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Differential impact of beliefs on valence and arousal

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Many cognitive accounts of emotional processing assume that emotions have representational content that can be influenced by beliefs and desires. It is generally thought that emotions also have non-cognitive, affective components, including valence and arousal. To clarify the impact of cognition on these affective components we asked participants to rate sentences along cognitive and affective dimensions. For the former case, participants rated the believability of the material. For the latter case, they provided valence and arousal ratings. Across two experiments, we show that valence and arousal are differently influenced by beliefs, suggesting that these two largely independent affective components of emotion differ in their cognitive penetrability. While both components depended upon overall comprehension of sentence meaning, only valence was influenced by the consistency of the sentences with participants' beliefs (i.e., whether it was believable or unbelievable). We discuss the implications of these findings for understanding cognition–emotion relationships.

Keywords: Valence; Arousal; Belief; Cognition; Affect; Emotion.

It is widely accepted that valence and arousal are two core affective dimensions of emotion. Empirical findings indicate that the two are largely independent of each other and are associated with different aspects of our emotional experiences (Barrett & Russell, 1998, 1999; Lang, Greenwald, Bradley, & Hamm, 1993; Russell, 1980). This two-dimensional structure is commonly used as a tool for categorising the affective quality of emotion. Cognitive accounts view emotions as containing representational, intentional content, alongside their non-cognitive, affective components. However, relatively little is known about how the affective components may be influenced by cognitive processes. Such knowledge would add to our understanding of the role cognition plays in emotion.

Valence relates to the pleasantness (or unpleasantness) of an object or experience. Emotions associated with pleasantness are commonly linked to approach responses, while emotions associated with unpleasantness are linked to avoidance responses. As such valence likely contains some understanding of the object's potential impact on

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our (or another's) wellbeing—i.e., it may be directed/referential. Arousal, on the other hand, involves an attention orienting response, which affects our physiological state and action readiness, but which is generally thought to be undirected/non-referential. Lang et al. (1993) showed that valence and arousal can be dissociated on the basis of their associated visceral responses and facial expressions. The two dimensions have also been found to rely on at least partly dissociable neurophysiological mechanisms (Adolphs, Russell, & Tranel, 1999; Anderson et al., 2003; Bayer, Sommer, & Schacht, 2010; Gianotti et al., 2008; Lewis, Critchley, Rotshtein, & Dolan, 2007; Small et al., 2003).

These data point to how valence and arousal may differ at a processing level. More specifically, studies have found that arousal-related responses are unaffected by diverted attention and do not rely on conscious awareness or evaluation of the stimulus, whereas valence responses are controlled and dependent on attentional resources (Cunningham, Raye, & Johnson, 2004; Kensinger & Corkin, 2004). From this, arousal may be considered as occurring at a more stimulus-driven level, depending directly on our perception of the state of the world. Valence, on the other hand, may require intermediary internal computations that are more likely to be influenced by our beliefs and desires. However, the basic cognitive processes that underlie, influence, and differentiate valence and arousal are largely unknown.

Understanding the extent to which cognitive processing is necessary for each of these core affective dimensions of emotion may be an important step forward in the study of emotion and cognition. One way of assessing the level of cognitive involvement in a process is by testing the extent to which it is "cognitively penetrable". According to Pylyshyn (1986), a process is cognitively penetrable if it can be influenced by our beliefs or goals, while a cognitively impenetrable process is one that is completely resistant to such mediating processes. Moreover, a cognitively impenetrable process is assumed to be attributable solely to the functional architecture of the system, meaning that it can be considered primitive and non-representational. On the other hand, a process cannot be solely determined by the functional architecture of a system if changing ones beliefs or goals alters the process itself.

The suggestion that emotions are affected by cognitive processes is not a new idea (Frijda, 1986; Lazarus, 1984; Scherer, Schorr, & Johnstone, 2001). However, while much work has attempted to break emotion down to its more basic components, this has commonly only gone as far as separating its non-cognitive, affective components (including valence and arousal) from its cognitive states and action tendencies. Little work has tested empirically the extent to which the affective components may contain, or be influenced by, cognitive information (without actually redefining them as cognitive states). Across two experiments, the current study aimed to test the cognitive penetrability of valence and arousal by comparing the extent to which a stimulus' believability impacts upon participants' ratings of its valence and arousal.

EXPERIMENT 1

Methods

Participants. Twenty Canadian individuals participated in Experiment 1 for university credits (16 female, $M_{age} = 22.1$ years). Each gave fully informed consent to participate. The study was approved by the York University Research Human Participants Ethics Committee.

Stimuli. Stimuli comprised 128 written statements in a 2×2 design, with factors for affective content (affectively charged/neutral) and believability (believable/unbelievable). This provided 32 items per condition. Stimuli were selected based the appropriateness of believability, valence and arousal ratings from an initial pilot study (12 participants). Affectively charged statements were all of negative valence. We made efforts to match affectively charged and neutral statements in terms of the subject matter described, with the aim that only their affective content would differ, and not other aspects of their informational

content. Affectively charged statements were grouped into 8 "themes", based on their subject matter (comprising oil spills, terrorist attacks, seal clubbing, needle sharing in drug users, animal cruelty, abortion, prisoners of war, and the death penalty), and neutral statement were written on the basis of an affectively neutral equivalent of each theme (comprising respectively of clean tap water, airplanes, feeding animals, sewing, farm animals, pregnancy, caged animals, and chairs). For example, when an affectively charged theme concerned abortion, the neutral theme concerned the normal growth of a child during gestation. Example stimuli are shown in Table 1 and all stimuli can be found in supplementary Table S1.

Procedure. Prior to the main task, participants were presented with information and photographs associated with each of the eight themes used in the statements to be rated. Participants were informed that they should read this information carefully as their memory would be tested immediately afterwards. Pictures were incorporated (one per theme) to provide further information in support of the beliefs encouraged by the written content and also enhance the expected affective response. The pictures were not related to the individual statements to be rated, but rather to the theme as a whole. For example, one neutral theme concerned clean tap water, and the associated picture showed water running from a tap.

In the main experimental procedure, each of the 128 items was presented once in random order. One break was provided halfway. For each item, participants were asked to provide three ratings (the order of which was randomised trial-by-trial to reduce expectancy effects). These ratings comprised 9-point scales for: (1) *valence*, with lower numbers indicating more affectively negative statements and higher numbers indicating more affectively positive statements; (2) *arousal*, with lower numbers indicating calming statements and higher numbers indicating arousing statements; and (3) *believability*, with lower numbers indicating greater unbelievability and higher numbers indicating greater believability. The meaning of neutral ratings was also described for each scale. Reaction times (RTs) were also recorded. The effects of affective content and believability on each of the three ratings, and on RT, were tested with 2×2 repeated-measures analyses of variance (ANOVAs), with factors for Affective Content (affectively charged/neutral) and Believability (believable/unbelievable).

Table 1. *Experimental design with examples of the stimuli used in Experiment 1*

	Believable	*Unbelievable*
Affective	Seal clubbing is not ethical	Seals do not feel pain
Neutral	Lions are carnivores	Lions are not carnivores

Results

Manipulation check. Items assumed a priori to be believable were indeed found to have higher ratings of believability ($M = 7.09$, $SE = 0.19$) than those assumed to be unbelievable ($M = 3.02$, $SE = 0.23$), $F(1, 19) = 115.92$, $p < .0001$, $d = 0.86$ (Figure 1a). There was no Affective Content $\times$ Belief interaction in believability ratings, $F(1, 19) = 1.50$, *ns*, $d = 0.07$, showing that believability ratings were equivalent for affectively charged and neutral items. The affective content manipulation of the stimuli was also successful, as shown by more negative valence ratings for the affectively charged items ($M = 4.07$, $SE = 0.22$) than for neutral content items ($M = 5.00$, $SE = 0.12$), $F(1, 19) = 20.42$, $p < .001$, $d = 0.58$. Items with affectively charged content were also rated as more arousing ($M = 5.53$, $SE = 0.40$) than neutral items ($M = 3.67$, $SE = 0.39$), $F(1, 19) = 19.53$, $p < .001$, $d = 0.51$.

Correlation between ratings across all trial types. The mean Pearson's correlation coefficient between valence and arousal ratings (across all trial types) was $-.116$ ($SE = 0.11$) and was not significantly different from zero, $t(19) = -1.013$, $p = .324$. This finding supports previous evidence that valence and arousal are largely independent of each other (e.g., Barrett & Russell, 1998).

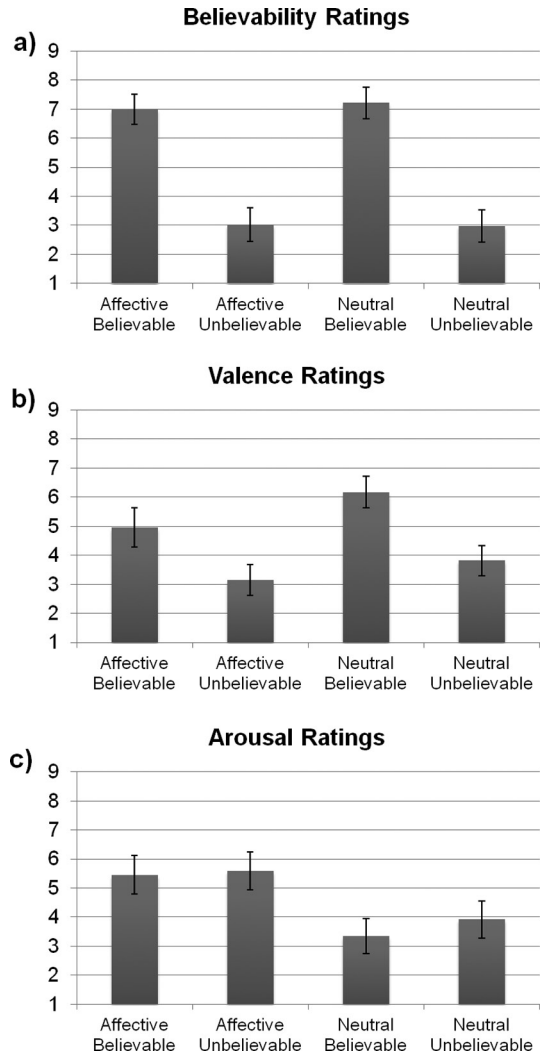

Figure 1. *Results of Experiment 1. Shown are the average ratings of (a) believability, (b) valence, and (c) arousal for a priori believable and unbelievable items of affectively charged (negative) and neutral content. Error bars show the standard error of the mean.*

There was, however, a strong positive correlation between ratings of valence and believability (*Mean* $r = .582$, $SE = 0.07$), $t(19) = 8.457$, $p < .0000001$, such that more unbelievable content was generally rated as more negatively valenced. This was not the case for arousal, which showed no overall correlation with believability ratings (*Mean* $r = .037$, $SE = 0.09$), $t(19) = 0.418$, $p = .680$.

Impact of belief on valence ratings. The correlations presented above do not separate out our four stimulus conditions. Therefore, we performed one 2×2 ANOVA for each of the three rating types, with factors for a priori Affective Content (affectively charged/neutral) and Believability (believable/unbelievable). With valence ratings as the dependent measure, the ANOVA showed a significant impact of item Believability onto their rated valence, with believable content being rated as more positive ($M = 5.57$, $SE = 0.29$) than unbelievable content ($M = 3.50$, $SE = 0.20$), $F(1, 19) = 25.95$, $p < .0001$, $d = 0.52$ (Figure 1b). The inverse effect was not found, such that the affectively charged (i.e., negatively valenced) items were not rated as more unbelievable ($M = 5.01$, $SE = 0.10$) than the neutral items ($M = 5.10$, $SE = 0.12$), $F(1, 19) = 0.60$, *ns*, $d = 0.03$.

There was also a Content × Believability interaction in valence ratings, $F(1, 19) = 6.22$, $p < .05$, $d = 0.25$, such that there was a greater effect of believability on neutral items ($M_{\text{believable}} = 6.18$, $SE = 0.23$; $M_{\text{unbelievable}} = 3.83$, $SE = 0.24$), $t(19) = 5.87$, $p < .001$, than for affectively charged items ($M_{\text{believable}} = 4.97$, $SE = 0.38$; $M_{\text{unbelievable}} = 3.17$, $SE = 0.22$), $t(19) = 4.07$, $p < .001$. While the difference is significant for both content types, this content effect may be explained by a floor effect for affectively charged items, since the already negative valence here would leave less room for unbelievable items to be rated as even more negative. This may be unlikely since 9-point rating scales were used. This interaction may rather be due to differences in the nature of participants' beliefs for affectively charged versus neutral material (but not the strength of these beliefs since belief ratings were equivalent between the two conditions), e.g., neutral items were generally about something physical in the world, while affectively charged items were of a more moral nature. In this case, although the believability ratings for affectively charged and neutral items were equivalent, violations of the beliefs may have a differential impact for affectively charged and neutral material.

Impact of beliefs on arousal ratings. In contrast to valence, the believability of the items had little

effect on ratings of their arousal, such that arousal ratings were similar for believable ($M = 4.42$, $SE = 0.36$) and unbelievable items ($M = 4.76$, $SE = 0.38$), $F(1, 19) = 1.09$, *ns*, $d = 0.05$ (Figure 1c). There was, however, a Content × Believability interaction on arousal ratings, $F(1, 19) = 4.46$, $p < .05$, $d = 0.19$. Like for valence, though of lower significance, this was such that there was a slight, but insignificant, effect of Believability on arousal ratings for neutral items ($M_{\text{believable}} = 3.38$, $SE = 0.41$; $M_{\text{unbelievable}} = 3.94$, $SE = 0.45$), $t(19) = -1.46$, $p = .16$, which was not at all present for affectively charged items ($M_{\text{believable}} = 5.47$, $SE = 0.43$; $M_{\text{unbelievable}} = 5.59$, $SE = 0.42$), $t(19) = -0.41$, $p = .69$.

Reaction times. There was a main effect of affective content on RT, $F(1, 19) = 21.45$, $p < .001$, $d = 0.53$, such that RTs were longer to rate an affectively charged item ($M = 4{,}999$ ms, $SE = 471$) than a neutral item ($M = 4{,}365$ ms, $SE = 424$). There was also a main effect of rating type on RT, $F(1, 19) = 4.37$, $p < .05$, $d = 0.19$, such that participants were slower to give valence ratings ($M = 5{,}041$ ms, $SE = 503$) than arousal ($M = 4{,}396$ ms, $SE = 459$), $t(19) = 2.64$, $p < .05$, or believability ratings ($M = 4{,}608$ ms, $SE = 418$), $t(19) = 2.20$, $p < .05$. Although arousal ratings were associated with the shortest RT, they were not significantly shorter than believability ratings, $t(19) = -0.95$, *ns*. There were no effects of Believability on RT, $F(1, 19) = 0.30$, *ns*, $d = 0.02$, or interaction of Affective Content and Believability, $F(1, 19) = 0.32$, *ns*, $d = 0.02$, for any of the ratings.

Discussion

The results of Experiment 1 reveal that valence and arousal are differently influenced by the extent to which information is in keeping with our beliefs. While reported arousal appears to be independent of the believability of the content, reported valence is mediated by beliefs, such that unbelievable content is experienced as more negatively valenced than believable content. The direction of this influence on valence may stem from the frustration or conflict incurred by content incongruent with our beliefs, and/or a tendency to doubt the validity of one's beliefs in the face of such incongruency. In the case of believable content, increased pleasure may result from belief confirmation and from an absence of conflict. Interestingly, beliefs do not have the same impact on arousal.

It is important to note that, while there were no differences in the believability ratings for the affectively charged and the neutral items, there was found to be a stronger impact of believability on valence ratings for neutral items compared to affectively charged items. One explanation for this may be that some of the neutral items were of a more objective nature (often describing something physical about our world, e.g., that "lions are carnivores", compared to the more subjective nature of "Osama bin Laden was a terrorist") and so violation of such beliefs may have had a stronger affective impact. This interaction was also present in the case of arousal, such that unbelievable content encouraged increased ratings of arousal only in the case of the neutral items (though not significantly), suggesting that this effect may come from a different underlying cause to that driving the main effect we found of believability on valence ratings. This study focuses on relationships between strengths of affective responses and beliefs (with physical impossibilities and more subjective unbelievability treated as equivalent although perhaps with the former being associated with stronger beliefs). Therefore, we do not address deeper issues of how the underlying *natures* of these beliefs influence affect. Additionally, this effect was not replicated in Experiment 2, suggesting that it may not be a robust finding.

If arousal is completely independent of beliefs, then removing the sense of congruence, or incongruence, with beliefs should have little or no impact on ratings of arousal. In other words, if arousal stems only from the affective content of the individual words in the statements used, and not from the meaning implied by the sentence as a whole, then scrambling the order of the words in these same statements should result in equivalent

levels of arousal as when the statement is semantically intact. If valence is less independent of statement meaning, however, then scrambling the word order should eliminate (at least in part) the resulting sense of valence. We carried out a second experiment to test this.

EXPERIMENT 2

Methods

Participants. A new cohort of 20 individuals participated in Experiment 2 for university credits (17 female, $M_{age} = 20.25$ years). These participants were from the UK. Each gave fully informed consent to participate. The study was approved by the University of Hull Ethics Committee.

Stimuli. Experiment 2 used the same stimuli as in Experiment 1. However, a random set of 64 of the 128 written statements was selected for each participant to be scrambled (equal number from each of the four stimulus conditions). This provided a $2 \times 2 \times 2$ fully factorial design, with factors for Affective Content (affectively charged/neutral), Believability (believable/unbelievable) and Scrambling (scrambled/intact), with 16 items per condition. Critically, due to random selection of trials for scrambling for each participant, there was no bias in which items participants would see intact and which they would see scrambled, and statements would only ever be seen once by each participant (either scrambled or intact). Word scrambling was performed using a random number generator, which randomly permutated the words in the statement. Example stimuli are shown in Table 2.

Procedure. The procedure was identical to that of Experiment 1. Prior to the main task, participants read the same pre-test information and saw the same pictures. The three ratings were described in the same way. Additional instructions were then given, that half of the statements would be semantically intact (such that their meaning could be understood) and the remaining half would be scrambled (such that the order of the words would be mixed up and, thus, the propositional meaning obscured). It was emphasised to all participants that they should avoid attempts to reorder the words in these scrambled statements. After each experiment, participants were asked how easily they were able to avoid such reordering. All participants claimed that they were able to do this the majority of the time; however 18 out of 20 participants claimed that reordering was more automatic for some items (especially the shorter statements). The effects of affective content, believability and scrambling on each of the three ratings, and on RT, were tested with a $2 \times 2 \times 2$ repeated-measures ANOVA.

Results

Replicated effect of belief on valence, but not arousal, ratings for intact stimuli. In the case of the semantically intact statements, we replicated the significant impact of item believability onto their rated valence as found in Experiment 1, again with believable content being rated as more positive ($M = 4.23$, $SE = 0.09$) than unbelievable content ($M = 4.02$, $SE = 0.07$), $F(1, 19) = 11.86$, $p < .005$, $d = 0.38$ (Figure 2b intact bars). The inverse effect was again not found, such that the affectively charged (i.e., negatively valenced) items were not rated as more unbelievable ($M = 4.88$, $SE = 0.11$) than the neutral items ($M = 4.86$, $SE = 0.11$), $F(1, 19) = 0.04$, *ns*, $d = 0.002$. As in Experiment 1, there was no significant impact of

Table 2. *Experimental design with examples of the stimuli used in Experiment 2*

	Believable	*Unbelievable*
Affective	Seal clubbing is not ethical	Seals do not feel pain
Neutral	Lions are carnivores	Lions are not carnivores
Affective scrambled	Ethical seal not clubbing is	Do feel seals pain not
Neutral scrambled	Carnivores lions are	Not lions are carnivores

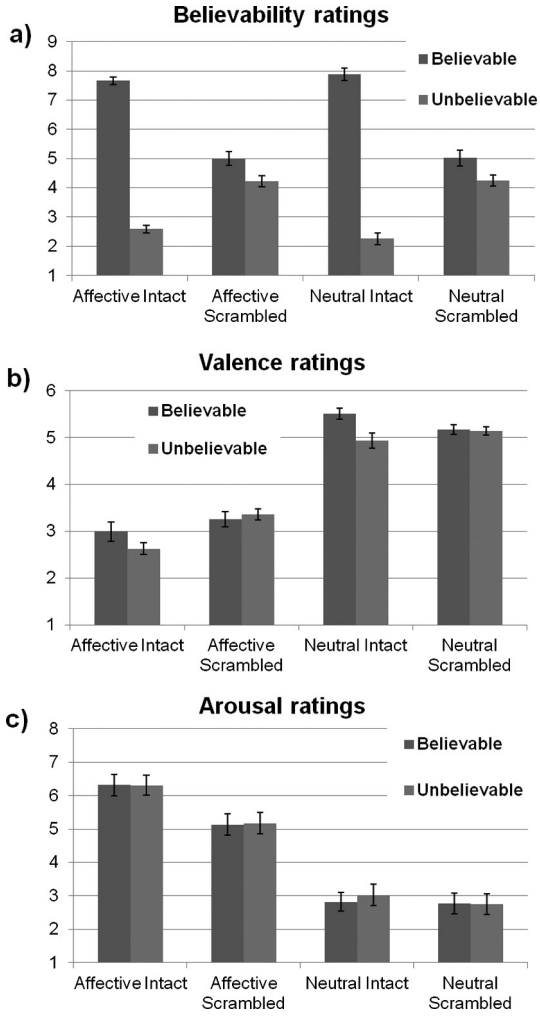

Figure 2. *Results of Experiment 2. Shown are the average ratings of (a) believability, (b) valence, and (c) arousal for a priori believable (blue) and unbelievable (red) items of affectively charged (negative) and neutral content, and for semantically intact (unscrambled) versus scrambled sentences. Error bars show the standard error of the mean.*

item Believability on arousal ratings, $F(1, 19) = 0.66$, *ns*, $d = 0.03$, such that arousal ratings were similar for believable ($M = 4.36$, $SE = 0.24$) and unbelievable items ($M = 4.41$, $SE = 0.25$) (Figure 2c intact bars).

While Experiment 1 showed an Affective Content × Belief interaction, such that the influence of believability on valence was greater for neutral items than for affectively charged items, this was not replicated here, $F(1, 19) = 1.57$, *ns*, $d = 0.08$, despite the equivalent task and stimuli. The same effect was also not replicated in the case of arousal ratings, $F(1, 19) = 0.63$, *ns*, $d = 0.03$. This lack of replication suggests that this interaction is not a robust effect.

Impact of scrambling on valence and arousal. If valence is influenced by item believability, then scrambling should eliminate (at least in part) the valence difference between believable and unbelievable items, since removing propositional meaning eliminates the understanding of congruence (or incongruence) with one's beliefs. This was, indeed, the case, as shown by a Scrambling × Believability interaction on valence ratings, $F(1, 19) = 15.74$, $p < .001$, $d = 0.45$ (Figure 2b). This removal of the believability effect on valence for scrambled items was shown in both the affectively charged and neutral content items, and there was no three-way interaction of Affective Content, Belief and Scrambling, $F(1, 19) = 0.14$, *ns*, $d = 0.01$.

In the case of arousal ratings, there was no Scrambling × Believability interaction, $F(1, 19) = 0.33$, *ns*, $d = 0.02$ (Figure 2c). Neither semantically intact nor scrambled statements showed any influence of item believability on arousal ratings. When comparing valence and arousal ratings in the same ANOVA, there was a significant interaction between rating and the main effect of belief, $F(1, 19) = 6.68$, $p < .02$, $d = 0.26$, and this was driven by a difference between believable and unbelievable items in the case of valence, $t(19) = 3.44$, $p < .005$, and no difference in the case of arousal, $t(19) = -0.81$, $p = .43$.

Interestingly, scrambling had other direct effects on *both* valence and arousal, which were not mediated by item believability. There was a main effect of Scrambling on both valence ratings, $F(1, 19) = 10.09$, $p < .005$, $d = 0.35$, and on arousal ratings, $F(1, 19) = 16.23$, $p < .001$, $d = 0.46$, as well as an Affective Content × Scrambling interaction for both valence ratings, $F(1, 19) = 9.56$, $p < .01$, $d = 0.34$, and arousal ratings, $F(1, 19) = 23.67$, $p < .001$, $d = 0.56$. These effects were such that the semantically

intact affectively charged statements were generally rated as more negative than the scrambled affectively charged items (2.81 compared to 3.31), $t(19) = -3.49$, $p < .002$, as well as more arousing (6.42 compared to 5.29), $t(19) = 5.27$, $p < .001$, while no such differences were shown in the case of the affectively neutral items ($p > .3$).

Manipulation check. Again items assumed a priori to be believable showed higher ratings of Believability ($M = 6.39$, $SE = 0.16$) than those assumed to be unbelievable ($M = 3.35$, $SE = 0.09$), $F(1, 19) = 401.83$, $p < .00001$, $d = 0.96$ (Figure 2a intact bars). Scrambling had a strong effect on these believability ratings, as expected, with the difference between believable and unbelievable items being largely (but not completely) eliminated, $F(1, 19) = 232.15$, $p < .00001$, $d = 0.92$ (Figure 2a scrambled bars). That the difference was not entirely eliminated was likely due to the fact that all scrambled statements still contained all the elements of grammatically intact statements, and so propositional meaning may sometimes have been inferred by automatic reordering of words. This may have been especially apparent in the items containing fewer words (e.g., in the case of the scrambled statement "Carnivores lions are"). However, when we tested all the subsequent analyses after removing trials containing sentences of five words or fewer, we found no differences in the results.

The affective content manipulation of the stimuli was again successful, as shown by more negative valence ratings for the affectively charged content items ($M = 3.06$, $SE = 0.12$) than for neutral content items ($M = 5.19$, $SE = 0.10$), $F(1, 19) = 155.08$, $p < .00001$, $d = 0.89$. Items with affectively charged content were also rated as more arousing ($M = 5.85$, $SE = 0.26$) than neutral items ($M = 2.92$, $SE = 0.27$), $F(1, 19) = 163.39$, $p < .00001$, $d = 0.90$.

Reaction times. Again there was a main effect of affective content on RT, $F(1, 19) = 30.19$, $p < .001$, $d = 0.61$, such that RTs were longer to rate an affectively charged item ($M = 4{,}308$ ms, $SE = 204$) than a neutral item ($M = 3{,}747$ ms, $SE = 185$). There was also a main effect of rating type on RT, $F(1, 19) = 7.36$, $p < .02$, $d = 0.28$, again such that participants were slower to give valence ratings ($M = 4{,}250$ ms, $SE = 209$) than arousal ($M = 3{,}823$ ms, $SE = 192$), $t(19) = 4.42$, $p < .001$, or believability ratings ($M = 4{,}009$ ms, $SE = 194$), $t(19) = 2.05$, $p < .05$. As in Experiment 1, arousal ratings were associated with the shortest RT, but were only trend significantly shorter than believability ratings, $t(19) = -1.56$, $p = .13$. As in Experiment 1, there were no effects of Believability on RT, $F(1, 19) = 0.05$, *ns*, $d = 0.002$. There was a trend effect of scrambling on RT, $F(1, 19) = 3.56$, $p = .075$, $d = 0.16$, with slower RT for scrambled ($M = 4{,}188$ ms, $SE = 213$) compared to semantically intact items ($M = 3{,}867$ ms, $SE = 198$), but this effect did not interact with rating type.

Discussion

In Experiment 2, we replicated the significant impact of item believability onto valence ratings, and the lack of such an effect on arousal ratings. The effect of believability on valence ratings was eliminated with semantic scrambling, as would be expected if valence depends on understanding the extent to which the statement is in accordance with one's beliefs. Arousal ratings were unaffected by belief congruence with either semantically intact or scrambled versions of the statements. Interestingly, our hypothesis that arousal ratings would be unaffected by sentence scrambling (i.e., if arousal is completely independent of beliefs) was not supported. The main effects of semantic scrambling suggest that *both* valence *and* arousal are strengthened by general comprehension of meaning, but only within those items that already contain affectively charged words (i.e., when there is already a level of stimulus-driven affective activation). In other words, while the extent to which the meaning is congruent or incongruent with one's beliefs only influences ratings of valence, and not arousal, both of these components of affect rely, in part, on being aware of the overall sentence meaning. They do not depend entirely upon it, however, since even the

scrambled affectively charged statements are still rated as more negative and more arousing than both the scrambled and intact neutral statements (i.e., they are both also influenced by the individual affectively charged words even when not embedded in a complete sentence).

GENERAL DISCUSSION

Our findings show that valence and arousal are differentially influenced by consistency with prior beliefs. Given what we understand about valence and arousal, this asymmetric effect of beliefs is not surprising. Scherer, Dan, and Flykt (2006) found differences in the types of appraisals associated with the valence and arousal of emotional pictures. Furthermore, Schachter and Singer (1962) proposed that arousal remains unspecific until some level of appraisal occurs, and Cochrane (2009) described arousal as simply "a general condition for the occurrence of an emotion, rather than a way to differentiate within the field of emotions". Together, these hint at arousal being primary to, and separated from, the appraisal process. If arousal is stimulus driven (i.e., generated directly from our perception of a relevant change in our environment), with no reliance on intermediary cognitive processes, then this could allow for it to be resistant to influence by cognitive processes, such as the evaluation of truth. The quicker RTs for arousal ratings, compared to valence, is also in keeping with arousal being of a more stimulus-driven level of activation, without the need for extensive cognitive appraisal.

These findings provide some insight into an unresolved debate regarding affective independence and primacy (Lazarus, 1984; and see Zajonc, 1984, for the argument for cognitive primacy). This debate concerns whether emotion can occur without, and indeed prior to, any amount of cognitive processing. The debate has been confused, however, by the fact that it usually concerns *emotion* (a multicomponential state, which comprises both cognitive and affective components) rather than addressing the affective components themselves. Our findings indicate not only that these affective components can be influenced by cognitive processes, but also that the extent of this influence depends upon which component of affect is being considered. Whether our data supports Lazarus' or Zajonc's arguments depends first upon whether one believes arousal to be sufficient for the experience of emotion, or whether valence is also necessary, or indeed whether these affective components are enough without further appraisal. Lazarus (1984) wrote that arousal will "produce an emotion only if we appraise the encounter (e.g., the physical and social conditions and the bodily state it produces) as having a bearing on our well-being". Our findings may indicate that valence falls into the category of what Frijda (2005) labelled "second order emotional experience", involving elaboration about the event, one's response and of the potential consequences, and so may not fit as neatly into a category of affective process. On the other hand, arousal may be a less specific, more primitive response, prioritising orienting of attention and preparation for action, and so may be more non-cognitive than many (if not all) of the other components of our emotional experiences.

Our data show that valence and arousal are differentially influenced by beliefs, such that valence, but not arousal, is influenced by the extent to which stimuli are consistent or inconsistent with beliefs. However, the results also show that arousal is not completely stimulus driven. The effect of sentence scrambling shows that both valence and arousal are enhanced by, though not completely dependent upon, general comprehension of meaning. Indeed some evidence shows that arousal-related brain responses (e.g., in the amygdala) do appear to be shaped by cognitive processing (e.g., in the prefrontal cortex; Hariri, Bookheimer, & Mazziotta, 2000; Lieberman, Hariri, Jarcho, Eisenberger, & Bookheimer, 2005). Such interactions, along with our findings, suggest that it would be misleading to consider affective and cognitive responses as completely independent and sequential.

In summary, we have shown that two core components of our emotional experiences, valence and arousal, which are generally considered to be

of a non-cognitive, affective nature, are penetrable to different degrees by cognitive processing. While both of these affective components depend, to some extent, upon general comprehension of meaning in written statements, only valence is influenced by the consistency of the statements with one's beliefs about the world.

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