A neuroimaging investigation into figurative language and aesthetic perception

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Abstract (120 words max.)

This study builds on previous work by Citron and Goldberg (2014) in which silent reading of taste metaphors, e.g., *She looked at him* <u>*sweetly,*</u> was shown to elicit stronger emotional neural responses than their literal counterparts. Since metaphors are often used as a stylistic device in poetry and narrative to elicit aesthetic experiences, we aimed to investigate whether the emotional engagement in response to these expressions is driven by their implicit evaluation as more aesthetically pleasing stimuli. We found that, even though taste metaphors were rated as more beautiful than their literal renderings, beauty ratings did not elicit stronger emotional responses in the brain. Rather, increasing beauty activated the primary somatosensory cortex, associated with bodily sensations in response to touch.

Introduction

Figurative expressions are pervasive in everyday communication and are used for a range of rhetorical purposes. For example, novel metaphors are used as a persuasive tool in advertising, e.g., *Red bull gives you wings* (McQuarrie & Mick, 1996); irony is used to express negative remarks in a less direct way, e.g., *What a sunny day* when experiencing a thunderstorm; idiomatic expressions such as *That was a bitter pill to swallow* have been shown to be both persuasive and indirect (Citron et al., 2016; Drew & Holt, 1988, 1998); and finally, proverbs such as *Not every cloud rains* are generally true statements used for educational purposes such as sharing savvy knowledge coming from life experiences.

Among figurative expressions, conceptual metaphors in particular help people explain and understand abstract concepts in more concrete terms (Gibbs, 2006; Lakoff & Johnson, 1980). For example, in *The exam ran smoothly,* the concept of smooth surface, that can be easily touched and therefore also imagined, is used to explain that taking the exam did not cause big struggle (a more abstract concept).

Figurative expressions are also typically used in literature (poems, narrative books, etc.) to evoke aesthetic experiences; that is, to elicit pleasurable feelings associated with the perception of beauty. Writers can use different figures of speech such as sarcasm, hyperbole, simile, or metaphor to elicit surprise in the reader by manipulating (implied) meaning (e.g., Miall & Kuiken, 1994); similarly, manipulation of rhyme and meter in poetry, or the use of alliteration (to create sound repetitions), are also aimed at eliciting aesthetic effects at the phonological and/or prosodic levels (e.g., Lea, Rapp, Elfenbein, Mitchel, & Romine, 2008; Menninghaus et al., 2015; Van Peer, 1990). In both cases, some elements (semantic or perceptual) are made particularly salient, i.e., *foregrounded*, by contrasting them with more familiar, *background* elements (Miall & Kuiken, 1994); for example, in an extract of *Hope* by Emily Dickenson, HOPE is conceptualised as a BIRD. Familiar elements of both concepts (background) are used to create a novel metaphorical association (foreground) that becomes particularly salient: *Hope is the thing with feathers / That perches in the soul, / And sings the tune–without the words, / And never stops at all, […]*.

Emotional engagement

In recent years, neuroscientific research on the comprehension of figurative language has shown that highly conventional metaphors such as *She looked at him sweetly* evoke stronger emotional responses at the neural level than almost identical literal expressions that contained an equal amount of emotional information, i.e., *She looked at him kindly*; in fact, reading metaphorical formulations activated a region of the brain called amygdala significantly more strongly than their literal counterparts (Citron & Goldberg, 2014). This region typically responds to emotionally intense experiences, or contextually salient stimuli such as encountering a bear or seeing water in the desert (Cunningham & Brosch, 2012; Garavan, Pendergrass, Ross, Stein, & Risinger, 2001; Hamann & Mao, 2002). This finding has been replicated using both natural stories and simple, isolated sentences that contained metaphors not related to taste, in native as well as second language speakers (Citron, Güsten, Michaelis, & Goldberg, 2016; Citron, Michaelis, & Goldberg, 2016), and is supported by a meta-analysis of 23 neuroimaging studies of figurative language comprehension (Bohrn, Altmann, & Jacobs, 2012). Similarly, a study using Spanish translations of English metaphors showed enhanced physiological reactions to metaphorical than literal renderings (Rojo, Ramos, & Valenzuela, 2014).

Such convergent empirical evidence now opens the question of why is it that figurative formulations are more emotionally engaging. What makes them more engaging? One possibility is that the automatic activation of concrete semantic representations through the metaphorical mapping recruits somatosensory and motor representations, i.e., engages cortical areas responsible for the bodily perception of external stimuli (Barsalou, 1999; Pulvermueller, 1999; Zwaan & Taylor, 2006), hence engaging the reader at the perceptual, beyond the linguistic, level of representation. This *embodied simulation* of abstract, metaphorical concepts in turn engages the reader more strongly at the emotional level too.

A related possibility also involves the fact that metaphors, even if highly conventional, do activate, at least in part, their literal meanings (Citron & Goldberg, 2014; Desai, Binder, Conant, Mano, & Seidenberg, 2011; Glucksberg, 1991; Lacey, Stilla, & Sathian, 2012); hence, multiple and richer meanings are activated concurrently. Blending Theory suggests that, during metaphor comprehension, not only are some characteristics of the concrete domain attributed to the abstract domain by enriching it, but rather interactions between the two domains give rise to a new conceptual package, the *blend*, i.e., metaphor comprehension leads to the emergence of new meanings (Cánovas, Valenzuela, & Santiago, 2015; Fauconnier & Turner, 2008). We propose that juggling multiple meanings concurrently may be experienced as solving a puzzle, and may in turn engage the reader at the emotional level as a form of reward for having found a plausible interpretation.

Finally, emerging empirical research into aesthetic perception shows that rhetorical devices used in literary texts or poems do not only affect aesthetic appreciation itself, but also emotional responses (e.g., Bohrn, Altmann, Lubrich, Menninghaus, & Jacobs, 2012; Cupchik, Oatley, & Vorderer, 1998; Jacobs, 2015a;

Kuehnast, Wagner, Wassiliwizki, Jacobsen, & Menninghaus, 2014; Lüdtke, Meyer-Sickendieck, & Jacobs, 2014). Therefore, it is possible that figurative expressions, even if conventional and used in non-literary contexts, may be perceived as aesthetically more pleasing, i.e., beautiful, compared to their literal counterparts.

The present study

The present study specifically focuses on this latter proposal. In particular, it aims to test the hypothesis that highly conventional metaphors are perceived as more beautiful than their literal counterparts, and to explore the neural correlates of beauty perception during reading of highly common sentences used in everyday life, both metaphorical and literal.

Here, we build from previous work on taste metaphors by Citron and Goldberg (2014), in which simple sentences containing a taste word used metaphorically, e.g., *That was a <u>bitter</u> breakup*, and their literal counterparts, *That was a <u>bad</u> breakup*, were silently read for comprehension while brain activity was recorded through a magnetic resonance imaging (MRI) scanner. After the experiment, we asked the same participants to rate the very same sentences for their degree of beauty and familiarity, i.e., how beautiful they found each formulation and how often they think such a formulation is used.

Since previous literature has shown that the degree of familiarity with an expression (proverbs in this case) is positively correlated with its perceived beauty (Bohrn, Altmann, Lubrich, Menninghaus, & Jacobs, 2013), we decided to measure this variable along with beauty, to then be able to look at the unique contribution of each of them by statistically controlling for the other variable.

Neural correlates of aesthetic perception

In terms of neural correlates, the emerging neuroscientific literature on aesthetic perception has shown that three main neural networks are involved: (1) when stimuli of increasing beauty are processed (paintings, sculptures, poems, and other forms of art), the activation of primary sensory and motor areas is significantly enhanced, i.e., the cortical regions that are used to see, hear, touch, smell, taste or move the body respond more strongly to stimulations that are aesthetically pleasing (for reviews, see Chatterjee & Vartanian, 2016; Di Dio & Gallese, 2009; Kirsch, Urgesi, & Cross, 2016); (2) in addition, the neural network responsible for emotion processing is also more strongly recruited when perceived beauty increases, especially so in studies that analysed subjective judgments of beauty from the participants tested (Cupchik, Vartanian, Crawley, & Mikulis, 2009; Winston, O'Doherty, Kilner, Perret, & Dolan, 2007). This network generally includes areas such as the amygdala, the anterior insular cortex (AIC), the anterior cingulate cortex (ACC) and the orbitofrontal cortex (OFC) (Lindquist, Wager, Kober, Bliss-Moreau, & Feldman Barrett, 2012); (3) finally, the most typical response to aesthetic perception consists in the activation of the reward system (Bohrn, et al., 2013; Vartanian & Goel, 2004), involving the caudate nucleus and the OFC (hence partially overlapping with the emotion network) (Elliot, Friston, & Dolan, 2000; Kringelbach, 2005). The reward system has been discovered by asking participants to gamble or to make decisions that either led to gains or losses (Bechara, Damasio, & Damasio, 2000) and its activation is modulated by emotion-regulation strategies (Delgado, Gillis, & Phelps, 2008).

The only study to date that has specifically investigated the neural correlates of aesthetic perception in highly conventional (often figurative) expressions is the one by Bohrn et al. (2013), in which common proverbs, proverb variants and literal control sentences were presented to participants. Increasing subjective ratings of beauty, collected after the experiment, were correlated with the functional MRI images previously recorded during silent reading of such expressions, followed by a semantic task. Beyond the previously mentioned positive correlation between beauty and familiarity ratings, the authors found that increasing beauty activated the reward system as well as a neural network associated with theory of mind (ToM), i.e., understanding other people's perspective and intentions (Frith & Frith, 2012; Spreng & Grady, 2010). While the latter finding can be due to the fact that moral values and norms are conveyed through proverbs (and may have been violated in the proverb variants used), the former finding of reward response shows that even highly conventional expressions, not embedded in a poem or a longer narrative, *can* elicit aesthetic experiences. In fact, the choice of proverbs from the authors was motivated by the fact that these may be considered as the smallest unit of literary text, on which stylistic devices such as *defamiliarisation* can be applied (Bohrn, Altmann, Lubrich, et al., 2012; Miall & Kuiken, 1994).

However, the growing research field of neuroaesthetics still witnesses only a handful of empirical studies on literary perception (Altmann, Bohrn, Lubrich, Menninghaus, & Jacobs, 2012; Bohrn, et al., 2013; Hsu, Conrad, & Jacobs, 2014; Hsu, Jacobs, Altmann, & Conrad, 2015; Jacobs, 2015b for an overview; Lehne et al., 2015), and specifically on figurative language (Bohrn, Altmann, Lubrich, et al., 2012; Bohrn, et al., 2013).

Therefore, the present study employs both an *a priori*, hypothesis-driven approach based on our previous empirical research, together with a more exploratory approach based on the current literature on neuroaesthetics in literary reading. First of all, we test the hypothesis that highly conventional metaphorical expressions are rated as more beautiful than their literal counterparts. Second, we test the hypothesis that the enhanced emotional engagement in response to figurative formulations, i.e., enhanced activation of the (left) amygdala, is due do an implicit evaluation of these stimuli as more beautiful; hence, we hypothesise that increasing beauty ratings for metaphorical and literal sentences will be positively correlated with increasing activation of the amygdala. Third, we explore the neural correlates of implicit aesthetic perception during silent reading, expecting one or more of the three neural networks previously reviewed (perceptual and motor, emotion, and reward systems) to respond to increasing beauty ratings. Finally, in terms of familiarity ratings, we expect more familiar sentences to be easier to process and therefore to activate the default mode network (Mason et al., 2007)

Method

The original experiment was conducted at the Dahlem Institute for the Neuroscience of Emotions (DINE) at the Free University of Berlin. This study consists in secondary analyses of previously collected data from Citron & Goldberg (2014).

Participants

Participants were all right-handed, young healthy adults, native speakers of German. However, the sample of this study differs slightly from the original one because only 25 out of the 26 participants responded to the post-scan online questionnaire (see procedure for more details). Therefore, the data of 25 native German speakers were analysed in this study, 6 men and 19 women, aged between 19 and 37 years (M_{age} = 26.3, SD = 4.9).

Materials

The full list of items employed by Citron and Goldberg (2014) as well as in the present study, and their respective ratings are reported in Appendix A for free use by other researchers.

Citron and Goldberg (2014) employed 74 sentences: 37 metaphorical sentences were created by using a taste-related word, e.g., “The break up was very bitter for him”, and 37 literal counterparts were created by replacing this word with a literal one matched in meaning, i.e., “The break up was very bad for him”. All metaphors employed are highly conventional German expressions. Metaphorical and literal sentences were extensively rated on a range of variables by an independent group of participants prior to the fMRI experiment: the two types of sentences differed significantly in taste-relatedness and metaphoricity, were rated as highly similar in meaning, and were statistically matched for emotional valence, emotional arousal, imageability, length in words and length in letters. Metaphors were rated as slightly less familiar than literal sentences. Please refer to Citron and Goldberg (2014) for the descriptive and inferential statistics and for more details about the stimuli.

In the present study, fresh ratings for beauty and familiarity were collected after the fMRI experiment through online questionnaires, from the same group of participants who took part in the experiment. The instructions presented to participants read as follows (English translation from original German):

BEAUTY

Please rate how beautiful you find the formulation and the choice of words of every sentence, on a scale from -3 "not at all beautiful" to +3 "very beautiful". With "beautiful" or "not beautiful" we DO

NOT mean whether a sentence describes a happy or sad event. In case you have no tendency, you can express it by choosing 0, i.e., the middle of the scale.

FAMILIARITY

Please rate how familiar you find each sentence, i.e., in your view, is the sentence relatively often used or rarely? Please rate the familiarity of each sentence on a scale from -3 "very rarely used" to +3 "very often used".

Procedure

Details about the fMRI experiment can be found in Citron and Goldberg (2014). Here, we report only essential information to facilitate comprehension of the present study. During the experiment, all sentences were presented on a screen, one at a time, in randomised order, and were intermixed with sequences of hash mark strings (as visual baseline). Participants were asked to silently read each sentence for comprehension. Eight additional filler sentences were intermixed with the other stimuli and followed by a yes/no comprehension question, to ensure participants were paying attention. The stimuli were presented in two separate runs, with a short break in between.

After the experiment was over, the experimenter contacted the same participants via email to complete an online questionnaire on Survey Monkey. Participants rated all the sentences (both metaphorical and literal ones) on 7-point Likert scales in terms of perceived beauty and familiarity. The task lasted approximately 20 minutes.

Data analysis

Rating data. A partial correlation was conducted to explore the relationship between beauty and familiarity, by partialling out the effects of the following variables: emotional valence, valence squared[1], emotional arousal, metaphoricity, taste-relatedness, meaning similarity, imageability, length in words, and length in letters. All controlled variables were rated by an independent group of participants (Citron & Goldberg, 2014). These participants also rated familiarity, which we will refer to as "pre-familiarity" to distinguish it from the variable rated in the present study by the same participant who took part in the experiment. A partial correlation was also conducted between familiarity and pre-familiarity to confirm the slight imbalance in familiarity between metaphorical and literal sentences and the generalizability of ratings between different participant samples.

In order to test our first hypothesis, namely whether conventional metaphors are perceived as more beautiful than their literal counterparts, an independent-samples t-test was performed, comparing beauty ratings between metaphors and their literal counterparts. Similarly, a t-test comparing familiarity ratings was also performed.

Statistical analyses of fMRI data. Please refer to Citron and Goldberg (2014) for details about the acquisition of structural and functional MRI images as well as the pre-processing of functional images.

The statistical analyses were performed using the SPM8 toolbox (Wellcome Trust Centre, www.fil.ion.ucl.ac.uk/spm). A first general linear model was used, including one factorial regressor defining the onsets of each sentence (either metaphorical or literal), one parametric regressor containing beauty ratings that were

[1] Valence squared represents the extent to which a stimulus is emotionally valenced, independently of whether its polarity is positive or negative. Valence squared differs from emotional arousal, which consists in the degree of physiological activation elicited by a stimulus, even though the two variables are highly correlated.

centred on their mean rating[2], followed by other three factorial regressors containing trials of no interest, i.e., hash mark strings, filler sentences, and the questions. In addition, we had 6 regressors for movement parameters.

Since it is known that familiarity and beauty are highly correlated with each other (Bohrn et al., 2013), and this was confirmed in the present study, a second general linear model was used, identical to the first model described above except for the inclusion of an additional parametric regressor consisting in familiarity ratings, also centred on their mean rating. This model allows the investigation of the unique contributions of beauty and familiarity ratings.

One-sample T-tests were defined for each participant: increasing beauty for the first model; increasing beauty and, in a separate test, increasing familiarity for the second model. Such contrasts allow the exploration of which regions of the brain show a significant increase in activation by increasing beauty (or familiarity) ratings. The contrast images obtained were then input in the group-level analysis, and both directions were tested, i.e., increasing as well as decreasing beauty and familiarity. These analyses were conducted at the whole-brain level. For significance levels, a standard voxel-level threshold of $p < 0.005$ uncorrected was used, along with a cluster-level threshold, corrected for false discovery rate (FDR), of $p < 0.05$ (Lieberman & Cunningham, 2009).

Additionally, based on our second hypothesis of enhanced emotional engagement (i.e., amygdala activation) associated with increasing beauty perception, small-volume correction (SVC) on the amygdala bilaterally was applied to the

[2] The default orthogonalisation in SPM was switched off and replaced by manual orthogonalisation through centering of the parametric regressor(s). This procedure avoids order effects, i.e., if automatic orthogonalisation is switched on, each parametric regressor is orthogonalised with respect to previous modulators, whose variance then weighs more than the variance explained by later modulators.

contrasts in which beauty ratings increased. The SVC was based on the Talairach Deamon (TD) Brodmann areas atlas, as implemented in the WFU PickAtlas toolbok (Maldjian, Laurienti, Kraf, & Burdette, 2003); a voxel-level threshold of $p < 0.001$ uncorrected was chosen and family-wise error (FWE) correction applied at the peak level with a threshold of $p < 0.05$ (Bennett, Wolford, & Miller, 2009).

Results

Ratings of beauty and familiarity

The descriptive statistics shown in Table 1 shows that the stimuli used were perceived as slightly beautiful, with the median lying slightly above the middle of the scale (i.e., 0); furthermore, the stimuli were perceived as relatively familiar overall, with metaphors rated as less familiar than literal sentences. Finally, familiarity shows a wider range of variability compared to beauty.

Highly significant positive partial correlations were found between beauty and familiarity ($r = 0.67$, $p < 0.001$), confirming previous findings in the literature (Bohrn et al., 2013) and indicating the need to control for familiarity when correlating beauty ratings to the functional images, as well as between familiarity and pre-familiarity ($r = 0.69$, $p < 0.001$), indicating a fair reliability of ratings between different participant samples.

A t-test revealed no significant difference in beauty ratings between metaphorical and literal sentences ($t(72) = 1.10$, *ns*). However, when familiarity was used as a covariate to partial out its effect, a significant difference was found, whereby metaphors are indeed perceived as more beautiful than literal sentences (*estimated marginal means*: metaphors = 0.33, *SEM* = 0.09; literal s. = 0.23, *SEM* =

0.09; $F(73, 1) = 17.85$, $p < 0.001$). Metaphors were also rated as slightly less familiar than their literal counterparts ($t(72) = 3.10$, $p < 0.01$), replicating and confirming what previously reported in Citron and Goldberg (2014).

Table 1. Descriptive statistics for beauty and familiarity ratings, for all 74 sentences as well as broken down by sentence type: 37 metaphorical, 37 literal.

Statistics	All sentences		Metaphors		Literal sentences	
	Beauty	Familiarity	Beauty	Familiarity	Beauty	Familiarity
Median	0.34	0.68	0.32	0.24	0.36	1.10
Mean	0.28	0.65	0.19	0.32	0.36	0.98
SEM	0.08	0.11	0.10	0.16	0.11	0.14
Range	3.04	3.96	2.72	3.80	2.76	3.96
Minimum	-1.28	-1.68	-1.28	-1.68	-0.96	-1.56
Maximum	1.76	2.28	1.48	2.28	1.76	2.24

Brain imaging results: beauty

The first model including only one parametric regressor of beauty ratings revealed significant enhanced activation of the left post-central gyrus in response to increasing beauty (see Table 2), at the whole brain level. This region consists in the primary somatosensory cortex, usually active in response to stimulation of the human body through touch. In addition, a marginally significant cluster of activation was also found in the right pre-central gyrus, corresponding to the primary motor cortex (MNI 51 -6 40, cluster size = 274, $p = 0.07$). No clusters of activation were found by decreasing beauty ratings. In the second model including both beauty and familiarity ratings as regressors, no clusters of significant activation were found by increasing beauty while controlling the effect of familiarity. This is likely due to the larger variability of familiarity ratings that explains most of the variance in our data. The SVC on the amygdala revealed no peaks of significant activation, in either model.

Table 2. Regions showing significant increase in BOLD signal change in response to increasing beauty ratings and increasing familiarity ratings, at the whole brain level. A significance threshold of $p < 0.005$ uncorrected was applied, followed by FDR correction at the cluster level. Legend: Hemi. = hemisphere; L = left; cluster size is in voxels; T = peak t value; X, Y, Z: MNI coordinates; BA = Brodmann area.

Broader area	Hemi.	Region	Cluster size	T	X, Y, Z
First model: Increase in beauty					
Parietal lobe	L	Post-central gyrus	521	5.14	-50 -10 36
		Post-central gyrus (BA 43)		4.15	-56 -9 19
		Post-central gyrus		3.52	-62 -3 22
Second model: Increase in familiarity (with beauty controlled)					
Parietal lobe	L	Inferior parietal lobule	493	4.36	-50 -45 43
		Inferior parietal lobule (BA 40)		3.74	-57 -42 45
		Inferior parietal lobule		3.66	-48 -39 36

Brain imaging results: familiarity

When increasing familiarity ratings while controlling for beauty in the second model, a significant increase in activation was found in the left inferior parietal lobule (IPL; see Table 2), at the whole brain level. In addition, three marginally significant clusters of activation were observed in the right supramarginal gyrus (MNI 36 -55 33, cluster size = 271), right middle frontal gyrus (MFG, BA 8; MNI 34 20 45, cluster size = 290), and left superior and middle frontal gyri (S/MFG, BA 6; MNI -27 8 66, cluster size = 254; all *ps* = 0.08). The IPL is part of the default mode network, typically active during baseline conditions or breaks in between the presentation of stimuli. This network indexes the disengagement of the brain from a cognitively demanding task, possibly accompanied by mind wandering or focus on internal mental states (Buckner, Andrews-Hanna, & Schacter, 2008; Mason, et al., 2007). In the present study, increasing the sentences' familiarity led to higher ease of processing/comprehension and therefore reduced engagement of cognitive resources. Even though we cannot interpret the marginally significant results, such regions are also part of the default mode network (Buckner, et al., 2008); this qualitative observation provides a context for the significant IPL activation, which confirms its interpretation as engagement of the default mode network. No clusters of significant activation were found when decreasing familiarity ratings.

Figure 1A.

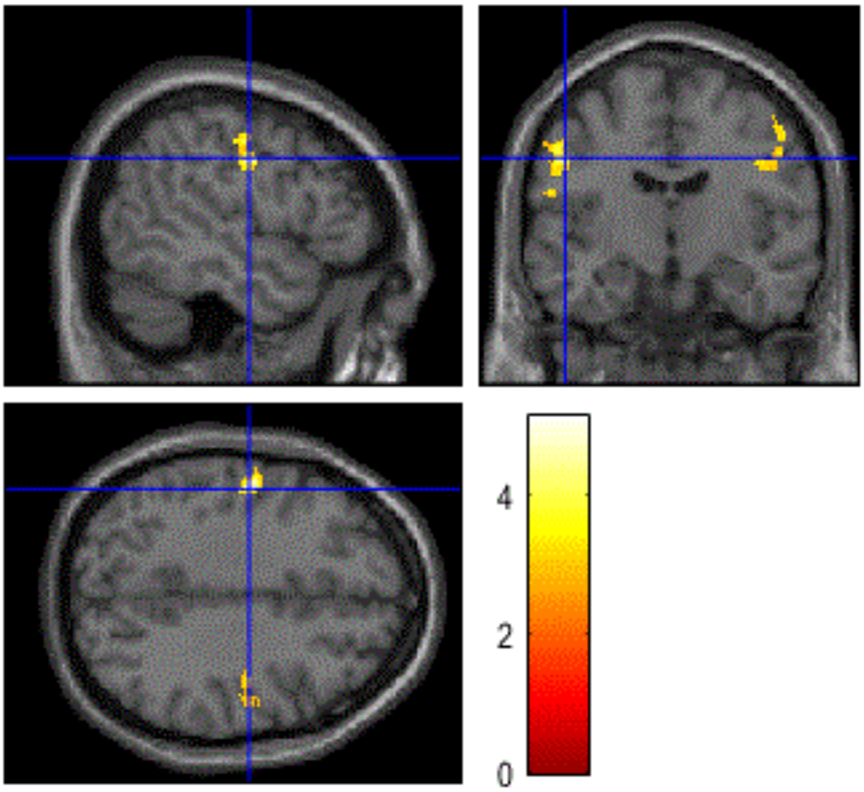

Figure 1B.

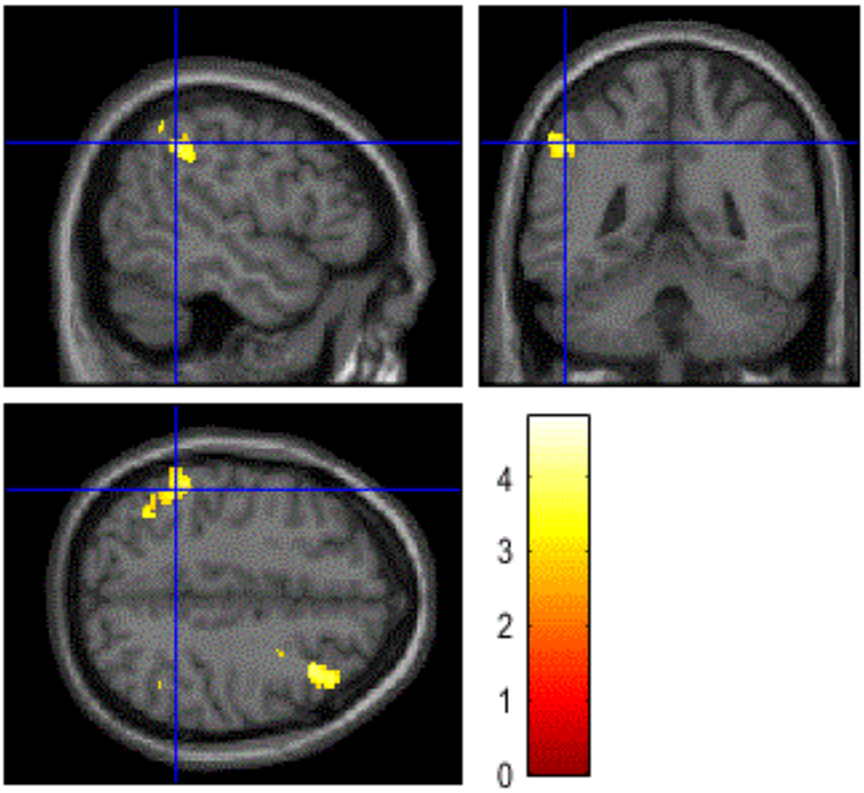

Figure 1. Regions showing significant increase in activation in response to: A) increasing beauty ratings, left post-central gyrus (MNI -50 -10 36); involvement of its right homologue as well as the right pre-central gyrus is visible, although these did not reach standard significant levels; B) increasing familiarity ratings while controlling beauty, left inferior parietal lobule (IPL; MNI -50 -45 43); involvement of the righ supramariginal, middle frontal and superior frontal gyri is also visible, although these did not reach standard significance levels. A significance threshold a the voxel level of $p < 0.005$ uncorected was applied, followed by FDR correction ($p < 0.05$) at the cluster level.

Discussion

The present work aimed to test the hypothesis that the stronger emotional engagement recently shown during the comprehension of conventional metaphors compared to their literal counterparts may be due to conventional metaphorical expressions being implicitly perceived as more aesthetically pleasing, i.e., beautiful, than their literal renderings. Testing this hypothesis by conducting secondary data analyses of previously published neuroimaging data (Citron & Goldberg, 2014) also opens other related questions such as whether highly conventional metaphorical expressions read in isolation can at all be perceived as more beautiful, given no poetic or literary context; furthermore, in light of the paucity of neuroimaging studies on aesthetic perception and figurative language, this study also provides an exploration into which neural networks may be involved.

First of all, the rating results showed that highly conventional, taste-related metaphors and their literal versions were perceived as just slightly beautiful overall, with very little variability. More variability was found in the ratings of familiarity, with our sentences perceived as relatively familiar overall, but with metaphors rated as slightly less familiar than the literal sentences (confirming the previous finding by Citron & Goldberg, 2014). Nevertheless, metaphors were perceived as significantly more beautiful than their literal counterparts when familiarity was controlled, therefore suggesting that even highly conventional expressions, as opposed for example to novel metaphors used in poetry, can be perceived as more aesthetically pleasing.

However, increasing beauty ratings did not correlate with enhanced activation of the (left) amygdala, which was previously found more active during reading of figurative compared to literal expressions (Bohrn, Altmann, & Jacobs, 2012; Citron & Goldberg, 2014; Citron, Güsten, et al., 2016; Forgács et al., 2012). This suggests that the stronger emotional engagement previously found is not likely due to an implicit aesthetic evaluation of the linguistic materials used. Hence, the question of what is it that makes figurative language more emotionally engaging cannot be answered by the results of the current work. Alternative explanations for the stronger engagement will be further discussed later below.

Somatosensory representations

The exploratory analyses at the whole brain level revealed that increasing levels of perceived beauty are associated with increased activation of the left primary somatosensory cortex. This finding is in line with the broader literature on neuroaesthetics, encompassing different forms of artwork and not necessarily including language; such literature has witnessed the recruitment of somatosensory, although more often motor, representations during art appreciation (Chatterjee & Vartanian, 2016; Di Dio & Gallese, 2009; Kirsch, et al., 2016). In particular, activation in the somatosensory cortex has been shown to be modulated by “objective beauty”, i.e., the manipulation of body proportions in statues, whereby original, proportionate statues are perceived as more beautiful than modified, disproportionate ones (Di Dio, Macaluso, & Rizzolatti, 2007). However, it was the observation of disproportionate statues that elicited enhanced activation in the left post-central gyrus, when compared with the proportionate ones (Di Dio, et al., 2007). Furthermore, activation of both pre- and post-central gyri (primary motor and somatosensory cortices, respectively) has been shown during the aesthetic judgment of human faces and bodies; activations in these areas were significantly enhanced in response to faces and bodies judged as neutral, compared to both beautiful and ugly ones (Martín-Loeches, Hernández-Tamames, Martín, & Urrutia, 2014). In line with en embodied account of cognition, the authors proposed that participants use the mental representation of their own face and body while judging those of other people

(Barsalou, 2008; Carota, Moseley, & Pulvermueller, 2012; Martín-Loeches, et al., 2014). Finally, activation of the left post-central gyrus has been reported during language processing and in particular lexical retrieval, independently of the type of processing required (semantic or syntactic), the word class or concreteness (Friederici, Opitz, & von Cramon, 2000), as well as during an inferential semantic retrieval task (Marconi et al., 2013).

In our study, the present finding can be interpreted in terms of enhanced simulation of bodily sensations during comprehension of sentences rated as increasingly beautiful. In this regard, the type of sentences used describe people and sensations (e.g., listening to a choir singing, appreciating a man's attractiveness, being annoyed by someone’s rough manners; see Appendix A). Apparently, the more beautiful the formulations, the stronger the evoked bodily sensations. This interpretation is supported by a study showing activation of somatosensory representations during processing of words denoting body parts (Carota, et al., 2012), and it also makes sense in light of the fact that the post-central gyrus is associated with the retrieval of lexical and semantic representations (Friederici, et al., 2000; Marconi, et al., 2013).

More generally, our results point toward the recruitment of the somato-motor system during aesthetic perception, but show no evidence of activation of either the reward or the emotion systems. This may be due to the fact that highly conventional expressions used in ever-day conversation are very easy to understand and do not present the expert reader with a particularly challenging, and therefore possibly rewarding, comprehension task. Unlike our study, Bohrn et al.’s (2013) results did show recruitment of the reward system but not the somato-motor system. This discrepancy can be explained if we consider the materials used in each study. Bohrn et al. (2013) employed proverbs and proverb variants, with some variants aimed at eliciting foregrounding effects (Bohrn, Altmann, Lubrich, et al., 2012; Miall & Kuiken, 1994). Such stimuli are more complex than the highly conventional expressions used in our study; hence, the participants in Bohrn et al.'s (2013) study have probably engaged in more complex semantic associations and meaning-making processes to make sense of the proverbs they read, and these operations may have led to an eventually rewarding experience. On the other hand, our stimuli may contain a higher number of concrete terms and words related to bodily sensation and experiences, therefore engaging the somatosensory system more strongly. Finally, the relatively low level of beauty perception elicited by our sentences was probably not enough to elicit emotional responses in the readers.

Increasing familiarity ratings led to stronger engagement of the default mode network, in line with the idea that the easier to process the stimuli become, the less the cognitive resources are needed to understand them; this finding is perfectly in line with what found by Bohrn et al. (2013).

Interestingly, the increasing recruitment of somatosensory representations driven by increasing beauty perception is reminiscent of what A.G. Baumgarten, the coiner of the term aesthetics, thought about poetry. According to him, poetry is aimed at conveying truth by means of sensible representations, or imagery drawn from the senses, and the perfection of a poem may lie in its medium, i.e., the words it uses, the imagery it arouses, and the relationship between them (Aschenbrenner & Holther, 1954; Baumgarten, 1983; Guyer, 2014). Clearly, the present finding needs further replication with a range of different poetic and literary materials. Nevertheless, it reminds us of a key function of poetics and opens the door to further research into its neural correlates.

Emotional engagement

The question of what makes conventional figurative expressions more emotionally engaging still needs to be addressed in future research. The present study seems to rule out an explanation in terms of enhanced perception of metaphorical formulations as beautiful, that is, even though these are evaluated as more beautiful than their literal counterparts, the degree of perceived beauty does not engage emotion-related areas and in particular the amygdala. Instead, some other characteristic of metaphorical formulations must drive the activation of this area, which was found in Citron and Goldberg (2014).

Recent findings from our lab seem to point toward our second proposal of concurrent activation of multiple semantic representations, i.e., literal and metaphorical meanings as well as their interaction and the emergence of novel concepts (Fauconnier & Turner, 2008; Glucksberg, 1991); In fact, conventional metaphors not related to taste were shown to activate a network of brain areas associated with executive control and ambiguity resolution more strongly than their literal counterparts, i.e., bilateral inferior frontal gyrus, anterior and middle cingulate cortex, and anterior insula (McNab et al., 2008); this network was found in response to metaphors embedded in natural stories (Citron, Güsten, et al., 2016) as well as in simple sentences such as the ones employed in the current study (Citron, Michaelis, et al., 2016). We interpret such neural pattern as reflecting the activation of more than one semantic representation, which need to be juggled and eventually selected to work out what the intended message is, and successfully understand. This "problem solving" activity in turns evokes stronger engagement of the reader at the emotional level. Further in line with this interpretation is a finding of a positive interaction between left amygdala and left IFG activation during reading of idiomatic compared to literal expressions (Citron, Cacciari, Funcke, Hsu, & Jacobs, 2016); in other words, the stronger the executive control operations such as inhibition and ambiguity resolution indexed by the IFG, the stronger the emotional engagement indexed by the amygdala.

Conclusions

The present study showed that conventional metaphorical expressions related to taste can be perceived as more aesthetically pleasing than their literal counterparts, when meaning, imageability, emotional content and familiarity are kept equal, even if they are not presented in a poetic or literary context. However, the stronger emotional engagement previously found in response to conventional metaphors is not due to their higher level of perceived beauty, since increasing beauty did not lead to increased activation of the amygdala. Interestingly, increasing beauty activated part of the somato-motor neural system associated with aesthetic perception, and in particular the primary somatosensory cortex, suggesting an increasing contribution of mental representations related to bodily sensations in response to increasingly beautiful linguistic stimuli. The present work rules out an interpretation of emotional engagement in terms of implicit aesthetic appreciation of metaphorical stimuli, and leaves the door open for future studies to explore other potential explanations. In addition, the present findings are reminiscent of the key role of poetics and literary texts in eliciting imagery drawn from the senses, and encourage replications as well as further investigations into the neural correlates of aesthetic perception during literary reading.

Author contributions and acknowledgments

This project has been conducted as part of EAZ's bachelor dissertation, under the supervision of FMMC. Both authors analysed the data together and interpreted the results. FMMC wrote up most of the manuscript, while EAZ contributed to the method, results, and discussion sections. The authors thank Professor Adele Goldberg for her advice and suggestions on a previous version of this manuscript.

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Caption

Appendix A. Full list of sentences and words created and used in Citron and Goldberg (2014), along with their English translations, and rated variables. Means and standard deviations (SD) are reported.

Note: The ratings for familiarity and beauty of the sentences were specifically collected for the analyses performed in the current study, from the same group of participants who took part in the functional MRI experiment in Citron and Goldberg (2014). All other ratings for sentences and all ratings for isolated words (or word pairs) were obtained in a preparatory study from a different sample of participants than the one who took part in the experiment (see Citron and Golberg, 2014, for further details).