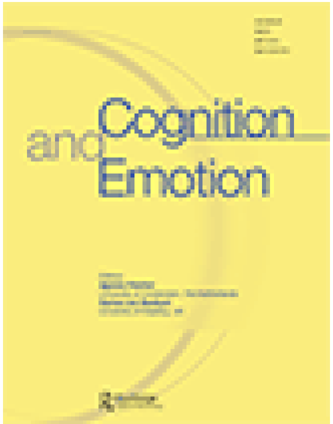

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Practice makes perfect: Training the interpretation of emotional ambiguity

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Practice makes perfect: Training the interpretation of emotional ambiguity

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The interpretation of emotionally ambiguous words, sentences, or scenarios can be altered through training procedures that are collectively called cognitive bias modification for interpretation (CBM-I). In three experiments, we systematically manipulated the nature of the training in order to discriminate between *emotional priming* and *ambiguity resolution* accounts of training effects. In Experiment 1 participants completed word fragments that were consistently related to either a negative or benign interpretation of an ambiguous sentence. In a subsequent semantic priming task they demonstrated an interpretation bias, in that they were faster to identify relatedness of targets that were associated with the training-congruent meaning of an emotionally ambiguous homograph. We then manipulated the training sentences to show that interpretation bias was eliminated when participants simply completed valenced word fragments following unrelated sentences (Experiment 2), or completed fragments that were related to emotional but unambiguous sentences (Experiment 3). Only when participants were required to actively resolve emotionally ambiguous sentences during training did changes in interpretation emerge at test. Findings suggest that CBM-I achieves its effects by altering a production rule that aids the selection of meaning from emotionally ambiguous alternatives, in line with an *ambiguity resolution* account.

Keywords: Cognitive bias modification; Interpretation; Emotional ambiguity; Interpretation bias; Emotion.

Ambiguity is a pervasive element of spoken and written language. Often information can be emotionally ambiguous, in that at least one meaning carries valence. We typically resolve such ambiguities effortlessly and without awareness. Interpretation can be guided by a number of factors including linguistic or situational context, current mood or trait factors (Eysenck, Mogg, May, Richards, & Mathews, 1991; Halberstadt, Niedenthal, & Kushner, 1995; Nygaard & Lunders, 2002). Experimental approaches show that emotional interpretation biases can be altered through training procedures—collectively called cognitive bias modification for interpretation (CBM-I)—that can shift interpretation in a positive or negative direction (Grey & Mathews, 2000;

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Mathews & Mackintosh, 2000; for reviews see Blanchette & Richards, 2010; Koster, Fox, & MacLeod, 2009; Woud & Becker, 2014). Most research on CBM-I has focused on its clinical outcomes (such as mood, emotional reactivity or emotion regulation, e.g., Beard & Amir, 2008; Mackintosh, Mathews, Yiend, Ridgeway, & Cook, 2006; Salemink, van den Hout, & Kindt, 2009) often referred to as *far-transfer* effects (Hertel & Mathews, 2011). However, less is known about *near-transfer* effects—changes in interpretive processes that can shed light on the cognitive mechanisms that subserve interpretive change. A better understanding of the mechanisms that contribute to interpretation bias and its modification will extend our theoretical knowledge about emotional interpretation more broadly, and could guide the development of better therapeutic interventions that specifically target key processes.

Studies of near-transfer effects consist of a training phase, designed to alter interpretation in a consistent direction, followed by a test phase to probe interpretation. The scenario-based training procedure, first used by Mathews and Mackintosh (2000), leads participants to create emotionally consistent interpretations by generating a solution to a disambiguating word fragment at the end of a sentence. For example, a participant might read the following scenario: *Your partner asks you to go to an anniversary dinner that their company is holding. You have not met any of their work colleagues before. Getting ready to go, you think that the new people you will meet will find you b_r_ng/fri_ndl_ [boring/friendly].* Following this a block of critical sentences are presented that remain ambiguous even after the word fragment has been solved (e.g., *Your friend asks you to give a speech at her wedding reception. You prepare some remarks and when the time comes, get to your feet. As you speak, you notice some people in the audience start to l__gh [laugh]*). In a later test phase, participants are presented with the titles of the scenarios and must rate test sentences on their similarity to their memory of that scenario. Options reflect possible negative or positive (or benign[1]) interpretations of the previous scenarios and negative or benign foils, and participants must indicate how similar in meaning each sentence is to the meaning of the original. Interpretation bias is inferred if participants are more likely to endorse the test sentences that are related to critical scenarios in a training-congruent way.

Scenario-based training procedures reliably induce interpretation biases (Hallion & Ruscio, 2011). However, this paradigm does not allow us to identify the critical aspects of training that engender interpretation change. Two potential (and not mutually exclusive) mechanisms are emotional priming and training of ambiguity resolution processes. According to an *emotional priming* account, repeated activation of a particular valence during training broadly facilitates similar responses to ambiguous information (Grey & Mathews, 2000), through a process akin to spreading activation. Alternatively, according to an *ambiguity resolution* account, training induces the use of an implicit production rule that shifts selection towards emotionally congruent meanings (Clarke et al., 2014; Mathews, 2012). In a scenario-based CBM-I training task, participants read semantically and affectively rich sentences, they resolve emotional ambiguity, and they generate valenced words to complete the fragments. They therefore generate and select emotional meanings at a number of levels. Interpretation biases induced by such tasks could be consistent with either *emotional priming* or *ambiguity resolution* accounts.

One way to distinguish between these two alternatives is to systematically manipulate the extent to which training requires the active resolution of ambiguity. If an interpretation bias arises through the activation of emotional information, then it should be observed whenever training requires the generation of emotional meanings, regardless of whether those meanings are ambiguous or not. However, if an interpretation bias reflects training of a selection process,

[1] Some studies compare negative to positive training, but more commonly positive and neutral scenarios are combined and categorised as benign.

then it should only be observed when training requires the active selection of a valenced meaning amongst alternatives. If training arises through both mechanisms, then removing the need for ambiguity resolution from the training procedure should attenuate, but not eliminate training effects. Clarke and colleagues (2014) used this approach with a modified scenario-based training procedure that emphasised the use of imagery during training (Holmes, Mathews, Dalgleish, & Mackintosh, 2006). Participants were randomly assigned to either an *ambiguity present* or *ambiguity absent* training condition. In the *ambiguity present* condition, they heard and imagined themselves in scenarios that remained emotionally ambiguous until they were resolved, in either a negative or benign direction, upon the presentation of the final word(s). In the *ambiguity absent* condition participants heard and imagined either negative or benign scenarios that contained no emotional ambiguity; that is, each scenario had its valence established in the first few words. In both conditions, 10 critical scenarios were included that remained ambiguous (e.g., *You are trying out some new recipes you found and begin preparing a dish to serve your family that night when your partner comes in and makes a comment about the smell*). In the later test phase, participants rated the similarity of negative and benign interpretations of the previous ambiguous scenarios (cf. Mathews & Mackintosh, 2000). Consistent with the *ambiguity resolution* account, training-congruent interpretation biases only emerged when participants resolved emotional ambiguity and not when they simply heard and imagined unambiguous emotional scenarios. Therefore, activation, *and* later selection from competing alternatives during training seem to be necessary conditions for an interpretation bias to emerge on a near-transfer task.

However, evidence for an *emotional priming* account has been observed in experiments using different training and test paradigms. Researchers using these paradigms (e.g., Hoppitt, Mathews, Yiend, & Mackintosh, 2010a) distinguish between *active training* (which requires the resolution of ambiguity) and *passive training* (which does not). Grey and Mathews (2000; Experiment 3) used a homograph relatedness judgement in training, and a semantic priming task at test. In a typical active homograph training paradigm, participants first see an ambiguous homograph (e.g., *drop*) followed by a word (or fragment) related to either its negative or benign meaning (e.g., *break* or *water*). Responses at test (relatedness judgement or fragment completion) are facilitated if participants access the training-congruent meaning of the homograph. To test the effects of passive training, Grey and Mathews flipped the order of presentation of the words, arguing that the reverse order (*water-drop*) did not require participants to select between competing meanings of the homograph. To test near-transfer effects, participants then completed a primed lexical decision task in which they saw a new homograph (as a prime) followed by a target related to its negative or benign meaning. Consistent with an *emotional priming* account, Grey and Mathews found that the reversed order training paradigm produced similar levels of interpretation bias to the traditional training method.

Similar conclusions can be drawn from a study by Hoppitt and colleagues (2010a). In an active training condition participants saw a homograph (e.g., *growth*) followed by a fragment to be completed, that was related to either its negative (*cancer*) or benign (*height*) meaning. In a passive training condition, participants saw only an unambiguous prime (e.g., *tumour*) and then completed the same fragment (e.g., *cancer*). The test phase was the same primed lexical decision task as used by Grey and Mathews (2000). They found that both training conditions induced similar interpretive biases, consistent with an *emotional priming* account.

Mathews (2012) suggested that the inconsistency in findings of emotional priming effects might arise because the semantic priming task provides a more sensitive measure of online interpretive processing than the similarity judgement that is traditionally used with scenario-based training (e.g., Clarke et al., 2014; Hirsch & Clark, 2004; Mathews & Mackintosh, 2000). Consider the differences between tasks. In the traditional scenario-based paradigm participants are asked at test which of several possible sentences is most similar to a scenario they read or heard several minutes previously. It does not assess a participant's immediate interpretation of the ambiguous scenario, but rather their memory of that interpretation. Performance therefore reflects the sum of interpretive processes that might have acted during encoding of the scenario, but also during subsequent storage, and eventual retrieval. Performance may also reflect biases in decision processes that guide selection of the most familiar option, or demand characteristics if participants become aware of their training condition (Lawson & MacLeod, 1999; Salemink, van den Hout, & Kindt, 2007a). Given that emotional biases are also evident in memory and decision processes (Blanchette & Richards, 2010; Mathews, 2012; Salemink, Hertel, & Mackintosh, 2010; Tran, Hertel, & Joormann, 2011) the similarity judgement at test may not be an ideal measure of interpretation per se.

Interpretation processes that are affected by training, such as meaning activation and selection, might be better captured by tasks that reflect an "online" judgement of meaning such as a semantic priming task (e.g., Grey & Mathews, 2000, 2009; Hoppitt et al., 2010a). Research on ambiguity resolution in non-emotional contexts has established that upon the initial presentation of an ambiguous prime, all its meanings are activated, although possibly in a graded fashion, with dominant meanings being more strongly activated than subordinate meanings. However, over time, context and meaning frequency interact to guide the selection of an appropriate meaning (e.g., Simpson & Burgess, 1985; Swinney, 1979; Tanenhaus, Leiman, & Seidenberg, 1979). These stages can be accessed by manipulating the time between the prime and target (stimulus onset asynchrony; SOA). At short SOAs of less than 250 ms, all meanings may be accessed. However, at longer SOAs of greater than 700 ms, appropriate meanings are selected and alternative meanings are suppressed. Semantic priming tasks in interpretation bias experiments typically use a longer SOA, and therefore tap the activation *and* selection of emotional meaning as it unfolds. Because semantic priming tasks capture interpretation "as it happens", they may be sensitive enough to capture *emotional priming* effects.

The overarching aim of our experiments was to distinguish between *emotional priming* and *ambiguity resolution* accounts of CBM-I, by determining the role of ambiguity resolution in changing the online interpretation of emotional meaning. We used a variant of the scenario-based training task in which participants read emotionally ambiguous sentences paired with a word fragment to be completed. The word fragment was consistently related to either the negative or benign meaning of the sentence. Our training differed slightly from the traditional scenario-based procedure in that the word fragment was not the last word of the sentence, but was an associate of either the negative or benign interpretation. This means that all of the training sentences themselves remained ambiguous, but we hypothesised that the consistently valenced fragments would induce training congruent biases in interpretation. In the testing phase, participants completed a semantic priming task to assess online interpretation of emotionally ambiguous words. We used a relatedness judgement (as opposed to the more common lexical decision) in the priming task at test because we wanted to force selection of meaning for the homograph prime and so directly engage interpretive processes (Balota & Paul, 1996). In Experiment 1 we established that the training paradigm produced the expected interpretive bias. In Experiments 2 and 3 we manipulated the training phase to determine the critical role of ambiguity in training.

EXPERIMENT 1

The purpose of Experiment 1 was to ensure that our scenario-based training produced the expected interpretation bias on the semantic priming task. During training, participants read ambiguous sentences (e.g., *The dog is running towards you.*) and then completed related word fragments that were either consistently negative (e.g., *a_ta_k [attack]*) or benign (e.g., *pl_y [play]*). In the test phase, they judged the relatedness of word pairs that consisted of an ambiguous prime (e.g., *terminal*) followed by a target that was related to either the prime's negative (e.g., *cancer*) or benign (e.g., *airport*) meaning. The relatively long SOA (750 ms) allowed time for both activation and selection of the meaning of the prime before the onset of the target (e.g., Neely, 1977; Swinney, 1979).

METHOD

Participants

Seventy-one undergraduate students (29 men, 42 women; mean age: 19.25 years) participated for course credit. All were native English speakers with normal or corrected-to-normal vision. Participants reported no current or previous diagnoses of depression. The study was approved by the Human Ethics Committee, Victoria University of Wellington. All participants gave written informed consent prior to participation.

Stimuli and apparatus

We conducted a series of pilot experiments to develop and select the materials for the training phase (sentences and word fragment) and the test phase (homograph primes and associated targets).

Sentences

Seventy-nine emotionally ambiguous, self-referential sentences were constructed that had one negative and one benign interpretation. The sentences were adapted from Mathews and Mackintosh (2000) and Mogg, Bradbury, and Bradley (2006), with additional sentences generated by our research team. Nine pilot participants reported the first three words that came to mind after reading each sentence. Sentences that consistently produced (over 65% of the time) a negative or benign associate as the first response were eliminated. This left 45 sentences for which pilot participants spontaneously generated both negative and benign associates.

Word fragments

One negative and one benign associate were selected from the most commonly produced responses during piloting. Independent samples *t*-tests confirmed that negative and benign associates did not differ in length, frequency, orthographic neighbourhood size or orthographic frequency (Medler & Binder, 2005; Wilson, 1988). Valence information was collected from a large corpus of affective norms (Warriner, Kuperman, & Brysbaert, 2013) and independent samples *t*-tests confirmed that words used as fragments in the negative training phase were significantly more negative (M = 2.87, SD = 0.86) than benign fragments (M = 6.61, SD = 0.187), $t(86) = 16.37$, $p < .001$. Fragments were constructed primarily by removing a consonant and a vowel from each word, with some variations for short words. Further pilot testing with 17 people ensured that negative and benign fragments were equally difficult to complete. Pilot participants saw each training sentence once; half the sentences were paired with their negative word fragment and half with their benign word fragment. Participants pressed the space bar to indicate that they had solved the word fragment and then entered their response. Ease of completion was operationalized as the time taken to press the space bar after the onset of the word fragment for correct solutions. Independent samples *t*-tests confirmed that there were no significant differences in time taken $t(88) = 1.36$, $p = .18$ or accuracy $t(88) = 0.84$, $p = .48$ in solving negative or benign word fragments.

Homograph primes

Emotionally ambiguous primes were chosen from 143 homographs with one negative and one benign meaning, collected from a number of sources (Gawlick-Grendell & Woltz, 1994; Gee & Harris, 2010; Gorfein, Viviani, & Leddo, 1982; Twilley, Dixon, Taylor, & Clark, 1994). Norms were consulted to eliminate homographs that were strongly biased to either the negative or benign meaning, or that had more than two common meanings. This process led to a final set of 52 emotionally ambiguous homograph primes.

Associated targets

One benign and one negative related target were chosen for each prime from the University of South Florida Free Association Norms (Nelson, McEvoy, Walling, & Wheeler, 1980). Five pilot participants generated associates to each ambiguous prime to ensure that they were similarly ambiguous for native speakers of modern New Zealand English. Independent samples *t*-tests confirmed that negative and benign targets did not differ in length $t(88) = 0.05$, $p = .96$ or word frequency $t(88) = 1.18$, $p = .24$. Valence ratings were obtained from the affective norms database for each target (Warriner et al., 2013). Note that target words did not necessarily need to be valenced themselves to be related to the valenced meaning of an ambiguous word (e.g., *fall—over*), however, independent *t*-tests confirmed that negative targets were rated as significantly more negative ($M = 3.48$, SD = 1.18) than benign targets ($M = 6.39$, SD = .98) $t(102) = 13.63$, $p < .001$. Each ambiguous prime was paired with two related and two unrelated targets. The related targets were the associates of the negative and benign meanings. Unrelated targets were one negative and one benign low frequency word chosen from the affective norms for English words database (Bradley & Lang, 1999). Prime-target pairs were then assigned to two lists for the purposes of counterbalancing stimulus presentation. Each prime appeared twice on each list, once with a related target and once with an unrelated target of the opposite valence.

Participants were seated at a viewing distance of approximately 60 cm. Stimuli were presented using a Dell PC computer with a 23-inch Alienware 2310 monitor, running Psychology Software Tools' E-Prime Suite version 2.0 (Schneider, Eschman, & Zuccolotto, 2002). They appeared centrally in Calibri size 18 font, in lower case black letters on a white background.

Procedure

Participants were randomly assigned to receive either negative or benign training. Participants first completed a training phase, during which they read ambiguous sentences and completed word fragments that were consistently associated with either a negative or benign interpretation of the sentence. They then proceeded directly to a test phase, in which they judged the relationship between homograph primes and targets related to either its negative or benign interpretation. Training commenced with a centrally presented sentence. (e.g., *The boss wants to see you.*) After reading the sentence, participants pressed the space bar to bring up a word fragment to be solved (e.g., *f_red [fired]* or *pr_mote*d [*promoted]*). When participants had solved the word fragment they pressed the space bar and then typed the answer in full. Participants were not explicitly told that the sentences and word fragments were related. However, they completed three practice trials before completing 45 training sentences in which unambiguous emotional sentences were related to valenced fragments. The practice trials therefore made the relationship between the sentences and fragments salient. During the test phase, all participants completed the same semantic priming task to assess the presence of an induced interpretation bias. An ambiguous homograph prime was presented centrally on the screen (e.g., *shoot*) for 250 ms followed by a target that was either related (e.g., *gun* or *bamboo*) or unrelated (e.g., *lonely* or *canoe*) to the negative or benign meaning of the prime. The time between the onset of the prime and the onset of the target (SOA) was 750 ms. Participants indicated whether the target was related or unrelated to the prime by pressing the 1 or 2 key on the number pad of the keyboard. Participants responded to 104 trials presented in random order; 52 targets were unrelated to the primes and 52 targets were related (26 negative targets and 26 benign targets in each relatedness condition). The target remained on-screen until response, and was followed by an inter-trial interval of 1000 ms.

Data analysis

Analyses focused on the performance on the semantic priming task in the test phase as a function of training valence. Performance was transformed into a sensitivity (*d'*) measure to indicate participants' ability to discriminate between related and unrelated word pairs. Those with *d'* values less than 1.0 in any condition were excluded. The primary dependent variables were mean response times and accuracy on related trials. Semantic priming studies using a lexical decision task often calculate a priming measure (the response time advantage for related over unrelated trials), however, such a measure is inappropriate to use with a relatedness task, because the related judgement "yes" differs in many ways from the unrelated judgement "no". Training condition (negative or benign) was a between-subjects variable, and target valence (negative or benign) was a within-subjects variable. Interpretation bias is indicated by an interaction between training condition and target valence in which biased interpretations are shifted towards the training valence.

RESULTS AND DISCUSSION

Five participants were removed from the analysis based on the performance criterion. There were 33 participants remaining in each training condition. The mean time taken to correctly complete word fragments during the training phase was 2661 ms and the overall accuracy was 94%. Mean response times (ms) and accuracies across conditions are presented in Table 1.

Response times

Response times (RTs) to related targets were analysed in a 2 (training: negative vs. benign) × 2 (target valence: negative vs. benign) mixed analysis of variance (ANOVA) with training as a between-subject variable and target valence as a within-subject variable. A significant training by target valence interaction was observed $F(1, 64) = 6.79$, $p = .01$, $\eta_p^2 = .09$ (see Figure 1). Paired-

Table 1. *Mean response times and accuracy for relatedness judgements as function of training for all experiments*

	Training condition	Related target valence		Unrelated target valence		Related target valence		Unrelated target valence	
		Negative	*Benign*	*Negative*	*Benign*	*Negative*	*Benign*	*Negative*	*Benign*
		Response times (ms)				*Accuracy*			
Experiment 1	Negative	919 (180)	961 (150)	1117 (268)	990 (322)	0.83 (0.12)	0.84 (0.11)	0.84 (0.18)	0.90 (0.12)
	Benign	943 (199)	902 (174)	1021 (240)	933 (230)	0.78 (0.14)	0.82 (0.11)	0.88 (0.11)	0.93 (0.09)
Experiment 2	Negative	947 (204)	911 (150)	1057 (297)	996 (261)	0.78 (0.10)	0.81 (0.09)	0.90 (0.10)	0.95 (0.05)
	Benign	904 (168)	879 (152)	1010 (269)	968 (301)	0.79 (0.11)	0.80 (0.08)	0.90 (0.08)	0.95 (0.06)
Experiment 3	Negative	940 (196)	932 (146)	1101 (249)	1069 (262)	0.79 (0.11)	0.78 (0.09)	0.88 (0.11)	0.96 (0.03)
	Benign	912 (166)	889 (136)	1057 (161)	1002 (194)	0.80 (0.10)	0.83 (0.10)	0.87 (0.12)	0.93 (0.07)

Note: Standard deviations in parentheses.

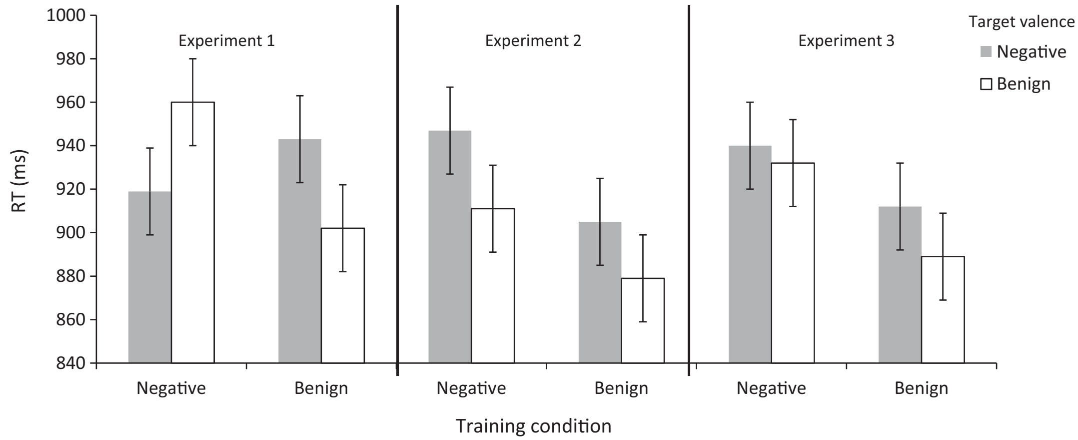

Figure 1. Response times (ms) for relatedness judgements as a function of training, across Experiments 1–3. Error bars are standard errors of the difference between negative and benign targets.

samples *t*-tests revealed that participants in the negative training condition were significantly faster to judge negative associates of ambiguous primes as related than benign associates, $t(33)$ = 2.06, p = .04, d = 0.25. Participants in the benign training condition showed a trend in the opposite direction; they were marginally faster to judge benign associates as related than negative associates $t(33)$ = –1.67, p = .10 d = –0.22. This training × target valence interaction indicates successful induction of an interpretation bias.

Accuracy

Accuracy was calculated as the proportion of correct responses made to negative and benign related targets. Accuracy was analysed similarly to RT in a 2 (training: negative vs. benign) × 2 (target valence: negative vs. benign) mixed ANOVA. The training × target valence interaction was not significant, $F(1, 64)$ = 2.59, p = .11, η_p^2 = .04, however, the pattern of results mirrored that in the RT analyses (see Table 1). A main effect of target valence approached significance, in that participants were more accurate in identifying relationships between primes and benign, as opposed to negative, targets, $F(1, 64)$ = 3.03, p = .08, η_p^2 = .04.

Experiment 1 shows that our scenario-based training task induced an interpretive bias as indicated by a semantic priming task. Our training procedure differed slightly from the traditional scenario-based training paradigm, in which the word fragment is typically the last word of the sentence or scenario and so ultimately constrains the emotional interpretation of the sentence. In our paradigm, the sentence itself remained ambiguous, but the fragment was consistently related to either its negative or benign interpretation. Despite our procedural differences, training produced a typical interpretation bias, as indicated by the training × target valence interaction. Moreover, the effect size for the critical interaction (η_p^2 = .09) was similar to that reported in other studies that use semantic priming tasks to assess interpretation (e.g., Hoppitt et al., 2010a, η_p^2 = .12).

Although the interpretation bias might have been induced by active interpretation of the ambiguous sentences (consistent with an *ambiguity resolution* account) it might alternatively have been induced by generation of the word fragments, which were themselves more negative in the negative training condition. In Experiment 2, we removed the relationship between the scenarios and the word fragments to determine whether the generation of negative or benign words was itself sufficient to induce biases at test. If the simple generation of negative or benign words via the fragment completion task is sufficient to induce a bias (as would be predicted by an *emotional priming* account) then we expect to observe induced biases similar to those observed in previous CBM-I research and in Experiment 1. However, if consistently activating negative or benign meanings is not sufficient to induce an interpretation bias then participants should not demonstrate the training × target valence interaction.

EXPERIMENT 2

The goal of Experiment 2 was to determine whether the valenced word fragment completion on its own could have altered interpretation. To maintain the same structure in the training phase, we replaced all the training sentences with filler sentences that were unambiguous, unemotional and unrelated to the word fragment. The word fragments themselves remained the same as those used in Experiment 1. Therefore, the only source of emotionality was the word fragment itself, and the opportunities for ambiguity resolution were eliminated. The test phase remained identical to that in Experiment 1.

METHOD

Participants

Seventy-four undergraduate students (20 men, 54 women; mean age: 21.4 years) participated for course credit. All were native English speakers with normal or corrected-to-normal vision. Participants also reported no current or previous diagnoses of depression. They were randomly assigned to receive either negative or benign training. The study was approved by the Human Ethics Committee, Victoria University of Wellington. All participants gave written informed consent prior to participation.

Design and materials

The training sentences were rewritten so that they were no longer related to the negative and benign word fragments. The sentences remained self-referential but were neutral in valence. As the training sentences were no longer related to the fragments, and therefore did not facilitate fragment completion, some fragments were slightly altered by removing different letters after piloting in order to equate them for difficulty.

Procedure

The procedure, design and analyses were identical to that of Experiment 1.

RESULTS AND DISCUSSION

Accuracy and mean RTs are reported in Table 1. The mean time taken to correctly complete word fragments in the training phase was 2547 ms and the overall accuracy was 96.3%. Four participants were excluded for failing to meet the performance criterion. Analyses were conducted on the remaining 70 participants; 34 in the negative training condition and 36 in the benign training condition.

Response times

RTs to related targets were analysed in a 2 (training: negative vs. benign) × 2 (target valence: negative vs. benign) mixed ANOVA with training as a between-subject variable and valence as a within-subject variable. Importantly the interaction did not approach significance, $F(1, 68) = .12$, $p = .74$, $\eta_p^2 = .01$, indicating that the completion of valenced fragments did not induce an interpretation bias. A marginal effect of target valence was found whereby participants were faster to identify benign associates of ambiguous primes as related than negative associates, $F(1, 68) = 3.86$, $p = .05$, $\eta_p^2 = .05$. No other significant effects were observed.

Accuracy

Accuracy was analysed in a 2 (training: negative vs. benign) × 2 (target valence: negative vs. benign) mixed ANOVA. No significant effects were observed.

Experiment 2 showed that the generation of valenced meaning through the solving of word fragments was not sufficient to induce an interpretation bias. This finding is inconsistent with a *emotional priming* account of interpretation bias, and rules out the generation of valenced fragments as the source of interpretation bias in Experiment 1. Fragment completion is commonly used in both scenario-based and homograph training paradigms (e.g., Clarke et al., 2014; Grey & Mathews, 2000; Hoppitt et al., 2010a) yet, to our knowledge, ours is the first study to explicitly test the role of valenced fragment completion on interpretation bias.

However, it is still possible that in Experiment 1, it was the comprehension of a valenced scenario (instead of the ambiguity), in combination with the word fragment completion task, that activated a semantically rich valenced context which could induce an interpretation bias through an *emotional priming* mechanism. In order to differentiate between *emotional priming* and *ambiguity resolution* accounts, in Experiment 3 we rewrote the training sentences from Experiment 1 so that they were no longer ambiguous but were explicitly negative or benign in valence and still related to the fragment. This allowed us to determine whether reading semantically rich and explicitly valenced scenarios was sufficient to induce a bias or whether resolution of ambiguity, as in Experiment 1, was a critical factor for inducing an interpretation bias.

EXPERIMENT 3

The sentences from Experiment 1 were reconstructed as unambiguously negative and benign statements. If, as predicted by an *emotional priming* account, repeated activation of an emotional category can account for the changes following training, then we expect to still see the training by target valence interaction that shows facilitation of training-congruent meanings at test.

METHOD

Participants

Seventy-four undergraduate students (all women; mean age: 18.60 years) participated for course credit. All had normal or corrected-to-normal vision and English was their native language. Participants also reported no current or previous diagnoses of depression. They were randomly assigned to receive either negative or benign training. The study was approved by the Human Ethics Committee, Victoria University of Wellington. All participants gave written informed consent prior to participation.

Materials

An unambiguous negative sentence and an unambiguous benign sentence were constructed from each original ambiguous sentence used in Experiment 1. For example, the ambiguous scenario, *You hear your friends discuss a party you were unaware of* (word fragment: *excluded/invited*) became either *Nobody told you to come to the party* (word fragment: *excluded*) or *Everybody told you to come to the party* (word fragment: *invited*), depending on the training condition. Otherwise all materials were the same as those in Experiment 1.

Procedure

The procedure, design and analyses were identical to that of Experiment 1.

RESULTS AND DISCUSSION

Accuracy and mean RTs are reported in Table 1. The mean time taken to correctly complete word fragments in the training phase was 2484 ms and the mean overall accuracy was 95%. Three participants were excluded from analysis based on the performance criterion. Analyses were conducted on data from the remaining 71 participants; 34 in the negative training condition and 37 in the benign training condition.

Response times

RTs to related targets were analysed in a 2 (training: negative vs. benign) × 2 (target valence: negative vs. benign) mixed ANOVA. No significant effects were observed. Notably, the interaction between training and target valence did not approach significance $F(1, 69) = .22$, $p = .64$, $\eta_p^2 = .01$, indicating that valenced, but unambiguous, scenarios did not induce an interpretation bias.

Accuracy

Accuracy was similarly analysed in a 2 (training: negative vs. benign) × 2 (target valence: negative vs. benign) mixed ANOVA. No significant effects were observed.

Experiment 3 showed that the repeated activation of negative meanings (via reading semantically rich scenarios) coupled with the selection of a valenced meaning (through the completion of word fragments) was not sufficient to induce an interpretation bias. As in Experiment 2, this finding is inconsistent with an *emotional priming* account of induced interpretation bias. This experiment closely parallels the structure of the *ambiguity absent* condition in the scenario-based training used by Clarke and colleagues (2014) and our similar finding replicates and extends their work to show that unambiguous (but semantically and affectively rich) training does not induce a bias, even when interpretation is probed with a semantic priming task.

We note that all participants in Experiment 3 were women as opposed to a majority of women in the first two experiments. Those experiments were not designed to assess sex differences, and the sex ratio mirrored that in our undergraduate participant pool. Sex differences have not previously been reported in CBM-I studies, although most studies include a majority of female participants and results are rarely reported or analysed by sex. In the absence of any systematic study of sex differences in the CBM-I literature, it is possible that results here may not generalise to men.

GENERAL DISCUSSION

In this series of experiments we demonstrate that the resolution of ambiguity in sentence-based training is necessary to induce an interpretation bias. Induced bias was evident in Experiment 1 when training involved ambiguous sentences, but was eliminated in Experiments 2 and 3. Experiment 2 showed that the repeated generation of valenced words (via fragment completion) was not sufficient to induce an interpretation bias and Experiment 3 showed that exposure to valenced sentences was not sufficient either. These results argue against an *emotional priming* account for near-transfer effects following training, and provide further support for the *ambiguity resolution* account of CBM-I, which proposes that repeated training in the resolution of emotional ambiguity results in the induction of an implicit production rule. Following training, participants continue to apply this rule when encountering novel emotionally ambiguous words.

The interpretation bias that was produced in Experiment 1 is consistent with the findings from other scenario-based CBM-I studies (e.g., Clarke et al., 2014; Mathews & Mackintosh, 2000), even though we used a slightly modified training procedure. Other studies tested interpretation with a recognition memory task that can be influenced by post-lexical processes in memory and decision-making (Salemink et al., 2007a, 2010; Tran et al., 2011). Here we see that similar biases can be observed in a semantic priming task that captures the initial interpretation of ambiguous words, and discounts memory and demand explanations for the effect. Further evidence against demand effects is demonstrated by the results of Experiment 3 which could be considered the most explicit valence manipulation. If demand effects (such as participants' explicit understanding of the training manipulation) were responsible for the observed biases at test in Experiment 1, then we would expect to see an even stronger interpretation bias following the explicitly emotional training in Experiment 3.

The interpretation bias was eliminated in Experiments 2 and 3 when ambiguity was removed from the training phase. This finding replicates that reported by Clarke and colleagues (2014) who found that ambiguity during scenario based-training was necessary to produce an interpretation bias on a similarity judgement at test. We extend their finding by showing that ambiguity is similarly necessary even when interpretation is tested with a semantic priming task that is likely to be sensitive to emotional priming.

However, our results are at odds with other studies that have used semantic priming tasks at test and found results that are consistent with an *emotional priming* account. Why might these studies have observed emotional priming when we didn't here? The answer may lie in task demands. Both studies that report emotional priming effects (Grey & Mathews, 2000; Hoppitt et al., 2010a) used the presentation of word pairs during both training and test. In Grey and Mathews (2000) participants explicitly judged the relationship between two words during training, and in Hoppitt et al. (2010a) they were instructed to use the prime to help them solve the following word fragments. Both studies then used the same primed lexical decision task at test, in which novel homographs primed lexical decisions related to training-congruent meanings, regardless of whether ambiguity was present during training or not. We see two possible explanations for the discrepancy between their findings and ours.

First, both experiments that have shown emotional priming effects involved a high degree of procedural overlap between training and test which could encourage the continuation of specific cognitive processes or strategies across phases, in line with a transfer-appropriate processing explanation (Hertel & Mathews, 2011; Mathews, 2012). Training tasks in both studies required the generation of associations between valenced words (with or without the need for ambiguity resolution) which may have led to similar emotional activation in the structurally similar test phase. On the other hand, our use of procedurally distinct training and test phases may have eliminated this possible transfer and required the recruitment of alternate cognitive strategies such as the implicit production rule involved in selecting a specific meaning from valenced alternatives. The use of alternative testing procedures with even less procedural overlap (e.g., Salemink, van den Hout, & Kindt, 2007b) could further our understanding of the importance of procedural overlap for the production of ambiguity resolution vs. emotional priming effects.

A second possible explanation for our conflicting results is that we used a relatedness judgement in the test phase, whereas Hoppitt and colleagues (2010a) and Grey and Mathews (2000) used a primed lexical decision task. Lexical decisions are proposed to draw heavily on orthographic and phonological information and are therefore likely to reflect an early stage of lexical access which could be modulated by emotional priming. In contrast, a relatedness decision draws heavily on semantic information, and is therefore likely to reflect the later selection stage of processing (Balota & Paul, 1996; Hino, Lupker, & Pexman, 2002). We chose to use a relatedness decision at test to tap into online interpretation processes directly. Further experiments will be necessary to determine whether lexical decision and relatedness tasks are differentially sensitive to emotional priming.

Evidence is accumulating that interpretation bias, for the most part, reflects an alteration in the selection processes that we use to assign meaning in ambiguous situations. Emotional priming effects, to the extent that they are observed at all, appear to be subject to very specific procedural constraints. They may also be very short-lived. We have focused here on near-transfer effects in an effort to delineate the mechanisms by which training alters interpretation. However, even in situations where emotional priming might be observed, ambiguity resolution during training still appears to be necessary for the creation of far-transfer effects, as assessed by emotional response or vulnerability to emotional challenge (Hertel & Mathews, 2011). For example, even though Hoppitt and colleagues (2010a) observed effects of passive training on primed lexical decision (a near-transfer task), only active training affected anxiety when participants later viewed a video of a car accident (a far-transfer task). Similar effects of active training on far-transfer are reported by Hoppitt, Mathews, Yiend, and Mackintosh (2010b) who found that active training in a traditional scenario-based paradigm was necessary to alter emotionality of mental images generated in response to ambiguous sentence. Thus while emotional priming may be an occasional side-effect of training, it cannot be the primary mechanism that produces either near- or far-transfer effects. A limitation of this study is that we did not include an emotional reactivity manipulation or mood measure; an important extension of our work will be to further clarify the relationship between the near-transfer effects we report here and far-transfer effects seen in other studies. In future research it will be valuable to include both near-transfer and far-transfer tasks in the same study, which will make it possible to test whether far-transfer tasks are mediated by near-transfer alterations in interpretation (e.g., Salemink et al., 2007a).

The conclusion that CBM-I training procedures alter production rules that are used to select meaning in ambiguous situations is far from an explanation of the mechanisms by which that selection takes place. We know very little about the mechanisms that we use to select meaning, especially in complex emotion-laden situations that are typically assessed with far-transfer tasks and that are the primary interest of those who are concerned with clinical applications of CBM-I (e.g., Beadel, Smyth, & Teachman, 2014; MacLeod, Koster, & Fox, 2009). We have a better understanding of the mechanisms of meaning selection on language tasks, because ambiguity resolution has been a focus of psycholinguistic research for decades (e.g., Gorfein, Brown, & DeBiasi, 2007; Simpson & Burgess, 1985; Swinney, 1979). We therefore think there is potential benefit in continuing to examine the effects of training on near-transfer linguistic tasks (such as semantic priming) to better elucidate the selection mechanisms at play. Ambiguity resolution in language has also been a focus in neuroimaging and electrophysiological research (e.g., Ihara, Hayakawa, Wei, Munestsuna, & Fujimaki, 2007; Swaab, Brown, & Hagoort, 2003), which could provide a further avenue for exploration of the neural mechanisms that subserve interpretation change. A better understanding of how training alters ambiguity resolution in linguistic contexts might then inform hypotheses regarding the mechanisms we use to select interpretations in the more complex emotional situations that are abundant in all our lives.

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