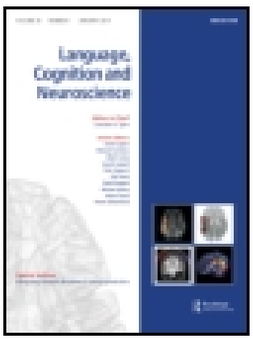

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RESPONSE ARTICLE

On the limits of affective neurolinguistics: a "universe" that quickly expands

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ABSTRACT

In our target article (Hinojosa et al., 2019. Affective neurolinguistics: Towards a framework for reconciling language and emotion. *Language, Cognition and Neuroscience*, 1–27. https://doi.org/10.1080/23273798.2019.1620957), we reviewed neuroimaging studies that examined the effects of emotional content on several language-related processes and provided a framework that aimed to account for the representation of emotional lexical features in the brain. The commentaries to our article call the attention on several challenges that investigations concerned with the neurobiological bases of the interplay between emotion and language processing will have to face in the future. Crucially, they also highlight the need of expanding the theoretical and research limits of affective neurolinguistics to incorporate issues such as the communicative functions of affective language or the linguistic and people's contextual factors involved in the production and comprehension of emotional language. In our response to the commentaries, we have summarised evidence that supports these claims and provide insights on the direction that affective neurolinguistics might follow during its expansion.

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One outstanding question in science concerns the evolution of the Universe and, more specifically, its expansion rate. Recent calculations of the Hubble constant, an index of the rate of expansion of our Universe, have challenged previous estimations based on the observations of the cosmic microwave background from the Planck satellite by showing that the universe is expanding faster than it was previously thought (Riess, 2020). In a similar vein, several eminent researchers in the fields of neurolinguistics and affective neuroscience have nicely emphasised in response to our target article (Hinojosa et al., 2019; henceforth HM&F) that the expansion of the "universe" of affective neurolinguistics is quickly accelerating. Remarkably, the amplitude and diversity of these comments provide several insights regarding the possibilities and paths that such expansion might follow. Some of the commentaries focus on developments and open questions that should be considered in future studies on the interplay between emotion and word/sentence processing under the theoretical framework outlined in HM&F. These research questions include the distinction between emotion-label and emotion-laden words (Wu & Zhang, 2019), the specificity of verbal emotional processing (Herbert, 2019; Kissler, 2019), the role of valence and arousal in semantic and syntactic combinatorial processing during sentence comprehension (Fraga, 2019; Molinaro, 2019) or the interplay between emotion and figurative language (Citron et al., 2020). Another set of commentaries go further and are concerned with an extension of the theoretical and research programmes that should fall within the scope of affective neurolinguistics. This expansion includes aspects such as the communicative functions of emotional language (Duñabeitia & García-Palacios, 2019; Kissler, 2019; Van Berkum, 2019), the processing of emotion in non-native languages (Duñabeitia & García-Palacios, 2019; Kissler, 2019), the use of affective language in clinical contexts (Duñabeitia & García-Palacios, 2019), the role of individual differences (Duñabeitia & García-Palacios, 2019; Fraga, 2019), or the development of emotional language from childhood to adulthood (Duñabeitia & García-Palacios, 2019; Herbert, 2019). Although in HM&F we aimed to provide a starting point for affective neurolinguistics, which was grounded in those research questions that have deserved more attention up to date (mainly related to the effects of emotional features on the operations involved in language processing, as pointed out by Van Berkum, 2019), in this response we will go into more detail on some aspects of these commentaries to conclude that the "universe" of affective neurolinguistics is still expanding and that its limits are far from being firmly established.

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The specificity of affective language processing

Herbert (2019) and Kissler (2019) call our attention on the fact that some of the early ERP modulations (EPN, but also late latency responses such as the LPC) elicited by affective lexical items are also observed with other non-linguistic materials (pictures, faces), which points out to the lack of specificity and independence of emotional linguistic and non-linguistic input processing. In our view, this is neither surprising nor disturbing as early ERP components are mostly linked to basic human perception and capture of attention processes that are critical for survival. The approach and withdrawal to and from stimuli and events needs a fast categorisation of them as harmful or pleasurable, which needs to be fostered by an initial capture of attention. Just to take the EPN as an example, in our conception the most relevant finding for affective neurolinguistics would be that the timing of the EPN resembles that previously reported for semantic analyses in language processing studies (e.g. Hauk et al., 2006). Also, prior reports of word class effects for the EPN should be considered here (Kissler et al., 2009; Palazova et al., 2011). These finding suggests that the call for attentional resources indexed by the EPN may show some degree of sensitivity to semantic processes and to the access to grammatical word class information that occur during word comprehension. Of note, EPN effects for words show a delayed latency relative to those elicited by faces and images (e.g. Palazova et al., 2011). Additionally, different EPN effects for emotional words, pictures and faces have been reported when the processing of these stimuli has been directly compared in cross-domain studies (Bayer & Schacht, 2014). These findings might be the natural consequence of the symbolic mediated access to emotional information in words. As suggested by Herbert (2019), investigating the transfer of this symbolic verbal information into a non-verbal affective system is a question of outstanding interest for future research. Our claim is that rather than struggling at identifying a marker that specifically signals the processing of emotional words relative to affective faces or pictures, a more fruitful approach would be to search for emotional content effects on those ERP components and brain areas involved in language-related processes (e.g. emotion effects on the LAN component; Hinojosa et al., 2014) and, conversely, to manipulate linguistic variables in order to examine the impact on emotion-related ERP components and brain regions (e.g. word frequency effects on the LPC, Méndez-Bértolo et al., 2011).

Refining affective neurolinguistics

In a set of commentaries the authors highlighted the need of using more fine-grained theoretical conceptions (Kissler, 2019) or stimuli (Kissler 2019; Van Berkum, 2019; Wu & Zhang, 2019) in order to overcome some theoretical limitations of our current knowledge about the brain mechanism involved in the interplay between language and emotion. Kissler (2019) points to the pertinence of conducting studies grounded in theoretical views that go beyond the two dimensional model of emotion, which has been favoured in most studies within the field of affective neurolinguistics. In this sense, future studies could consider other dimensions such as *deliberateness/intentionality* (the degree to which an emotion is originated in and/or directed towards a specific object/person [e.g. fear] or not [e.g. anxiety]; Trnka, 2011), unpredictability (the degree to which the emotion is related to a novel/unfamiliar stimulus; Fontaine et al., 2007) or the origin of emotions (the extent to which the emotion arises from automatic or reflective-deliberative evaluative processes; Jarymowicz & Imbir, 2015). Nonetheless, to the best of our knowledge there are no prior neurobiological studies that have tested the role of those dimensions on the processing of linguistic stimuli. Following a different approach, a limited number of behavioural studies have been conducted under the assumptions of discrete models of emotion, which postulate a limited set of functionally distinct emotion categories such as happiness, fear, anger, sadness or disgust (Ekman, 1992; Panksepp, 1998). The results of these studies have shown processing differences for fear and disgust-related words (Briesemeister et al., 2012; Ferré et al., 2018), or for fear and anger-related words (Huete-Pérez et al., 2019). Some authors have proposed unifying frameworks for the dimensional and discrete conceptions (Panksepp, 2008; Russell, 2003). In agreement with these views, data from ERP and fMRI studies that orthogonally manipulated happiness (a discrete emotion) and positivity (a continuous affective dimension) using lexical decision paradigms have reported that discrete emotion effects occur earlier than dimensional effects (Briesemeister et al., 2014) and rely on the activation of different brain regions, i.e. the amygdala and the left inferior frontal cortex, respectively (Briesemeister et al., 2015). The data summarised here clearly emphasises the importance of expanding the theoretical framework favoured by most current research on the neural bases of affective language processing. Studies following this approach might be conducted in parallel with those carried out from a bi-dimensional approach that examines the contribution of both valence and arousal variables to aspects that still remain poorly understood,

such as the combinatorial operations of semantic and syntactic unification involved in sentence processing (as pointed out by Fraga, 2019 and Molinaro, 2019; see Ding et al., 2020 for a recent study on this issue).

Three commentaries claim for a need to focus on more fine-grained features of the stimuli. In this sense, Kissler (2019), Van Verkum, 2020 and, particularly, Wu & Zhang (2019) highlighted the importance of considering a critical distinction between words that directly refer to particular affective states such as *sad* or *excited* (emotion-label words) and those with an acquired affective connotation such as *money* or *garbage* (emotion-laden words). Behaviourally, evidence for this division is inconclusive since some studies failed to report processing differences between emotion-label and emotion-laden words (e.g. Martin & Altarriba, 2017). With a few exceptions (e.g. Moseley et al., 2012), affective neurolinguistics studies have largely ignored this distinction in the selection of the stimuli. However, some recent ERP studies aimed at directly comparing the neural responses underlying the processing of these two types of words. Zhang et al. (2017) observed enhanced N170 and LPC responses to emotion-label relative to emotion-laden words. Importantly, in this study both types of words were not matched in concreteness, a critical variable which according to some authors might explain differences between emotion-label and emotion-laden words. As pointed out by Kissler (2019), since emotion seem to play a fundamental role in the representation of abstract words (Kousta et al., 2011), the special status of emotion-label words would be simply the consequence of their higher degree of abstractness relative to emotion-laden words. Of note, when both types of words were matched in concreteness (Wang et al., 2019), differences were observed at the P2 component and only for positive words. Another important aspect to consider is that most researchers have relied on their own intuition for classifying words as belonging to either the emotion-label or the emotion-laden categories. Normative studies that provide objective criteria that allow a definition of these categories will be clearly of help for future research. Some steps in this direction are starting to be made (e.g. Pérez-Sánchez et al., submitted). In sum, evidence for a distinction between emotion-label and emotion-laden words is far from being conclusive and more studies are needed. In the meantime, a reasonable approach might be to avoid mixing these two types of words when designing experiments.

The characteristics of the participants

A set of commentaries pointed out to the need of accounting for the potential role of individual differences in the processing of emotional language (Duñabeitia & García-Palacios, 2019; Fraga, 2019). Undoubtedly, researchers interested in affective neurolinguistics should be concerned with the contribution of aspects such as participants' gender, social and cultural background, language and emotion skills, emotional mood, experience with an emotion, emotion sensitivity or personality traits and states, just to give a few examples. Being aware of their importance, a few behavioural studies have begun to examine these questions. For instance, individuals with high disgust sensitivity, as measured with the Disgust Scale (Haidt et al., 1994), show delayed reactions times (RTs) and make more errors to disgust-related compared to neutral words in a lexical decision task. In contrast, participants with low disgust sensitivity show a processing advantage for disgusting relative to neutral words (Silva et al., 2012). Also, it has been reported that higher BAS-Drive scores, which is an index of the persistent pursuit of goals, seem to be related to slowdown in processing of fear-related words but not of happiness-related or neutral words (Mueller & Kuchinke, 2016). Finally, several neuroimaging studies have found reliable effects of participants' mood in a variety of morphosyntactic, semantic and phonological processes involved in both language comprehension and production (e.g. Chwilla et al., 2011; Egidi & Caramazza, 2014; Hinojosa et al., 2017; Rodríguez-Gómez et al., 2019; Van Berkum et al., 2013). These findings highlight the need to take into account individual differences both in brain imaging studies and in neurobiological theories of emotion processing in reading tasks. Besides, this approach might be particularly helpful to explain inconsistencies on neural activation patterns or to overcome statistically non-significant findings based on group averaging (Eugene et al., 2003; Hamann & Canli, 2004).

Regarding other aspects of the characteristics of the participants, several commentaries (Duñabeitia & García-Palacios, 2019; Herbert, 2019) refer to the processing of emotional language in non-adult populations. To the best of our knowledge, there are no prior neuroimaging studies investigating the interactions between language and emotion in children, a critical issue that might be of help in understanding how language and emotional skills develop from childhood to adulthood (as pointed out by Herbert, 2019). Evidence from behavioural studies has shown that by the end of the third year most children have learnt words describing basic feeling such as *happy* or *sad* (Nook et al., 2017; Ridgeway et al., 1985), or that the acquisition of emotional words dramatically increases between 4 and 11 years of age (Baron-Cohen et al., 2010; Li & Yu, 2015). In addition, the results of our own normative investigation indicate

that valence and arousal ratings decrease as the age of the children increase (from 7 to 13 years of age; Sabater et al., 2020). Finally, another set of studies has reported that the effects of emotional content on lexical processing are evident in 5–6 years-old children. A processing advantage for positive words has been generally found (Lund et al., 2019; Sylvester et al., 2016), particularly for abstract words (Ponari et al., 2018). This facilitation possibly arises from an earlier acquisition of positive compared to neutral or negative words in child development (Baron-Cohen et al., 2010; Li & Yu, 2015). The results of these studies are promising in providing a starting point for those researches interested in investigating the neural mechanisms underlying the development of emotional language. In a similar vein, the neural bases of the processing of affective language in aging populations remain largely unknown. However, there is evidence suggesting that older relative to young adults regulate their emotions and actions more effectively in response to audio-taped recordings describing negative social exchanges (Charles & Carstensen, 2008), show an impaired performance in tasks in which they have to match vocal expressions to emotion labels (Ryan et al., 2009), or have reduced abilities to recognise prosodic expressions (Lambrecht et al., 2012).

Language and emotion in communicative contexts

Duñabeitia and García-Palacios (2019), Kissler (2019) and Van Berkum (2019) made similar concerns regarding the need of a twist from the topics of our review, focused on the question of how language comprehension varies as a function of emotion, to the question of how emotion varies as a function of language. Crucially, these authors have correctly emphasised the fact that language is a strongly contextualised phenomenon, so the communicative intention of a speaker/message might differ in emotional ways (e.g. being sarcastic, hurt feelings, compliment or praise the comprehender) that elicit emotional effects in the recipient depending on her/his own personal and contextual circumstances. We fully agree with the proposal that makes a call for moving beyond a narrowed examination of just "coded" meaning of words and utterances themselves to the study of a contextualised (pragmatic) communicative act. In close relationship with this framework, the commentary by Citron (2019) focuses on a very illustrative example of how language might be particularly suited to convey affect. Throughout her commentary, Citron nicely shows that metaphorical and figurative language (including idioms, which are conventional figurative expressions) elicits enhanced emotional effects in readers compared to matched literal counterparts. This is reflected in stronger activation of the amygdala (Citron et al., 2016; Citron et al., 2019). Research on the connections between figurative language and emotion is still scarce. The development of normative studies assessing the emotional properties of figurative language will arguably contribute to the development of this field (e.g. Citron et al., 2020; Gavilán et al., submitted). In fact, there are several open questions that might call the attention of researchers in the future. Just to give an example, it has been suggested that there is a close relationship between emotion and bodily figurative language (Foolen, 2012), which possibly arises from a bias to locate feelings in inner organs (e.g. in expressions such as *she broke my heart*). Neuroimaging and psychophysiological measures seem to be especially suitable to investigate this particular feature of emotional language.

We will not repeat here all the possibilities that incorporating communicative context offers to researches interested in affective neurolinguistics, since they have been very nicely and extensively described in some of the commentaries to HM&F's article (Duñabeitia & García-Palacios, 2019; Kissler 2019; Van Berkum, 2019). Additionally, Van Berkum (see Figure 1 of his commentary) and Kissler (Figure 3 of her commentary) provide a tentative theoretical framework to guide future research. Importantly, these theoretical considerations need to be followed by the implementation of more ecologically valid experimental settings (as pointed out by Kissler, 2019). Some initial steps have already been made in this direction. Several studies have shown that linguistic emotional contexts modulate ERP responses to forthcoming facial expressions of emotions (Aguado, Diéguez-Risco, et al., 2019; Aguado, Parkington, et al., 2019; Diéguez-Risco et al., 2013, 2015). From a different perspective, another set of studies found ERPs effects when a real person compared to a computerised random programme provided them with individual feedback evaluations on personal traits (Schindler et al., 2015; Schindler & Kissler, 2016). These results nicely illustrate how participants' attributions about the sender of emotional messages modulate their brain activity. In a subsequent study, the authors compared how personality feedback given by an expert psychotherapist, a layperson or a randomly acting computer influenced ERP activity. Attributed expertise modulated brain responses in a linear fashion since expert feedback elicited higher brain activity than the layperson, with computer feedback prompting the lowest effects (Schindler, et al., 2019). This finding also relates to the use of emotional language in clinical contexts, an issue to which the commentary by Duñabeitia and García-Palacios (2019) calls

for attention. Besides examining the use of expressive language to regulate emotions, to develop coping strategies or to express a patients' needs, it might be also interesting to explore other aspects such as how clinical psychologists communicate their own emotional reactions or how these reactions influence decisions in the interventions or in establishing an effective therapeutic relationship (Kimmerling et al., 2000). Also crucial to clinical contexts, we should investigate more on people's inner thought/language production, as people can surely influence their own emotions by the way they talk to themselves. Word choice (e.g. "I am a stupid/wrong") and the timing of these type of inner thoughts become relevant issues. Thus, individuals suffering depression symptoms, for example, are most likely constructing a failed and ill-timed emotional internal dialogue.

A final aspect that we will consider in our reply relates to the importance of the linguistic background of the participants for eliciting emotions (see the commentaries by Duñabeitia & García-Palacios, 2019, and Kissler, 2019). It has generally been reported that emotional stimuli presented in a non-native language elicit decreased emotional responses compared to those presented in a native language. This result possibly arises from experiencing an increased psychological distance when processing emotional stimuli in a foreign language (Costa et al., 2014). For instance, behavioural studies have reported that a foreign language reduces emotional reactivity to moral dilemmas (Costa et al., 2014), emotional narratives (Jankowiak & Korpal, 2018) or the self-bias effect (Ivaz et al., 2016). Similarly, neuroimaging studies of bilingualism and emotion have shown that there is a processing advantage for emotional words in a first compared to a second language (Jończyk et al., 2016) or that taboo words are perceived as less offensive when presented in a second language (Sulpizio et al., 2019). ERP and fMRI evidence suggest that different mechanisms mediate the effects of emotion in native and non-native languages (Chen et al., 2015). In this sense, processing emotional words in a native language elicits increased EPN amplitudes and reduced activation of occipital cortices and the left cerebellum, whereas smaller N400 responses and increased activation of the left cerebellum are associated with processing emotional words in a foreign language. In contrast, other studies have failed to observe such differences in the processing of emotional stimuli in native and foreign languages (Conrad et al., 2011; Ferré et al., 2018). The discrepant findings might be accounted for by some theoretical proposals that highlight the importance of context-related factors in language acquisition. According to the "emotional-context-of-learning hypothesis" (Caldwell-Harris, 2014) a language is perceived as more emotional when it has been learnt and is used in emotional contexts, a proposal that is consistent with evidence showing increased emotional effects in a second language for bilinguals immersed in the foreign culture compared to those using their second language only in formal academic settings (Degner et al., 2012).

Conclusions

Up to date, most studies within the field of affective neurolinguistics have been concerned with the effects of emotional features on the processing of words and sentences. Although there are still some questions that remain unexplored under this approach as we have tried to outline in our response to some of the commentaries (Fraga, 2019; Herbert, 2019; Molinaro, 2019), a critical issue concerns the lack of a mechanistic account that explains how emotional content influences language processing (Kissler, 2019). In other words, we ought to move from the need (perhaps motivated by a historical neglect) to prove that language and emotion are married to investigate how their marriage relationship works out. Going beyond that, several commentaries to HM&F made strong claims on the need of broadening the scope of affective neurolinguistcs (Citron, 2019; Duñabeitia & García-Palacios, 2019; Herbert, 2019; Kissler, 2019; Van Berkum, 2019). We are fully sympathetic to the authors' plea of contextualising affective neurolinguistics by incorporating to its research programme and theoretical framework aspects such as the communicative and pragmatic functions of emotional language or the social, emotional and personality background of the senders and the receivers. The nice commentaries to HM&F provide a new index of the expansion rate of the "universe" of affective neurolinguistics. It is clear now that this "universe" is expanding faster than previously estimated and that we are far from being able to establish the limits of such expansion.

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