 15 single words on the paper, to be used as reminders to themselves when executing their verbal retelling of the story. Participants were then seated in front of a video camera to record their retelling of the story. They were directed to carry out this retelling as though they were telling a friend or family member about the events they had just read about in the story. The experimenter started the recording and then left the room. Participants were given 10 minutes to record their retelling of the story. They were then debriefed, and the experimental session ended.

Results

This study investigated whether there is a content bias characterised by the preferential transmission of negative (over positive) information. A secondary aim is to determine whether anxiety modulates the social transmission of emotional information. To address these research questions, the video recordings of participants' retellings were first transcribed. Next a coder (blind to each participant's trait anxiety status) assessed each participant's story reproduction and indicated if each described event in the reproduction was present in the original story. This determined the negative and positive original story events that featured in each participant's retelling. Using the same approach as Eriksson & Coultas (2014), an event was considered to be present if the basic gist was the same as the event in the original story. A second independent coder, also blind to participant's anxiety status, coded a random selection of 10 transcripts (32%) using the same procedure. Inter-rater reliability was confirmed by the high Krippendorff's alpha, $\alpha=.99$. The first coder's

assessment of the transcripts was used in the final analysis. The average number of negative and positive story events that featured in participants' retellings is shown in Table 1.

Table 1

Mean (SD) number of story events that featured in participants' retellings of the original story.

Valence of the event	Low Trait Anxiety	High Trait Anxiety
Negative	6.25 (1.88)	6.07 (1.03)
Positive	6.19 (1.72)	5.80 (1.86)

The methodological approach used in the current study motivated by the need to overcome a limitation of Study Two. Specifically, the use of a social narrative, coupled with the inclusion of a short delay prior to transmission of the story script, was designed to prevent verbatim rehearsal of the stimulus material and encourage variation in the content that was transmitted by participants. Evidence that verbatim rehearsal was prevented would be a reduction in the number of story events that featured in participants' retellings, relative to the original story script. The average number of original story events (negative and positive combined) that featured in participants' retellings was 12.16 (SD=2.82), which was significantly lower than the 16 events (eight negative and eight positive) that featured in the original story script, $t(30)=7.59, p<.001$. This confirms that participants were prevented from engaging in verbatim recall.

To test whether there was a tendency for participants to transmit more negative information than positive information, the number of negative and positive story events that featured in participants' retellings was analysed using a logistic mixed-effects model. Trait Anxiety Status was also included as a fixed effect in the model to test whether anxiety modulated the social transmission of the emotional information contained in the original

story script. Analyses were conducted using the lme4 software package (Bates, Maechler, Bolker, & Walker, 2015) in R version, 3.2.2 (R Core Team, 2015). As recommended by Barr, Levy, Scheepers, and Tily (2013) the model tested included the maximal random effects structure appropriate for the data.

The initial model tested specified Valence of the event (negative vs. positive) and Trait Anxiety Group (low trait anxious vs. high trait anxious) and as fixed effects with interaction. The maximal random effects structure was specified, which included random intercepts for Participant and Event, as well as a by-Participant random slope for the effect of Valence of the event and a by-Event random slope for the effect of Trait Anxiety Group. The results of this model are shown in Table 2. The initial full model was compared to a model that excluded the interaction between Valence of the event and Trait Anxiety Group, preserving the same random effects structure. Model comparisons confirmed that excluding the interaction between the fixed effects did not significantly impact model fit, $\chi^2(1)=.01$, $p=.904$. Next, the fixed effect of Valence was tested by comparing a model with Valence as the only fixed effect to the null model, without any fixed effects. Model comparisons confirmed that the model with Valence as the only fixed effect did not provide a significantly better model fit than the null model, $\chi^2(1)=.17$, $p=.682$. Hence, contrary to expectations there was no evidence that participants' retellings featured more negative story events than positive story events.

Following this, the fixed effect of Trait Anxiety Group was tested by comparing a model with Trait Anxiety Group as the only fixed effect, to the null model, without any fixed effects. Model comparisons confirmed that the model with Trait Anxiety Group as the only fixed effect did not provide a significantly better model fit than the null model, $\chi^2(1)=.49$,

$p=.486$. Hence, there was no evidence that anxiety modulated the social transmission of the negative and positive story events.

Table 2

Results of the maximal model for the number of negative and positive story events that featured in participants' retellings of the original story (Trait Anxiety Group and Valence as fixed effects with interaction).

Predictor	Coefficient	SE	z
(Intercept)	1.79	.65	2.76**
Valence (Positive)	-.37	.81	.45
Trait Anxiety Group (Low Trait Anxiety)	.33	.61	.55
Valence*Trait Anxiety Group	.08	.60	.13
Model fit:			
AIC	474.5		
BIC	516.6		
Log-likelihood	-227.3		

Note. ** $p<.01$

Discussion

The primary aim of the current study was to determine whether there is a content bias characterised by the preferential transmission of negative (over positive) information. This was tested by examining the social transmission of a short story that contained an equal number of negative and positive story events. Participants first read the story and after a short delay, they recorded a video in which they orally retold the story to an imagined friend or family member. Participants' retellings were transcribed and then coded to determine the number of negative and positive story events that featured in the retellings. Analysis of participants' retellings of the original story script revealed that there was no statistically significant difference between the number of negative and positive story events that featured. Hence, there was no evidence that participants in the current study

preferentially transmitted negative emotional information over positive emotional information.

A secondary aim of the current study was to determine whether anxiety modulates the social transmission of emotional information, such that people with elevated anxiety vulnerability will be disproportionately likely to transmit negative (over positive) information, relative to people with low levels of anxiety vulnerability. To test for this anxiety-linked negative transmission bias, the current study compared the social transmission of the story script by participants who reported low levels of trait anxiety and those who report high levels of trait anxiety. Analysis of participants' retellings revealed that there was no statistically significant difference in the number of negative and positive story events that featured in the retellings generated by the two participant groups. Hence there was no evidence that anxiety modulated the social transmission of emotion information in the current study.

The experimental approach used in the current study was motivated largely by an attempt to overcome key methodological limitations that were identified in relation to Study Two. Specifically, it was thought that participants in Study Two may have engaged in verbatim recall of the stimulus materials used. If this was the case, then natural variation in the transmission of information would have been restricted, potentially obscuring any effect of anxiety. To prevent verbatim recall and encourage such variation, the current study used stimulus material that was considerably longer than that used in Study Two. Additionally, in the current study, after participants read the original story script there was a short delay (two minutes) before they retold the story. The delay was included to further disrupt verbatim memory of the story script. In the current study, the average number of original story events (negative and positive combined) that featured in participants' retellings of the

story significantly lower than the number that featured in the original story script. This confirms that participants were prevented from engaging in verbatim recall. In this regard, the current methodology was successful in capturing more naturalistic transmission than the approach used in Study Two.

Despite successfully preventing verbatim recall, it can be argued that a feature of the current methodology does not reflect naturalistic transmission processes. In the current study, participants were permitted to write down up to 15 words to be used as reminders to themselves when executing their retelling of the story. It's possible that by allowing participants to use these prompts, recall for certain story events may have been artificially inflated. This may have the effect of obscuring the proposed negative transmission bias by facilitating recall for positive story events. Without this recall aid, it's possible that participants may have recalled fewer positive story events, as predicted. To account for this possibility, the studies that follow in this thesis will prevent participants from using prompts during the transmission of the stimulus material.

The current study and Study Two which preceded it, investigated whether high levels of trait anxiety are associated with a disproportionate tendency to transmit negative information. No evidence of the proposed anxiety-linked negative transmission bias was found in these studies. However, it's possible that an anxiety-linked negative transmission bias may only be evident when people with elevated anxiety vulnerability are in an anxious mood state. There is considerable evidence from the cognition and emotion literature that an attentional bias favouring the processing of negative information is interactively determined by an individual's disposition to experience anxiety (trait anxiety) and an individual's current level of anxious mood (state anxiety). For example, using a modified version of the Stroop colour 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 the proposed anxiety-linked negative transmission bias may also be interactively determined by trait and state anxiety. To test this possibility, the study that follows will randomly allocate high and low trait anxious participants to receive either an elevated state anxiety induction procedure, or a reduced state anxiety induction procedure, prior to engaging in social transmission. As was the case in the current study, the stimulus materials will incorporate an equal number of negative and positive story events. Additionally, ambiguous story events that permit a negative or positive interpretation will be included in the story script used in that study. In this way, the study that follows will explore the preferential *selection* of emotional information and the *transformation* of emotional information during social transmission.

Conclusion

The current study tested whether there is a content bias involving the preferential transmission of negative information over positive information during social transmission. It was found that participants transmitted negative and positive story events with equivalent frequency in the current study. Hence, there was no evidence of the proposed negativity bias. Additionally, whether anxiety modulated the social transmission of this emotional information was explored by comparing the story retellings generated by participants with low and high levels of trait anxiety. There was no evidence that the number of negative and positive story events differed as a function of the participants' trait anxiety. One limitation of the current study was that participants were permitted to use reminders during their retellings of the story. It's possible that this feature of the current experiment may have

artificially inflated the transmission of the positive story events, obscuring the predicted negativity bias. To address this, the studies that follow will prevent participants from using reminders during social transmission.

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Chapter Five

Study Four

A key research question under investigation throughout this thesis is whether elevated anxiety vulnerability is associated with a disproportionate tendency to transmit negative information, relative to people with low levels of anxiety vulnerability. This question has so far been explored by comparing social transmission involving participants who report low levels of trait anxiety to those reporting high levels of trait anxiety. The studies presented in Chapters Three and Four did not find evidence that trait anxiety modulated the social transmission of emotional information. This might suggest that although elevated anxiety vulnerability is associated with a range of negative processing biases (cf. Mathews & MacLeod, 2005) these biases may be better conceptualised as anxiety-linked negative biases involving the *reception* of information. The studies presented so far in this thesis would suggest that this anxiety-linked negativity does not extend to the *transmission* of information. An alternative possibility is that it is not elevated anxiety vulnerability that influences social transmission but elevated anxious mood state (state anxiety).

The role of state anxiety in the social transmission of information

Anecdotal evidence suggests that an individual's mood state is relevant to understanding how emotional information is transmitted. For instance, the aftermath of the September 11 terrorist attacks was a period of heightened anxiety in which social interactions were dominated by the communication of negative information. Cohn, Mehl, and Pennebaker (2004) examined the online journal entries of over 1,000 people that were

written immediately prior to and in the aftermath of the attacks. Linguistic analysis of these journal entries demonstrated a preference for the expression of negative emotional information in the two weeks following the attacks, compared with the period immediately preceding them. Furthermore, the content of the negative emotional information was not specific to the attacks but appeared to generalise to other topics. This suggests that the during times of elevated state anxiety, people may preferentially transmit negative information.

The notion that state anxiety can influence the social transmission of information is not novel. In fact, it is a feature of early research into the spread of rumours. Rosnow (1980) argued that anxiety and uncertainty were essential conditions for the transmission of rumours. In a similar vein, Koenig (1985) argued that rumours will flourish during the '3 Cs' – conflict, crisis and catastrophe. During times of uncertainty, the transmission of rumours is thought to represent an attempt to gain clarity or to vent emotional distress. Despite the clear emphasis on situational factors in these accounts of rumour transmission, research in this area has actually explored the impact of three forms of anxiety on the rate of rumour transmission: trait anxiety; state anxiety and the level of anxiety that is elicited by the rumour itself (referred to as 'rumour anxiety').

Evidence suggestive of a positive effect on the rate of rumour transmission has been found for each of these aspects of anxiety. For example, Jaeger, Anthony & Rosnow (1980) used confederates to plant rumours during an introductory psychology class. A week later, participants were surveyed to determine whether they had passed on this rumour. It was found that participants who reported high levels of trait anxiety were more likely to have transmitted the rumour than those reporting low levels of trait anxiety. Walker and Beckerle (1987) explored the impact of state anxiety on the transmission of a rumour, planted by a

confederate. Participants in their study were asked to retake an oral exam. Whilst waiting to be tested, the confederate planted the rumour. Following this, half the participants witnessed another student fail the exam (high state anxiety condition) and the remaining participants were given easy sample questions to review (low state anxiety condition). It was found that elevated state anxiety was associated with increased rumour transmission. Finally, Kimmel and Keefer (1991) assessed the level of rumour anxiety evoked by a variety of rumours related to AIDS. It was found that rumours that evoked high levels of anxiety in the recipient were transmitted at a higher rate than those that evoked low levels of anxiety. These findings suggest that anxiety (in all three forms) can stimulate the social transmission of information.

Research by Pezzo and Beckstead (2006) suggests that elevated state anxiety may be associated with the increased transmission of certain types of information over others. In their study, students from the University of Virginia were surveyed in the weeks following a series of sniper-style shootings in Washington DC (approximately 90 miles away). Participants were asked to indicate their level of state anxiety in the weeks since the shootings. They were also asked to report the rumours they had heard during this time and indicate how anxious each of these rumours made them feel (rumour anxiety). It was found that elevated state anxiety was positively associated with the number of rumours transmitted during the study period, consistent with existing evidence that elevated state anxiety stimulates rumour transmission. A novel finding was that the effect of state anxiety interacted with the level of rumour anxiety. Participants who reported experiencing high levels of state anxiety were more likely to transmit rumours that evoked high levels of anxiety than rumours that evoked low levels of anxiety. In contrast, for people who reported experiencing low levels of state anxiety, the level of rumour anxiety did not influence the

rate of transmission. This finding suggests that the effect of state anxiety on social transmission may not be a general one. High levels of state anxiety may result in higher rates of transmission for certain types of information over others.

Beyond rumours

The extant literature on rumour spread, reviewed above, suggests that an individual's mood state is relevant to understanding how emotional information is transmitted. However, in exploring biases in the social transmission of information, the cultural evolution literature has largely ignored the context in which the social transmission occurs. Understanding the conditions under which certain biases are expressed would be undoubtedly valuable. For example, it would be beneficial to know if stereotype-consistency bias (Kashima, 2000; Lyons & Kashima, 2003, 2006) is amplified during times of uncertainty or intergroup tension. Furthermore, it would be advantageous to learn what conditions might attenuate this bias. In a similar vein, it would be beneficial to understand how elevated state anxiety might influence the social transmission of emotional information. Hence, the current study explores this issue by comparing social transmission under conditions that either elevate or reduce state anxiety.

The role of state and trait anxiety in determining negativity biases

As noted above, there is evidence that elevated trait anxiety is associated with higher rates of rumour transmission than low levels of trait anxiety (Jaeger et al., 1980). However, the studies presented so far in this thesis have not found evidence that elevated trait anxiety may differentially affect the transmission of negative and positive information. One

possibility is that elevated trait anxiety may only influence the social transmission of emotional information when state anxiety is also high. There is a growing body of literature that indicates that elevated state anxiety can have differential effects on people with low and high levels of trait anxiety (E. J. Edwards, Edwards, & Lyvers, 2015; M. S. Edwards, Burt, & Lipp, 2006). For instance, using a modified version of the Stroop colour naming task, MacLeod and Rutherford (1992) found that elevated state anxiety increased selective attention to negative information in high trait anxious participants but not low trait anxious participants. In their study, undergraduate university students who reported either high or low levels of trait anxiety were tested at two time points, when participants were likely to be experiencing differential levels of state anxiety. The first testing session took place less than one week before the end of semester exam period, when state anxiety was expected to be high. The second testing session took place 6 weeks later, when state anxiety was expected to be low. Participants' scores on the state version of the State-Trait Anxiety Inventory (STAI-S; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) verified that state anxiety was elevated during the first testing session, relative to the second session. The experimental task required participants to name the colour of negative or non-negative words that were presented on a screen, whilst ignoring the semantic content of the word. The time taken to name the colour was recorded, with longer naming latencies thought to indicate disruptions in colour naming due to processing of the semantic content of the word presented. It was found that at the first testing session, when state anxiety was elevated, high trait anxious participants were slower to name the colour of negative words, relative to non-negative words, suggesting a disruption in colour naming due to processing of the semantic content of the negative words. In contrast, low trait anxious participants were faster to name the colour of negative words, relative to non-negative words, suggesting that low trait anxious

participants avoided processing the semantic content of negative words. This anxiety-linked pattern of differential processing was not evident during the second testing session when state anxiety was low, relative to the first session. These findings suggest that elevated state anxiety can have differential effects on people with low and high levels of trait anxiety. Hence, the current study will randomly allocate participants who report either low or high levels of trait anxiety to one of two state anxiety induction conditions, designed to either elevate or reduce state anxiety.

The current study

In line with the primary aim of this thesis, the current study seeks to determine whether there is a negativity bias in the social transmission of emotional information. Specifically, the current study tests whether there is evidence of (i) a content bias characterised by the selective transmission of negative information over positive information and; (ii) guided variation involving the transformation of information in a negative, as opposed to a positive, manner. As outlined above, a key aim of the current study is to determine if elevated state anxiety is associated with a disproportionate tendency to transmit negative information, relative to reduced levels of state anxiety. Finally, the current study will also test whether any effect of state anxiety is differentially expressed by participants who report low and high levels of trait anxiety.

To address these aims, high and low trait anxious participants will be randomly allocated to one of two state anxiety induction conditions, designed to either elevate or reduce state anxiety. The experimental task requires participants to read and (after a delay) retell a short story that includes an equal number of unambiguously negative and

unambiguously positive story events. Analysis of participants' retellings of the story will determine the relative amounts of each type of information that feature. As in Study Three (Chapter Four) this will reveal whether there is evidence of a negative content bias involving the preferential transmission of negative over positive information.

Additionally, the short story used in the current study includes ambiguous story events that permit negative or positive interpretations. Analysis of participants' retellings of the story will determine the number of negative and positive resolutions of ambiguity that feature. This will reveal whether there is evidence of guided variation involving the transformation of ambiguity in a disproportionately negative manner during social transmission. The influence of state anxiety induction condition (elevated or reduced anxiety) and trait anxiety status (high or low trait anxiety) on the transmission of unambiguously negative and unambiguously positive events, as well as the resolution of ambiguous story events in a negative or positive manner, will also be assessed.

Overview and design

Low and high trait anxious participants were randomly allocated to receive one of two mood induction procedures designed to elicit differential levels of state anxiety. In one state anxiety induction condition, participants watched videos designed to reduce state anxiety (low state anxiety) and in the other state anxiety induction condition, participants watched videos designed to elevate state anxiety (high state anxiety). Participants were given a short story that contained a variety of unambiguously negative and unambiguously positive story events, as well as ambiguous story events that permit either a negative or positive interpretation. They were asked to read and then retell the story in writing for

another participant to read, by typing the story into a textbox on the computer screen.

Participants' retellings of the original story were then coded to determine the number of unambiguously negative and unambiguously positive original story events that featured, as well as the number of negative and positive resolutions of the originally ambiguous story events that featured.

Method

Participants

Participants in this study were 42 low trait anxious (18 female; 24 male) and 41 high trait anxious (27 female; 14 male) undergraduate psychology students from the University of Western Australia. To recruit participants of low and high trait anxiety status the same approach that was used in the preceding studies in this thesis was adopted here. A large sample of candidate participants (N=1,544) was initially screened using the State-Trait Anxiety Inventory, Trait Version, Form Y (STAI-T; Spielberger et al., 1983), to assess their level of trait anxiety. Low trait anxious participants were recruited from those scoring in the lower quartile of the STAI-T distribution, while high trait anxious participants were recruited from those scoring in the upper quartile of this distribution (in the present study this was scores <36 and >49 on the STAI-T, respectively). Participants were randomly allocated to state anxiety induction condition, resulting in 43 participants in the low state anxiety induction condition (22 low trait anxious; 21 high trait anxious) and 40 participants in the high state anxiety induction condition (20 low trait anxious; 20 high trait anxious).

It was necessary to verify that participants from the two trait anxiety groups, allocated to the low and high state anxiety induction conditions, differed in trait anxiety

status but not age or gender. A 2x2 ANOVA with trait anxiety status and state anxiety induction condition as between subjects factors confirmed that the age of low and high trait anxiety participants did not significantly differ, $F(1,79)=3.01, p=.087$. The age of participants in the low and high state anxiety induction conditions also did not differ, $F(1,79)=.42, p=.521$. There was also no difference in the age of the low and high trait anxious participants allocated to the low and high state anxiety induction conditions (trait anxiety x state anxiety interaction), $F(1,79)=1.58, p=.213$.

A chi-square, comparing the four groups resulting from the combination of each level of trait anxiety status and each level of state anxiety induction condition, confirmed that the gender ratio across groups did not differ, $\chi^2(3)=4.56, p=0.207$.

Materials

Experimental story. The story created for this study centred on a young girl who was travelling to the UK from Australia, and described a sequence of events that happened during her flight.¹² Each event was described using a single clause. There were eight unambiguously negative and eight unambiguously positive events included in the story. For example, *“The man in the seat next to her seemed to have a nasty cold”* was a negative event used in the story and *“When (the air hostess) returned she told Sarah that she would be moved to business class”* was a positive event used in the story. There were also eight ambiguous events that could be interpreted in either a negative or a positive manner. For example, *“Walking down the concourse, Sarah saw a young man take an old women’s bag”* was an ambiguous event that could be interpreted either negatively (i.e. the young man stole the

¹² See Appendix 3 for the original story script.

women's bag) or positively (i.e. the young man helped the old woman carry her bag). The unambiguously negative and unambiguously positive story events, and the ambiguous story events were interspersed with filler clauses ($n=33$) that were used to connect the events in a logical manner and to set the scene, for example, "*On the day of her trip Sarah arrived at the airport.*"

To verify that the unambiguously negative and positive 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 from 'Very unpleasant' (-3) to 'Very pleasant' (3), with a score of zero representing neutral valence. The mean rating for the unambiguously negative events was -1.81 ($SD=.62$), which was significantly lower than zero, $t(7)=8.27$, $p<.001$, indicating negative valence. The mean rating for the unambiguously positive events was 2.21 ($SD=.58$), which was significantly higher than zero, $t(7)=10.72$, $p<.001$, indicating positive valence.

For the ambiguous events, it was important to verify that the potential negative and positive interpretations had the intended valence. This was achieved by providing the same six judges with descriptions of the negative and positive resolutions of the ambiguous events, and having them rate these in the same manner that they had rated the unambiguously negative and positive events. The mean rating for the potential negative interpretations was -2.10 ($SD=.47$), which was significantly lower than zero, $t(7)=12.64$, $p<.001$, indicating negative valence. The mean rating for the potential positive interpretations was 1.44 ($SD=1.06$), which was significantly higher than zero, $t(7)=3.83$, $p=.006$, indicating positive valence.

To enable the interpretation of any differential pattern of effects for the unambiguous story events and the resolutions of the ambiguous story events, it was important to verify

that the unambiguously negative story events were of equivalent emotional intensity to the potential negative interpretations of the ambiguous story events, and that the unambiguously positive story events were of equivalent emotional intensity to the potential positive interpretations of the ambiguous story events. A *t*-test confirmed that the emotional intensity of the unambiguously negative story events and the potential negative interpretations of the ambiguous story events did not significantly differ, $t(14)=1.06$, $p=.307$. A second *t*-test verified that the emotional intensity of the unambiguously positive story events and the potential positive interpretations of the ambiguous story events did not significantly differ, $t(14)=1.80$, $p=.093$.

State anxiety induction videos. A video induction procedure was used to induce differential levels of state anxiety in participants randomly allocated to the high and low state anxiety induction conditions. Previous studies have demonstrated the effectiveness of videos in manipulating a variety of mood states, including state anxiety. For example, a study by Wilson et al. (2006) used film clips of real-life rescue operations to elevate state anxiety in undergraduate participants. The current study adopts a similar procedure. To select the videos for use in this study an initial pool of 36 videos was created. All videos were chosen for their capacity to either elevate state anxiety (18 videos) or reduce state anxiety (18 videos) and all videos were accompanied by audio. Some examples of videos designed to elevate state anxiety include a rally car crash, daredevils scaling high-rise buildings without ropes and a boat accident. Videos designed to reduce state anxiety included a documentary about birds, a cooking demonstration and a beach scene¹³. Each video was edited to be one minute long. To ensure that the two types of videos were

¹³ These materials are available online at: <http://comlab.me/ComLab/Negative-bias.html>

capable of inducing differential levels of state anxiety in the two participant groups, all videos were rated to assess their capacity to shift mood along a continuum from tense to relaxed. Six independent judges, blind to the purpose of the experiment, indicated 'the extent to which the videos would be likely to make you feel more or less tense'. Responses were recorded on a 7-point scale 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 videos and the four videos with the highest absolute positive ratings (reflecting the greatest capacity to induce high levels of state anxiety) were chosen for use in the high state anxiety induction condition (min rating: 2.17; max rating: 2.67). The four videos with the highest absolute negative ratings (reflecting the greatest capacity to elicit low levels of state anxiety) were chosen for use in the low state anxiety induction condition (min rating: -2.3; max rating: -2.0).

Mood ratings. To verify that the state anxiety induction procedure successfully induced differential levels of state anxiety in participants randomly allocated to the high and low state anxiety inductions conditions, visual-analogue mood scales (VAMS) were used. As the experience of anxiety involves a combination of somatic and cognitive symptoms (Beck, Epstein, Brown, & Steer, 1988), it was necessary to ensure that the measure of state anxiety employed in the current study reflected the combination of these symptoms. Hence, two scales were used, and an average of the scores on the two scales was computed to form a single index of state anxiety. The scales required participants to respond to the statements '*I am relaxed*' (somatic) and '*I am worried*' (cognitive) by moving a cursor along a line from '*Not at all*' to '*Very much*'. These two items 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 state anxiety.

Experimental hardware. The experiment was conducted on a desktop computer, with a standard keyboard and two-button mouse. Headphones were used to present the audio associated with the videos in the state anxiety induction phase, and participants were shown how to adjust the volume for comfort.

Experimental phases

The experiment involved two main phases: an encoding phase, in which participants read the story, and a transmission phase, in which participants executed their retelling of the story. Both phases were preceded by a state anxiety induction phase, designed to ensure that participants in the high and low state anxiety induction conditions were experiencing differential levels of state anxiety during encoding and transmission of the story. These phases are described in detail below.

State anxiety induction phase. The state anxiety induction procedure was the same for all participants, with the exception of the videos presented. The videos presented were determined by the state anxiety induction condition to which they were allocated. As mentioned above, two state anxiety inductions were used during the study, the first immediately preceded the encoding phase and the second immediately preceded the transmission phase. In both inductions, participants provided a baseline rating of their level of state anxiety using the VAMs. They then viewed two videos, presented one after the other, without a break between, before completing the VAMS a second time.

Encoding phase. During the encoding phase, participants were given the short story to read. They were asked to “...*carefully read the story as you will later be asked to retell the story for another person to read.*” 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. A progress bar presented on the screen indicated how much time they had left to read the story.

Transmission phase. During the transmission phase, participants were asked to “*retell the story you read earlier for another person to read*”, by typing it out on the keyboard. A textbox presented on the screen showed the text entered. Participants were told that the person who would receive their story would not see the original version, they would only see their retelling. In reality, participants’ retellings were not passed on to another participant but were recorded for later coding. Participants were told they would have 10 minutes to retell the story and a progress bar presented on the screen 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.

Procedure

All participants were tested individually. They were informed that the experiment examined individual differences in verbal and visual information processing and that further information about the goals of the study would be provided at the end of the session. Participants then completed the encoding and transmission phases in turn. As mentioned previously, each of these phases was preceded by a state anxiety induction phase. Once the

transmission phase had been completed, participants were debriefed and the experimental session ended.

Results

A number of issues were investigated in this study. Firstly, the number of unambiguously negative and unambiguously positive story events that featured in participants' retellings was analysed to determine if there is a content bias characterised by the preferential transmission of negative information over positive information.

Additionally, the impact of state and trait anxiety on the social transmission of the unambiguously negative and unambiguously positive story events was assessed. Next, the number of negative and positive resolutions of the originally ambiguous story events that featured in participants' retellings was analysed to determine if there is evidence of guided variation this study. Guided variation would be evidenced by participants exhibiting a disproportionate tendency to transform the ambiguous story events in a negative (as opposed to a positive) manner, during social transmission. The impact of state and trait anxiety on the resolution of ambiguous story events was also assessed.

State anxiety induction

To verify that the state anxiety induction procedure elicited the desired group difference in state anxiety level, separate 2x2x2 mixed-design ANOVAs were conducted on the state anxiety ratings provided by participants during the encoding and transmission phases of the experiment. State Anxiety Induction Condition (high state anxiety vs. low state anxiety) and Trait Anxiety Group (high trait anxiety vs. low trait anxiety) were treated as

between groups factors and Assessment Point (pre-induction vs. post-induction) was treated as a within-groups factor. The ANOVA carried out on the encoding phase ratings revealed a significant main effect of Trait Anxiety Group, $F(1,158)=33.22, p<.001$, such that high trait anxious participants rated their level of state anxiety higher than the low trait anxious participants at each assessment point (see Figure 1). There was also a significant interaction between State Anxiety Induction Condition and Assessment Point, $F(1,158)=29.65, p<.001$. Pairwise comparisons confirmed that ratings obtained from participants' in the high and low state anxiety induction conditions did not significantly differ prior to receiving the first state anxiety induction, $t(158)=.49, p=.629$. Following the first induction, participants in the high state anxiety induction condition reported significantly higher state anxiety than those in the low state anxiety induction condition, $t(158)=7.22, p<.001$. This confirms that the first state anxiety induction produced the desired difference in state anxiety level during the encoding phase.

The ANOVA carried out on the transmission phase ratings revealed a significant main effect of Trait Anxiety Status, $F(1,158)=28.19, p<.001$, such that high trait anxious participants rated their level of state anxiety higher than the low trait anxious participants at each assessment point (see Figure 1). There was also a significant interaction between State Anxiety Induction Condition and Assessment Point, $F(1,158)=12.89, p<.001$. Pairwise comparisons confirmed that ratings obtained from participants' in the high and low state anxiety induction conditions did not significantly differ immediately prior to receiving the second state anxiety induction, $t(158)=1.28, p=.203$. Following the second induction, participants in the high state anxiety induction condition reported significantly higher state anxiety than those in the low state anxiety induction condition, $t(158)=3.78, p<.001$. This

confirms that the second state anxiety induction produced the desired difference in state anxiety level during the transmission phase.

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

Transmission of unambiguously negative and positive story events

To determine whether there was a tendency for participants to transmit a greater number of unambiguously negative than unambiguously positive story events during social transmission, participants' retellings were first separated into their underlying events. Next, a coder, blind to participants' trait anxiety status and state anxiety induction condition, assessed each participant's retelling of the story and indicated if each described event in the retelling was present in the original story. This determined the number of unambiguously negative and unambiguously positive story events that featured in participants' retellings. Using the same approach as Eriksson & Coultas (2014), an event was considered to be present if the basic gist was the same as the event in the original story. A second coder, coded a random selection of 20 story reproductions (24%) using the same procedure. Inter-rater reliability was confirmed by the high Krippendorff's alpha, $\alpha = .97$. The first coder's assessment of each story retelling was used in the final analysis. The average number of negative and positive story events that featured in participants' retellings is shown in Table 1.

Table 1

Mean (SD) number of unambiguously negative and unambiguously positive original story events that featured in participant's retellings.

State Anxiety Condition	Trait Anxiety Group	Valence of the event	
		Negative	Positive
High State Anxiety	High Trait	6.30 (1.22)	4.65 (1.23)
	Low Trait	5.50 (1.64)	3.75 (1.74)
Low State Anxiety	High Trait	5.14 (1.74)	4.09 (1.51)
	Low Trait	5.40 (1.92)	4.23 (1.74)

The number of unambiguously negative and unambiguously positive story events that featured in participants' retellings was analysed using a logistic mixed-effects model. Analyses were conducted using the lme4 software package (Bates, Maechler, Bolker, & Walker, 2015) in R version, 3.2.2 (R Core Team, 2015). As recommended by Barr, Levy, Scheepers, and Tily (2013) the model tested included the maximal random effects structure justified by the experimental design. In instances where models with the maximal random effects structure did not converge on a solution, the random effects structure was simplified by removing a random slope (or slopes).

The model for the number of unambiguously negative and unambiguously positive story events that featured in participants' retellings specified Valence of the event (negative or positive), State Anxiety Induction Condition (high state anxiety or low state anxiety) and Trait Anxiety Group (high trait anxious or low trait anxious) as fixed effects with interaction. To control for any influence of event position on the transmission of the negative and positive story events, Event Position (3-39) was also included as a fixed effect. A random effects structure was specified that included random intercepts for Participant and Event, as well as a by-Participant random slope for the effect of Valence and a by-Event random slope for the effect of Trait Anxiety Group¹⁴ (see Table 2). This model was compared to a model that excluded the three-way interaction between Valence, State Anxiety Induction Condition and Trait Anxiety Group. Model comparisons confirmed that allowing fixed effects to interact did not significantly improve model fit, $\chi^2(1)=.03$, $p=.862$. Next, this reduced model

¹⁴ The initial model tested also specified by-Event random slopes for the effect of State Anxiety Induction Condition and the interaction of Trait Anxiety Group and State Anxiety Induction Condition. However, models with this more complex random effects structure did not converge on a solution and so the random effects structure was simplified by removing the by-Event random slopes involving State Anxiety Induction Condition.

was compared to a model that excluded the interaction between Trait Anxiety Group and State Anxiety Induction Condition. Model comparisons confirmed that including this two-way interaction did not significantly improve model fit, $\chi^2(1)=1.81$, $p=.179$. Following this, the reduced model was compared to a model that excluded the interaction between Trait Anxiety Group and Valence. Model comparisons confirmed that including this two-way interaction did not significantly improve model fit, $\chi^2(1)=.03$, $p=.874$. This reduced model was then compared to a model which excluded the two-way interaction between State Anxiety Induction Condition and Valence. Model comparisons confirmed that including this two-way interaction provided a marginally better model fit than the model that excluded the interaction between State Anxiety Induction Condition and Valence, $\chi^2(1)=3.22$, $p=.073$. Next, the fixed effect of Trait Anxiety Group was tested by comparing a model with Valence, State Anxiety Induction Condition and Trait Anxiety Group as fixed effects, allowing for the interaction of Valence and State Anxiety Condition, with a model which excluded Trait Anxiety Group as a fixed effect. Model comparisons confirmed that including Trait Anxiety Group as a fixed effect did not significantly improve model fit, $\chi^2(1)=.75$, $p=.376$. Hence, the best-fitting model for the number of unambiguously negative and positive story events that featured in participants' retellings specified Valence and State Anxiety Induction Condition as fixed effects, with interaction. As shown in Figure 2, all participants (regardless of State Anxiety Induction Condition or Trait Anxiety Group) tended to transmit more negative story events than positive story events. This finding supports the hypothesis that there is a negative content bias in social transmission, characterised by the preferential transmission of negative information over positive information. Furthermore, there was evidence that this effect was slightly more pronounced for participants who were induced to experience elevated state anxiety. This finding supports the proposal that elevated state anxiety is

associated with the disproportionate transmission of negative information, relative to positive information. However, this evidence should be considered cautiously, given the marginal nature of the effect.

Table 2

Results of the maximal model for the survival of negative and positive story events (Trait Anxiety Group, Mood Induction Condition and Valence of the story event as fixed effects with interaction, controlling for Event Position).

Predictor	Coefficient	SE	z
(Intercept)	2.46	.81	3.05**
Valence (Positive)	-1.46	.63	2.33*
State Anxiety (Low)	-.71	.39	1.84
Trait Anxiety Group (Low Trait Anxiety)	-.42	.43	.99
Valence*State Anxiety	.45	.38	1.16 ($p=.073$)
Valence*Trait Anxiety Group	-.10	.46	.22
State Anxiety * Trait Anxiety Group	.48	.53	.89
Valence* State Anxiety * Trait Anxiety Group	.10	.54	.18
Event Position	-.03	.02	1.34
Model fit:			
AIC	1543.9		
BIC	1621.8		
Log-likelihood	-757.0		

Note. ** $p<.01$; * $p<.05$

Figure 2. Mean number of unambiguously negative and positive story events that featured in participants' story reproductions. Error bars represent standard error of the means.

Resolution of originally ambiguous story events

To determine whether there was evidence of guided variation involving the transformation of information in a negative, as opposed to a positive, manner, a coder (blind to participants' trait anxiety status and state anxiety condition) judged if the originally ambiguous story events had been transmitted in a manner that retained their ambiguity or had been resolved in either a negative or positive manner. A second coder coded a random selection of 20 reproductions (24%) using the same procedure. Inter-rater reliability was high for judgements concerning the number of ambiguous scenarios that were transmitted in a manner that retained their ambiguity, $\alpha = .86$; the number of negative resolutions that

featured, $\alpha = 1$ (there were no disagreements); and the number of positive resolutions that featured, $\alpha = .98$. The first coder's assessment of the ambiguous story events was used in the final analysis. The average number of negative and positive resolutions of originally ambiguous story events that featured in participants' retellings, along with the number of ambiguous scenarios that retained their ambiguity, is shown in Table 3, and shows that very few resolutions of ambiguity (≤ 2 resolutions per participant) featured in participants' retellings.

Table 3

Mean (SD) number of ambiguous scenarios that were transmitted as ambiguous; and negative and positive resolutions of originally ambiguous story events that featured in participant's retellings.

State Anxiety Condition	Trait Anxiety Group	Ambiguous Scenarios	Valence of the Resolution	
			Negative	Positive
High State Anxiety	High	2.65 (1.35)	.95 (.89)	.75 (.79)
	Low	2.00 (1.75)	.70 (.80)	.70 (.86)
Low State Anxiety	High	1.62 (1.40)	.90 (.83)	.86 (.85)
	Low	2.23 (1.74)	.86 (.71)	1.00 (.87)

The number of the originally ambiguous story events that were resolved in a negative and positive manner were analysed using a linear mixed-effects model. Analyses were conducted using the lme4 software package (Bates et al., 2015) in R version, 3.2.2 (R Core Team, 2015). The initial model tested, specified Valence of the resolution (negative vs. positive), State Anxiety Induction Condition (high state anxiety vs. low state anxiety) and Trait Anxiety Group (high trait anxious vs. low trait anxious) as fixed effects with interaction. The maximal random effects structure was specified, which included a random intercept for Participant. The results of this model are shown in Table 4 and did not reveal

any significant main or interaction effects. To confirm this finding, the maximal model was compared to the null model, without any without any fixed effects. Model comparisons confirmed that the maximal model did not provide a significantly better model fit than the null model, $\chi^2(7)=2.83$, $p=.901$. Hence, there was no evidence of guided variation, characterised by a tendency to transform the ambiguous story events in a negative (as opposed to positive) manner during social transmission. Additionally, there was no evidence that the state anxiety induction that participants received, or their trait anxiety status, influenced the number of negative and positive resolutions of the originally ambiguous story events that featured in their retellings of the story (see Figure 3).

Table 4

Results of the maximal model for the resolution of originally ambiguous story events (Valence of the resolution, State Anxiety Condition and Trait Anxiety Group as fixed effects with interaction).

Predictor	Coefficient	SE	<i>t</i>
(Intercept)	.95	.18	5.27***
Valence of the resolution (Positive)	-.20	.26	.78
State Anxiety (Low)	-.05	.25	.18
Trait Anxiety Group (Low Trait Anxiety)	-.25	.26	.98
Valence * State Anxiety	.15	.36	.43
Valence * Trait Anxiety Group	.20	.36	.55
State Anxiety * Trait Anxiety Group	.21	.35	.59
Valence * State Anxiety * Trait Anxiety Group	-.02	.50	.03
Model fit:			
AIC	419.8		
BIC	415.0		
Log-likelihood	-199.9		

Note. ** $p<.001$

Figure 3. Mean number of originally ambiguous story events that were resolved negatively and positively in participants' retellings. Error bars represent standard error of the means.

Discussion

A number of issues were investigated in this study. As in previous studies presented in this thesis, the current study sought to determine whether there is a negativity bias in the social transmission of emotional information. Specifically, it tested whether there was evidence of (i) a content bias characterised by the selective transmission of negative information over positive information and; (ii) guided variation involving the transformation of information in a negative, as opposed to a positive, manner. Additionally, the influence of elevated levels of state anxiety and trait anxiety on the social transmission of valenced information was explored. The findings related to each of these aims, and the conclusions that can be drawn on the basis of these, will be reviewed in turn below.

Evidence of a negative content bias in social transmission

The first issue tested in the current study was whether there was evidence of a content bias, characterised by the preferential transmission of negative information over positive information. It was found that participants' retellings of the story featured a greater number of negative story events, than positive story events. This finding is consistent with the proposed negative content bias and suggests that negative information is preferentially transmitted during communication. This finding is also consistent with previous work by Eriksson and Coultas (2014), who found that stories that were higher in disgust content were transmitted with greater fidelity than stories lower in disgust content (see Chapter Four for a detailed discussion of this research). However, by directly comparing the transmission of negative and positive information, the current study demonstrates that this pattern is reflective of a selective bias favouring negative information, rather than a general bias for emotional information irrespective of valence.

As discussed in Chapter Four, Study Three did not find evidence suggestive of a negative content bias. A key methodological difference between the two studies may account for this discrepancy. Participants in Study Three were allowed the use of prompts during the social transmission of the short story. It was argued in the Discussion of that Chapter that this feature of the experimental methodology may have facilitated recall of the positive story events. The findings of the current study suggest that without the use of a recall aid, positive story events tend to be omitted, while negative story events survive in transmission.

Guided variation did not contribute to the resolution of ambiguity

The second issue explored in the current study was whether there was evidence of guided variation involving the transformation of originally ambiguous story events in a disproportionately negative manner during social transmission. Analysis of participants' retellings of the short story indicated that there was no difference in the number of negative and positive resolutions of ambiguity that featured. Hence, there was no evidence of the guided variation in the current study. However, examination of the total number of resolutions that featured in participants' retellings reveals that, on average, participants resolved only two of the eight originally ambiguous story events during transmission. With so few resolutions of ambiguity featuring in participants' retellings of the story, it is unlikely that the proposed negativity bias could be detected. It's possible that with greater opportunity for the transformation of ambiguity, a preference for negative resolutions may emerge. One way to explore this issue further would be to extend the current design to involve the serial reproduction of the short story. An additional finding of the current study was that, on average, participants faithfully transmitted two of the eight originally ambiguous story events. That is, during social transmission the ambiguity was preserved. This suggests that in a serial reproduction experiment involving multiple transmission episodes, additional resolutions of ambiguity may be observed. The final study presented in this thesis explores this possibility by adopting a serial reproduction design, involving the social transmission of the short story used in the current study, along four-person transmission chains.

The role of elevated state anxiety in the social transmission of valenced information

A key aim of the current study was to determine whether elevated state anxiety is associated with a disproportionate tendency to transmit negative information, relative to reduced levels of state anxiety. To test this, participants in the current study were allocated to one of two state anxiety induction conditions that either elevated or reduced state anxiety. As in previous studies presented in this thesis, the current study also compared the social transmission of low and high trait anxious participants. This was done to test whether elevated state anxiety may differentially affect people with low and high levels of trait anxiety. The current study found that the observed content bias, favouring the transmission of unambiguously negative story events over unambiguously positive story events, was slightly more pronounced for participants who were induced to experience elevated state anxiety. This evidence is consistent with existing evidence from the rumour transmission literature that a persons' emotional state can influence the social transmission of information (Pezzo & Beckstead, 2006; e.g. Walker & Beckerle, 1987). However, this study provides novel evidence that the influence of state anxiety on social transmission is not a general one. The evidence from the current study suggests that state anxiety stimulates the transmission of negative information to a greater degree than it does positive information. However, this finding should be considered with caution, given the marginal nature of the effect ($p=.073$).

To determine whether the observed influence of state anxiety on social transmission is a reliable effect, the study that follows will allocate transmission chains (rather than individuals) to receive the same state anxiety mood induction procedures that were employed in the current study. This approach provides a useful analogue of the processes described in the early rumour literature. As noted in the Introduction to this Chapter, early researchers of rumour transmission argued that rumours will spread during times of

conflict, crisis and catastrophe (the '3 Cs'), when state anxiety is likely to be elevated (Koenig, 1985; Rosnow, 1980). Although the current study explored this issue by observing a single transmission episode, much social transmission involves the repeated transmission of information by multiple people. Hence, by inducing transmission chains to experience either elevated or reduced state anxiety, the final study presented in this thesis provides a more naturalistic test of the proposal that state anxiety may be associated with a disproportionate tendency to transmit negative information, relative to reduced levels of state anxiety.

Elevated trait anxiety is not associated with enhanced transmission of negative information

A final issue explored in the current study was whether elevated trait anxiety may be associated with a disproportionate tendency to transmit negative information, relative to low levels of trait anxiety. Although previous studies presented in this thesis did not find evidence to support this proposal, it was argued that such effects may only be evident when people with elevated levels of trait anxiety are in anxious mood state. The current study did not find any evidence that elevated trait anxiety influenced the social transmission of valenced information. This was true, irrespective of whether participants were experiencing elevated state anxiety. Hence, the appropriate conclusion for the moment is that elevated trait anxiety does not confer a transmission advantage for negative over positive information.

Although the studies presented in this thesis did not find evidence of that elevated trait anxiety was associated with a disproportionate tendency to transmit negative information, it's possible that elevated trait anxiety may influence the social transmission of

valenced information in ways not directly tested in this thesis. One possibility is that elevated trait anxiety may influence social transmission only when the information to be transmitted is of personal relevance or relates to an area of particular concern or worry. As noted in Chapter Two, Study One found evidence of an anxiety-linked negative interpretation bias for ambiguous scenarios that permitted negative interpretations related to social harm, but not those related to physical harm. This finding was at odds with evidence from Eysenck et al. (1991) who did not find evidence of this kind of specificity in their study involving clinically anxious individuals who had been diagnosed with Generalized Anxiety Disorder. It was argued that at sub-clinical levels, anxiety-linked negative interpretation bias may be specific to the individual's primary area of concern but in more severe, clinical presentations, the tendency to favour negative interpretations of ambiguity generalizes to other domains. The same argument may be true of the proposed effect of elevated trait anxiety on the social transmission of valenced information. Future research could seek to explore this issue. One possibility is to explore the social transmission of information by participants who are clinically anxious, relative to non-anxious control participants.

Conclusion

The current study found evidence of a negative content bias characterised by the preferential transmission of negative information over positive information. In contrast, there was no evidence that guided variation operated in the current study to influence the resolution of ambiguity. However, analysis of participants' retellings of the story script revealed that very few resolutions of ambiguity featured. Given the evidence that some

originally ambiguous story events were transmitted in a manner that preserved their ambiguity, the study that follows will explore whether evidence of guided variation is found when multiple transmission episodes are considered. Hence, a serial reproduction design will be adopted to explore the social transmission of valence information across four-person transmission chains.

There was some evidence in the current study that the observed negative content bias was more pronounced for participants who had been induced to experience elevated state anxiety. However, this effect was marginal and so, should be treated cautiously. To determine if this effect is reliable, the study that follows will induce transmission chains (rather than individuals) to experience either elevated or reduced state anxiety, using the same state anxiety induction procedure used in the current study. Finally, there was no evidence in the current study, or those that preceded it, that elevated trait anxiety was associated with a disproportionate tendency to transmit negative information, relative low levels of trait anxiety. Hence, the appropriate conclusion for the moment is that elevated levels of trait anxiety do not confer a transmission advantage for negative information. As the findings of the current study suggest that elevated state anxiety may influence the social transmission of valenced information, the final study presented in this thesis will focus on further exploring this issue and will not examine trait anxiety. However, potential avenues of future research, outlined above, will be revisited in the final chapter of this thesis.

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Chapter Six

Study Five

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.

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.

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, 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.

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).

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.

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.

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.

Method

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 ($SD=4.22$)¹⁵ who received course credit for their participation. A one-way ANOVA revealed that the age of participants assigned to the elevated anxiety

¹⁵ Age was not entered by two participants.

and reduced anxiety mood induction conditions did not significantly differ, $F(1,364)=2.58$, $p=.11$. There was also no difference in gender ratio between participant groups allocated to each mood induction condition, $\chi^2(1)=.82$, $p=.37$.

Materials

Experimental 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 flight¹⁶. 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

¹⁶ See Appendix 3 for the original story script.

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 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.

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 scene¹⁷. 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.

¹⁷ These materials are available online at: <http://comlab.me/ComLab/Negative-bias.html>

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.

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. Participants retellings of the story were not corrected for spelling or grammar and were presented verbatim to the next participant in the chain (for participants in chain positions 1-3). Participants were tested during their regular tutorial classes.

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.

Mood manipulation

Figure 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 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, $F(1,366)=220.46, p<.001, \eta^2=.38$. 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, $F(1,366)=136.26, p<.001, \eta^2=.27$. 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.

Figure 3. Mean mood ratings for the anxiety VAMS reported during the experiment. Error bars represent standard error of the means.

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.

Figure 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.

Figure 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 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.

Table 1

Results of the best fitting model for the survival of unambiguous story events (position and valence as fixed effects without interaction, controlling for item position).

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

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

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.

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. Interrater 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.

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 Figure 3. Across successive transmission episodes very few ambiguous events remained ambiguous; ambiguous statements were either lost or participants resolved the ambiguity.

Figure 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.

Figure 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 model¹⁸ (same fixed effects and random effects structure used earlier). 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).

¹⁸ 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.

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 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.

Table 2

Results of the best fitting model for the resolution of originally ambiguous story events (position and valence as fixed effects with interaction).

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

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

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

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.

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. Furthermore, that the tendency to resolve ambiguity in a negative manner was only evident from chain position two onwards highlights the importance of considering the intergenerational consequences of social transmission. Had the current study explored only a single transmission episode, this effect would not have been observed. As noted by Caldwell and Millen (2010) in using transmission chain studies "...researchers can study how information can be shaped, degraded, or built upon over repeated transmission events...(hence) they provide a much better insight into the sorts of traditions that might actually be sustained in real populations."

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 Figure 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.

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 through two complementary 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 alternative 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 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.

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 in their study 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, & McD 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.

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.

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Chapter Seven

General Discussion

The primary aim of the current program of research was to determine if there is a general tendency for people to preferentially communicate negative information during social transmission. The cultural evolution literature reviewed in Chapter One highlights the role that cognitive processing biases play in shaping cultural change. Indeed, there is now a substantial body of work documenting the *interpersonal* consequences of a range of *intrapersonal* processing biases (see Chapter One for a detailed discussion of this literature). Given the extensive evidence that people preferentially process negative, over positive information (cf. Baumeister, Bratslavsky, Finkenauer, & Vohs, 2001) it was argued in Chapter One that there may be a commensurate negative bias in the social transmission of information. Drawing on the work of Boyd and Richerson (1985) and their colleagues, the studies presented in this thesis explored two complementary processes that contribute to cultural change. Specifically, this thesis tested whether there was evidence of (i) a content bias characterised by the selective transmission of negative information over positive information and; (ii) guided variation involving the transformation of information in a negative, as opposed to a positive, manner.

A related research question that was under investigation throughout this thesis was whether elevated anxiety (trait and/or state) may be associated with a disproportionate tendency to transmit negative information, relative to people with low levels of anxiety. This feature of the current program of research represents a novel contribution to the cultural evolution literature, which has, to date, focused exclusively on understanding the tendencies shared by people that contribute to cultural change. In exploring whether there are individual

differences in the social transmission of information the current thesis extends this body of work. The section that follows will review the findings of the studies presented in this thesis and discuss the conclusions drawn from these. Following this, the implications of this research for our understanding of cultural evolution, cognition and emotion are considered. Finally, potential avenues for future research that stem from this work are described.

Evidence of a negative content bias

The current program of research found evidence that people preferentially transmit unambiguously negative information over unambiguously positive information during social transmission. This issue was first explored in Study Three (see Chapter Four). In that study, participants transmitted a story that contained an equal number of unambiguously negative and unambiguously positive story events (henceforth referred to as negative and positive story events respectively). Participants read the story and, after a delay, they created a short video in which they retold the story to an imagined friend or family member. Transcripts of these retellings were coded to determine the number of negative and positive story events that featured. There was no evidence that participants in Study Three transmitted a greater number of negative story events than positive story events. However, a key methodological issue was identified that may have obscured evidence of the proposed effect. Participants in that study were permitted the use of prompts during social transmission. It was argued in Chapter Four that this recall aid may have facilitated the transmission of positive story events that might have otherwise been omitted from participants' retellings of the story. Hence, participants in Studies Four and Five were prevented from using recall aids during social transmission.

Addressing this methodological issue proved fruitful. Participants in Study Four were found to transmit a greater number of negative story events, than positive story events, consistent with the proposed negative content bias. This finding was replicated in Study Five, which adopted a serial reproduction design to explore the social transmission of emotional information across multiple transmission episodes. It was found that a greater number of negative story events, than positive story events, featured at each generation in the transmission chain.

The finding of a negative content bias is consistent with previous work by Eriksson and Coultas (2014), who found that stories that were higher in disgust content were transmitted with greater fidelity than stories lower in disgust content. As noted in Chapter Four, the preferential transmission of disgust information was explained by the researchers in terms of a general preference for *emotional* information, rather than a specific preference for *negative* information. However, in their study other types of emotional information, including positive emotional information, were not examined. By directly comparing the transmission of negative and positive information, the current program of research demonstrates that this pattern is reflective of a selective bias favouring negative information, rather than a general bias for emotional information, irrespective of valence.

Reconstruction or preservation? The finding that negative information is preferentially transmitted over positive information is at odds with research by Berger and Milkman (2012) who explored whether the valence of information influences the rate of online social transmission. In their study, news articles that appeared on the New York Times website across a three-month period were coded to determine the valence of each article. They then measured the frequency with which each article was shared. A key finding was that the articles that enjoyed the highest rates of transmission were predominantly

positively valenced. These seemingly contradictory findings may be related to the mode of transmission that was examined. Berger and Milkman examined online social transmission involving the sharing of articles in their original form. High fidelity transmission of this type is a feature of digital communication. However, it is qualitatively different from the social transmission explored in the current thesis. Whereas online social transmission (of the type examined by Berger and Milkman) is preservative, the studies presented here involved the reconstruction of the original story script during social transmission. Taken together, these findings suggest that the mode of transmission can have important consequences for the expression of content biases.

Content biases are not memory biases. As noted previously, Study Three did not find evidence of a transmission advantage for negative information when participants were permitted the use of prompts during social transmission. This speaks to the importance of memory processes in the expression of the observed negative content bias. However, it may be overly reductionist to equate content biases in social transmission with memory biases. There is evidence that content biases may only be evident when there is a clear intention to communicate. As noted in Chapter Four, in a serial reproduction experiment, Lyons and Kashima (2006) found that when participants were asked to retell a story for another participant to read, they communicated more stereotype-consistent information than stereotype-inconsistent information. However, when the instructions asked participants to accurately recall the story from memory (with no mention that it would be read by another participant) no such bias emerged. Participants in Study Three were told to imagine that were talking to a friend or family member when retelling the story. However, as participants were not told that their video-recorded retellings would viewed by another person, it's possible that the instructions did not ensure that communicative intent was present. In

contrast, participants in Studies Four and Five were explicitly told that their retelling of the story would be read by another participant. It may be that, consistent with Lyons and Kashima, communicative intent is a necessary precursor for the expression of the observed negative content bias.

A related issue is whether the relationship between the transmitter and receiver influences the expression of the observed negative content bias. There is existing evidence that transmitters tailor their communication to suit the recipient; a process known as 'audience design' (Brennan & Hanna, 2009). This variation in communication style as a function of the recipient is particularly relevant to the communication of emotional information. Brown and Levison (1987) argue that sharing emotional information can be socially risky and there is evidence that people prefer to share emotional personal information with close friends or family members rather than strangers (Rime et al., 1992). Consistent with this, Peters, Kashima and Clark (2009) found that people are more willing to communicate emotional social anecdotes to a friend than a stranger and this effect was greatest for anecdotes that evoke surprise or sadness. These findings point to the social transmission of emotional information being situated and suggests that the expression of the observed negative content bias may vary as a function of the relationship between the transmitter and receiver.

Evidence of a negativity bias in the transformation in ambiguity

The current program of research found evidence consistent with guided variation involving the transformation of ambiguity in a negative, as opposed to a positive, manner. Importantly, the studies presented in this thesis suggest that this form of negative

transmission bias may only be evident across multiple, rather than singular, transmission episodes. The initial exploration of this issue in Study Two involved the social transmission of ambiguous scenarios (that permit negative and non-negative interpretations) from one participant (the transmitter) to the another (the receiver). The representations that were formed of the ambiguous scenarios by transmitters and receivers were assessed to determine if the meaning that was encoded by receivers was commensurate with the pattern of interpretation shown by the transmitters.

The inclusion of low and high trait anxious transmitters was particularly diagnostic in addressing this research question. Consistent with the pattern of results obtained in Study One, it was found that high trait anxious transmitters were disproportionately likely to encode the negative meaning of ambiguous scenarios that permit negative interpretations related to social harm, relative to low trait anxious transmitters. Despite this, there was no evidence that the two groups of receivers (who were homogenous with respect to trait anxiety) differed in their interpretation of these scenarios. The receivers did not show a consistent preference for negative or non-negative meanings of the socially relevant ambiguous scenarios, irrespective of the trait anxiety status (and interpretation) of the transmitter. These findings suggest that transmitters did not communicate the encoded meaning to the receivers. Hence, Study Two did not find evidence that the ambiguous scenarios were transformed in a negative manner during social transmission.

A limitation of the experimental design used in Study Two was the requirement for transmitters to communicate the scenarios immediately after hearing them presented through headphones. As noted in Chapter Three, this may have resulted in verbatim recital of the scenarios. Under these conditions, it is likely that natural variation in the social transmission of information would have been constrained. Hence, the studies that followed employed

experimental designs which sought to encourage such variation. Two key methodological features were incorporated in subsequent studies to achieve this aim. Firstly, longer passages of text, that were unable to be recalled verbatim, were used as experimental stimuli. Secondly, social transmission occurred after a delay, rather than immediately following the presentation of the experimental stimuli.

In Study Four, participants were given a short story to read and (after a delay) retell for another person to read, by typing the story into a text box on a computer. The story contained a number of ambiguous scenarios that permitted negative and positive interpretations. Participants retellings of the story were coded to determine if the ambiguous scenarios were transformed during social transmission in a negative or positive manner. There was no evidence that participants in Study Four were disproportionately likely to resolve the ambiguity in a negative manner. However, only a small number of resolutions of ambiguity featured in participants' retellings. It was argued that with greater opportunity for the transformation of ambiguity, a preference for negative resolutions may emerge.

To provide greater opportunity for the transformation of ambiguity, the experimental design used in Study Four was extended to include multiple transmission episodes. In Study Five the same short story used in Study Four was transmitted along chains of four people. In this serial reproduction experiment it was found that across successive transmission episodes, negative resolutions of the ambiguous scenarios became increasingly more frequent, relative to positive resolutions. The finding supports the proposal that through guided variation, people are disproportionately likely to transform ambiguity in a negative (as opposed to positive) manner during social transmission.

Serial reproduction experiments can reveal the cumulative effects of subtle biases.

That guided variation was only evident in an experiment involving the serial reproduction

of information suggests that this transformative process may represent a relatively weaker force of cultural change than content biases, which involve selection among existing variants, at least in this case. As noted in Chapter One, although these two processes may arise from the same underlying cognitive processing tendencies, the conditions which give rise to them are quite different. Whilst content biases rely on variation in the existing environment, guided variation can occur in the absence of such variation. The findings of Study Five suggest that when variation is present, content bias result in a faster rate of change than guided variation.

The findings of Study Five highlight that subtle biases can have cumulative effects during social transmission that can contribute to cultural change ((Kirby, Dowman, & Griffiths, 2007; Thompson, Kirby, & Smith, 2016). A review of studies that have employed the method of serial reproduction reveals that, like the observed negative transformation bias, some transmission biases are often not evident in the output produced by first-generation participants but emerge after subsequent transmission episodes. For instance, as noted in Chapter Three, Lyons and Kashima (2001, 2003, 2006) have fruitfully employed the method of serial reproduction to explore a bias which favours the social transmission of stereotype-consistent information over stereotype-inconsistent information. In one such study, the selective transmission of stereotype-consistent information was first evident in the output generated by second generation participants (2001). For this reason, Caldwell and Millen (2010) argue that serial reproduction studies provide a better analogue of the processes involved in social transmission than dyadic designs that involve only a single transmission episode.

The amplification of weak biases has been explained as the result of Bayesian inference in which the cognitive (or ‘inductive’) bias forms the prior used by individuals, in

conjunction with the observed data, to make inferences. A number of researchers have demonstrated that when social transmission is modelled using principles of Bayesian inference, culture converges on the weak cognitive bias of its members (e.g. Griffiths & Kalish, 2007; Thompson et al., 2016). For example, Thompson, Kirby & Smith (2016) used this approach to model the cultural evolution of linguistic features and found that over multiple iterations weak inductive biases became behavioural universals. Furthermore, Bayesian models have been found to successfully predict the results of experimental studies that use the serial reproduction methodology (Griffiths, Christian, & Kalish, 2008; Xu & Griffiths, 2010).

The impact of anxiety on the social transmission of information

A key aim of the current thesis was to determine whether elevated levels of anxiety vulnerability were associated with a disproportionate tendency to transmit negative information, relative to people with low levels of anxiety vulnerability. The proposal that there may be anxiety-linked negative *transmission* biases was derived from consideration of the literature concerning cognitive processing biases in anxiety. As described in detail in Chapter One, there is extensive evidence that elevated levels of anxiety vulnerability are associated with a range of cognitive processing biases characterised by the preferential processing of negative information, over positive information, relative to people with low levels of trait anxiety (cf. Mathews & MacLeod, 2005). To explore this issue, the studies presented in this thesis compared the social transmission of emotional information by undergraduate students who reported either low or high levels of trait anxiety. Across three studies that explored this issue (see Chapters Three-Five), no evidence was found to suggest

that elevated levels of trait anxiety are associated with a disproportionate tendency to transmit negative information.

The finding that elevated levels of trait anxiety do not modulate the observed negative transmission biases is at odds with the argument made by Fessler, Pisor and Navarette (2014) that *“people who believe the world to be a dangerous place may...be particularly prone to differentially retain and propagate hazard information”* (p. 5). As noted in Chapter Five, one possibility is that in non-clinical populations, elevated trait anxiety may influence social transmission only when the information to be transmitted is of personal relevance or relates to an area of particular concern or worry. Study One found evidence that, for the undergraduate student sample tested, an anxiety-linked negative interpretation bias was specific to ambiguous scenarios that permit negative interpretations related to social harm. It was argued that this specificity may reflect the fact that young adults tend to worry more about social relationships than physical (health) concerns (Lindesay et al., 2006). In contrast, Eysenck et al., (1991) found that clinically anxious participants demonstrated a general anxiety-linked negative interpretative bias that was not restricted to an individual’s primary area of concern. This suggests that in more severe, clinical presentations of anxiety, the tendency to favour negative interpretations of ambiguity generalizes to a wide range of domains. Indeed, a defining feature of Generalised Anxiety Disorder is that the worries experienced by the individual extend across multiple domains (American Psychiatric Association, 2013). The same may be true of social transmission. It’s possible that the hypothesized effect of elevated anxiety vulnerability on the social transmission of emotional information may be found in studies involving clinical populations. An alternative line of investigation could involve studies that more directly tailor experimental materials to be exploit the worries reported by its participants.

The role of state anxiety in the social transmission of emotional information.

In Study Four, the exploration of anxiety-linked biases in transmission was expanded to consider the possibility that elevated state anxiety, rather than elevated trait anxiety, may confer a transmission advantage for negative (over positive) information. To test this possibility, participants were randomly allocated to receive one of two state anxiety induction procedures designed to either elevate or reduce state anxiety. The state anxiety induction procedure was administered prior to transmitting a short story that contained a variety of negative and positive story events. There was some evidence that the observed negative content bias (described previously in this Chapter) was more pronounced for participants who had been induced to experience elevated state anxiety. Although, as noted in Chapter Five, this effect was marginal.

Study Five, explored this issue further by randomly allocating transmission chains (rather than individual participants) to receive the same state anxiety induction procedures used in Study Four. In this study, there was no evidence that elevated state anxiety was associated with the preferential transmission of negative information over positive information. This suggests that the finding that elevated state anxiety augmented the observed negative content bias in Study Four, was not a reliable one. Hence, the appropriate conclusion for the moment is that elevated state anxiety is not associated with a transmission advantage for negative, over positive, information.

The existing evidence concerning the role of state anxiety on the social transmission of information, comes largely from the rumour transmission literature. As noted in Chapter Five, this research suggests that elevated state anxiety can stimulate the social transmission of information (Pezzo & Beckstead, 2006; Walker & Beckerle, 1987). It was argued in this thesis that high levels of state anxiety may result in higher rates of transmission for negative

information over positive information. However, the studies presented here suggest that the effect of state anxiety on social transmission may be more general than this.

Arousal stimulates the social sharing of information. A related area of research suggests that it is not state anxiety *per se* that stimulates the social transmission of information but the experience of *arousal* more generally. Berger (2011) contends that physiological arousal and the associated activation of the autonomic nervous system stimulate social sharing, irrespective of the specific emotion involved. By way of demonstration, Berger manipulated arousal in participants by having them either run in place, or sit still, before reading a news article that could be shared, via e-mail, should they wish. It was found participants who had run in place were more likely to share the news article. This effect was independent of the affective state of the participants, suggesting that the physiological arousal, rather than the emotional experience of the participants that was driving social transmission.

This argument has been extended to include the fact that arousal is elicited by the information itself. A number of studies have reported that information that evokes emotions characterised by high levels of emotion (e.g. anger, surprise) are associated with higher rates of online transmission than information that evokes low levels of emotion (Berger & Milkman, 2012; Stubbersfield, Flynn, & Tehrani, 2017). For instance, Eriksson, Coultas and de Barra (2016) found that participants self-reported arousal after reading news articles was a stronger predictor of their willingness to share the article with another person, than the valence of emotion they experienced.

In light of this research, it must be considered that the finding of negative transmission biases in the current program of research may be a function, not of the valence of the information, but the capacity for the information to elicit arousal. With respect to the

negative content bias observed in this thesis, it's possible that despite being matched for emotional *intensity* the negative and positive story events may have differed in the degree to which they elicited arousal in the participants. However, this arousal based account is harder to reconcile with the evidence of a guided variation, characterised by the disproportionately negative resolution of ambiguity. As noted in Chapter Six, for ambiguous story elements, the ambiguity has to be resolved *before* the associated arousal is experienced. Although arousal is clearly important in stimulating the social transmission of information, whether arousal can wholly account for the observed impact of valence is unclear.

State anxiety induction procedures. The state anxiety induction procedure used in the current study represents just one approach to inducing differentially anxious mood state in participants. Manipulation checks in Studies Four and Five confirmed that the procedures were successful in elevating and reducing anxiety (depending on the condition to which the participant was allocated). However, it's possible that the desired shift in anxious mood state did not endure for the length of time taken by participants to read and/or reproduce the short story used in those studies. In both studies, the mood ratings obtained from participants after they had read the story script revealed that the shift in state anxiety produced by first induction had dissipated by the time participants received the second 'top-up' induction. Hence, it's possible that a more robust state anxiety induction procedure may reveal reliable effects of elevated state anxiety on the social transmission of valenced information.

Future directions

The studies presented in this thesis suggest that people preferentially favour the transmission of negative information, over positive information. This represents evidence of a novel bias in the social transmission of information and adds to a growing list of social transmission biases that have been documented in the cultural evolution literature. These include biases for social information (Mesoudi, Whiten, & Dunbar, 2006) and stereotype-consistent information (Kashima, 2000; Lyons & Kashima, 2003, 2006), described in detail elsewhere in this thesis. As noted in Chapter Six, given the relative infancy of much of this research, we are yet to fully delineate these biases. In light of this, it's possible that the experimental materials employed in these studies may have exploited other social transmission biases that were not directly controlled for. One potential candidate that was noted in Chapter Six, is a bias which favours information pertinent to our survival (Stubbersfield, Tehrani, & Flynn, 2015). It's possible that as well as differing in emotional tone, the materials used in these studies may have differed in their relevance to our survival. Future research could seek to test whether biases for survival information and negative information operate independently of one another. Additionally, the current study did not explore the specific negative and positive emotions that were elicited by the materials used. Although the focus in the current program of research was on exploring how valence influences the social transmission of information, it's possible that the observed negativity bias may not be expressed equally for all emotions. As noted previously in this Chapter, the interplay between the evoked emotion and the arousal it elicits suggests that not all negative emotions may be associated with the same degree of preferential transmission (for example, sadness which is a negative emotion that elicits low levels of arousal (Berger, 2011; Berger & Milkman, 2012)). Additionally, information that evokes positive emotions that elicit high

levels of arousal (e.g. amusement) may be transmitted with greater fervor than some negative emotions that elicit low levels of arousal. Future research should seek to delineate whether the observed negativity bias is modulated by the specific emotion evoked and the arousal elicited.

In exploring the potential influence of elevated state anxiety on the social transmission of emotional information, Studies Four and Five highlight the importance of considering the context in which social transmission occurs. Although elevated state anxiety was not found to modulate the observed negative transmission biases, future research could fruitfully explore the conditions under which certain transmission biases are amplified or attenuated. Consider again, the preference for the transmission of stereotype-consistent, over stereotype-inconsistent information (Kashima, 2000; Lyons & Kashima, 2003, 2006). It would be beneficial to know if this stereotype-consistency bias may be amplified during times of uncertainty or intergroup tension. Furthermore, it would be advantageous to learn what conditions might attenuate this bias.

One possibility worthy of further exploration, raised earlier in this Discussion, concerns the role of communicative intent in the expression of social transmission biases. As noted previously, Lyons and Kashima (2001) found that stereotype-consistent bias only emerged under conditions with emphasised communicative intent. When the instructions emphasised the accurate recall of information, no such bias was found. This suggests that one way to attenuate stereotype-consistency bias is to encourage a focus on recall of information, removed from communication. It is yet to be established that the observed negative transmission biases are similarly influenced by communicative intent. However, if future research determined that this was indeed the case, it would be beneficial to learn the conditions under which this negativity bias could be attenuated.

A final consideration is the use, in the studies presented in this thesis, of stimulus materials that were carefully created to balance the quantity and intensity of positive and negative information they contained. This approach deviates from some previous studies of social transmission that employed the use of urban legends (e.g. Heath, 1996; Stubbersfield et al., 2017). The decision to create bespoke materials for use in this study was motivated by the level of experimental control this afforded. Carefully balancing positive and negative information enables a more direct test of the hypothesis that negative information will be preferentially transmitted in social transmission. However, the advantage of using urban legends, noted by Stubbersfield et al, lies in their status as cultural artefacts. These are narratives that have been transmitted naturally over many transmission episodes and so their ecological validity is assured. Future research exploring the observed negativity bias should aim to balance the desire for experimental control with the need to explore real-world social transmission.

Conclusion

A key feature of this thesis was a concerted effort to explore two processes that contribute to the evolution of culture: content biases and guided variation. As argued by Boyd and Richerson (1985) and more recently by Acerbi and Mesoudi (2015), these processes should not be considered mutually exclusive. The same cognitive processing that operates to influence selection among different variants during social transmission (content biases) can serve to guide the transformation of these variants (guided variation). Despite this, studies exploring the social transmission of information have tended to focus on one, or the other process. In the current program of research, both processes were explored, with reference to

the social transmission of emotional information. In doing so, convergent evidence of a negativity bias, characterised by the preferential transmission of negative, over positive, information and the disproportionately negative resolution of ambiguity was found.

In exploring the role that elevated levels of trait anxiety may play in the social transmission of information, this thesis makes a novel contribution to the cultural evolution literature. A primary focus of the study of cultural evolution has been revealing the tendencies that are shared by individuals that contribute to cultural change. However, as our understanding of these processes continues to grow, future research should seek to better understand individual differences in the expression of these processes. The studies presented in this thesis also examined role that state anxiety may play in the social transmission information. Although reliable effects of state anxiety were not found in this thesis, this endeavor highlights the importance of considering the context in which social communication occurs.

In conclusion, I found convergent evidence of a novel social transmission bias which favours the transmission of negative, over positive, information. Two complementary processes of cultural evolution were implicated in this negative transmission bias. Firstly, there was evidence of a negative content bias, characterised by the selective transmission of negative, over positive, information. Secondly, there was evidence of guided variation involving the transformation of ambiguity in a negative, as opposed to positive, manner. Elevated trait and state anxiety were not found to influence the expression of these effects. However, future research may reveal that one or both of these aspects of anxiety may modulate these effects.

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Appendices

1. Description of the model comparisons that were conducting during analysis of foil test sentences in Study 2.

To determine if participants in this study demonstrated a response bias, transmitters' and receivers' similarity ratings of the foil test sentences were analysed. The initial full model for participants' similarity ratings of the foil test sentences specified Role (transmitter or receiver), Scenario Type (physically relevant or socially relevant), Dyad Type (high or low trait anxiety dyad) and Valence of the foil (negative or non-negative) as fixed effects with interaction. A random effects structure was specified, which included random intercepts for Dyad and Item. A by-Dyad random slope for the effect of Valence was also specified, along with by-Item random slopes for the effects of Role, Dyad Type and Valence and the interaction of these effects. This model was compared to a model that excluded the four-way interaction between Role, Scenario Type, Dyad Type and Valence of the foil, retaining all lower order interactions. Model comparisons confirmed that including the four-way interaction between Role, Scenario Type, Dyad Type and Valence of the foil did not significantly improve model fit, $\chi^2(1)=.95$, $p=.329$. Next, the three-way interaction between Role, Scenario Type and Valence was excluded. Model comparisons confirmed that including this three-way interaction, did not significantly improve model fit, $\chi^2(1)=1.20$, $p=.273$. The three-way interaction between Role, Scenario Type and Dyad Type was then excluded. Model comparisons confirmed that including this three-way interaction, did not significantly improve model fit, $\chi^2(1)=.08$, $p=.777$. Next, the three-way interaction between Scenario Type, Dyad Type and Valence was removed. Model comparisons confirmed that

including this three-way interaction, did not significantly improve model fit, $\chi^2(1)=.33$, $p=.563$. The final three-way interaction, between Role, Dyad Type and Valence was then removed. Model comparisons confirmed that including this three-way interaction, did not significantly improve model fit, $\chi^2(1)=.63$, $p=.429$. Next, the two-way interaction between Role and Valence was excluded. Model comparisons confirmed that including this two-way interaction, did not significantly improve model fit, $\chi^2(1)=.78$, $p=.379$. Then, the two-way interaction between Role and Scenario Type was removed. Model comparisons confirmed that including this two-way interaction, did not significantly improve model fit, $\chi^2(1)=.76$, $p=.383$. Next, the two-way interaction between Role and Dyad Type was removed. Model comparisons confirmed that including this two-way interaction, did not significantly improve model fit, $\chi^2(1)=2.56$, $p=.110$. Following this, the two-way interaction between Scenario Type and Valence was removed. Model comparisons confirmed that including this two-way interaction, did not significantly improve model fit, $\chi^2(1)=1.83$, $p=.176$. Then, the two-way interaction between Scenario Type and Dyad Type was removed. Model comparisons confirmed that including this two-way interaction, did not significantly improve model fit, $\chi^2(1)=.67$, $p=.412$. Finally, the only remaining two-way interaction, between Dyad Type and Valence was removed. Model comparisons confirmed that including this two-way interaction, did not significantly improve model fit, $\chi^2(1)=2.18$, $p=.140$.

2. Material for Study Three

Julie was 17 when she first started her course at UWA (FS). She has two sisters who both attended UWA before her (FS). They had wished her well on her first day (FS). Arriving on campus for the first time she was amazed at the size of the place (FS). The university was established in 1911 and has the most beautiful old buildings (FS). Looking around Julie realised she was lost (FS). She was nervous as she approached a group of students to ask for directions (NE). They laughed at her as they told her she'd walked straight past the lecture theatre (NE). She was 15 minutes late when she pushed open the door (FS). The people at the back of the room looked irritated as they turned to look at her (NE). Julie was relieved when she saw her friend wave her over to a spare seat next to her (FS). After class her friend invited her to have lunch on the Oak Lawn (PE). The Oak Lawn is a meeting place for many students on campus (FS). It's right next the Student Guild Village which has a number of shops and food outlets (FS). During lunch they talked excitedly about a party they were going to that night (PE). Julie had a new dress that she wanted to wear (FS). They arrived at the party at 8pm and walked up the stone path to the front door (FS). Julie smiled when she saw a student she met in her biology class (FS). He had been really friendly, offering to share his notes with her (PE). She was excited as she walked over to say hi (PE). He looked confused as he asked 'Do I know you?' (NE) She couldn't believe that he had forgotten her (NE). Julie was certain that he could see her blushing (FS). His friends stared while she stood there awkwardly (NE). A little while later Julie was standing in the back yard (FS). She noticed how beautiful the house looked from there (PE). It was a big two-storey house (FS). There was a large decked veranda that overlooked a sparkling swimming pool (FS). Julie could hear someone singing karaoke inside the house (FS). Her friend had told her that she has a wonderful voice (PE). She decided to have a go herself (FS). After the song ended it

was Julie's turn (FS). She picked her favourite song to sing (FS). When the song started she heard the audience groan at her choice (NE). She was sure they could hear her voice quiver over the microphone (FS). The audience laughed at her when she messed up the words (NE). When the song finished she put the microphone down (FS). The audience clapped supportively for her (PE). As they left the party her friend told Julie how wonderful she looked in her new dress (PE). When she arrived home it was nearly midnight but she didn't feel tired (FS). She scooped out some ice-cream and switched on the TV (FS). There was a really old movie on (FS). She settled into the couch to watch (FS).

Note: FS = filler statement; PE = positive event; NE = negative event

3. Material for Studies Four and Five

Sarah is 18 years old./ She decided to take some time off before starting university./ Her parents were disappointed that Sarah didn't want to start uni right away. (Negative)/ Sarah's exam results were due out in a week./ She was sure she knew how she had done.

(Ambiguous)/ Her parents had made her promise to phone with the results./ They had always been supportive of her. (Positive)/ Sarah had decided to spend some time in the UK./

On the day of her trip Sarah arrived at the airport./ She was so excited. (Positive)/ Sarah boarded the plane and found her seat./ As she sat down Sarah found her seatbelt was broken. (Negative)/ She called for a flight attendant to ask to be moved to a new seat. / The flight attendant told Sarah she would check to see what seats were available./ When she returned she told Sarah that she would be moved to business class. (Positive)/ Sarah was thrilled. (Positive)/ As the plane sped down the runway Sarah noticed how jittery she felt.

(Ambiguous)/ When the seatbelt light went out Sarah unfastened her seatbelt and pushed her seat back./ The seat was so comfortable. (Positive)/ There was a young woman sitting in the seat next to Sarah./ Sarah decided to start a conversation with her./ The woman told her she was travelling for work./ As Sarah told her about her travel plans/ she could tell how interested the woman was in the conversation. (Ambiguous)/ An hour into the flight lunch was served./ There was a choice between fish and beef. / Sarah had once gotten food poisoning from bad fish, (Negative)/ so she chose the beef./ As Sarah smelled the food she realised she was hungry./ Sarah noticed that the meat had an unusual flavour. (Ambiguous)/

Sarah had a short stop-over in Dubai. / Walking down the concourse, Sarah saw a young man take an old woman's bag. (Ambiguous)/ As she walked on further, Sarah saw that one

of the stores was having a big sale. (Positive)/ She couldn't resist having a quick look./ She picked out a top to try on./ As she came out of the changerooms, Sarah overheard someone talking about how she looked. (Ambiguous)/ As Sarah left the store, / she found some money on the ground. (Positive)/ As she was putting the note in her pocket,/ Sarah heard a boarding call for her flight over the PA system./ Looking around Sarah realised she had no idea where her gate was. (Negative)/ She hurried over to an information desk to ask for directions/ and she started running toward her gate./ She got there just in time! (Positive)/ Sarah boarded the plane for the next leg of her trip./ The man in the seat next to her seemed to have a nasty cold. (Negative)/ Sarah got up from her seat/ and asked the flight attendant if she could be moved./ The flight attendant told her that she would have to stay in her allocated seat. (Negative)/ Sarah returned to her seat/ She was sure she would catch his cold. (Negative)/ During the flight Sarah got up to go to the toilet./ There was a long queue. (Negative)/ When Sarah reached the front, she was surprised by the condition of the toilet. (Ambiguous)/ She moved back to her own seat/ and reflected on her trip so far./ She had been surprised by the quality of the service on the flight. (Ambiguous)

Note: Each story event is separated by a slash. Negative: unambiguously negative story event, Positive: unambiguously positive story event, Ambiguous: ambiguous story event.