Journal of Environmental Management 206 (2018) 664–675

Contents lists available at ScienceDirect

Journal of Environmental Management

journal homepage: www.elsevier.com/locate/jenvman

Research article

Neural effects of environmental advertising: An fMRI analysis of voice age and temporal framing

Luis-Alberto Casado-Aranda*, Myriam Martínez-Fiestas, Juan Sánchez-Fernández

Department of Marketing and Market Research, University of Granada, Campus Universitario Cartuja, 18071, Granada, Spain

A R T I C L E I N F O

Article history:
Received 31 May 2017
Received in revised form
4 September 2017
Accepted 6 October 2017
Available online 10 November 2017

Keywords:
Environmental advertising
Voice age
Temporal frame
fMRI

A B S T R A C T

Ecological information offered to society through advertising enhances awareness of environmental issues, encourages development of sustainable attitudes and intentions, and can even alter behavior. This paper, by means of functional Magnetic Resonance Imaging (fMRI) and self-reports, explores the underlying mechanisms of processing ecological messages. The study specifically examines brain and behavioral responses to persuasive ecological messages that differ in temporal framing and in the age of the voice pronouncing them. The findings reveal that attitudes are more positive toward future-framed messages presented by young voices. The whole-brain analysis reveals that future-framed (FF) ecological messages trigger activation in brain areas related to imagery, prospective memories and episodic events, thus reflecting the involvement of past behaviors in future ecological actions. Past-framed messages (PF), in turn, elicit brain activations within the episodic system. Young voices (YV), in addition to triggering stronger activation in areas involved with the processing of high-timbre, high-pitched and high-intensity voices, are perceived as more emotional and motivational than old voices (OV) as activations in anterior cingulate cortex and amygdala. Messages expressed by older voices, in turn, exhibit stronger activation in areas formerly linked to low-pitched voices and voice gender perception. Interestingly, a link is identified between neural and self-report responses indicating that certain brain activations in response to future-framed messages and young voices predicted higher attitudes toward future-framed and young voice advertisements, respectively. The results of this study provide invaluable insight into the unconscious origin of attitudes toward environmental messages and indicate which voice and temporal frame of a message generate the greatest subconscious value.

1. Introduction

The growth of social problems resulting from the deterioration of the environment calls for changes in the behavior of members of society. Actions that are environmentally desirable such as lowering greenhouse gas emissions, reducing waste, and increasing clean energy and water, can only be met through higher levels of public participation (Brunson and Reiter, 1996; Mckenzie-Mohr, 2000). An approach with an outstanding potential to foster sustainable behaviors is the design of information-intensive advertising campaigns (VanDyke and Tedesco, 2016). Information offered to members of society or potential ecological consumers through advertising enhances awareness of environmental issues (Fraj-Andrés and Martínez-Salinas, 2007), encourages development of attitudes and intentions bolstering green consumption (Connell et al., 2014) and can even alter behavior (Han et al., 2010). Therefore, if designed properly, environmental messages can shape attitudes and decisions, and lead them in the direction of more responsible behaviors. Given the importance to a proper design of messages, most ecological advertising literature has focused on media features such us gain/loss framing (Tu et al., 2013) or message ambiguity (Leonidou et al., 2011) on attitudes, intentions or behaviors.

A media feature typical of environmental messages is temporal framing, a concept that in this case refers to the display of an ecological message using a specific reference to time (Chandran and Geeta, 2004). In environmental communication, a future frame (FF) reveals the consequences of acting in the future for/against the environment, while a past frame (PF) emphasizes the consequences of having acted for/against the environment (Antes and Mumford, 2009). Despite the importance afforded by many studies to future

* Corresponding author.
E-mail addresses: lcasado@ugr.es (L.-A. Casado-Aranda), mmfiestas@ugr.es (M. Martínez-Fiestas), sanchezf@ugr.es (J. Sánchez-Fernández).

https://doi.org/10.1016/j.jenvman.2017.10.006

framing (Kees, 2011; Xu et al., 2015), environmental communication research has advanced a variety of findings questioning which type of framing is more persuasive (Martin et al., 2011).

Ecological messages are habitually pronounced by voices differing in gender and age. While voice gender (male/female) has gained much interest in communication research, less attention has been paid to the question of whether the age of the voice, young (YV) or old (OV), plays a persuasive role and the current findings regarding this aspect are inconsistent (Mammarella et al., 2013; Zäske et al., 2013).

On the whole, there is little consensus regarding the media effects (e.g. attitudes toward messages) generated by the combination of temporal frames and voice age. Furthermore, most temporal framing and voice research has resorted to self-report techniques whose application requires revision due to the problem of the introduction of biases such as social desirability (Micu and Plummer, 2010). Both of these limitations highlight the importance of studies that analyze temporal framing and voice effects conjointly reverting to techniques such as neuroimaging that accurately measure underlying processes and neural mechanisms. One of the main benefits of adopting neuroscience methods in communication research is that it sheds light on how certain media features produce specific media effects (Weber et al., 2015). Given the potential of combining temporal framing and voice age in messages to promote responsible behavior (Trope and Liberman, 2003; Zäske et al., 2013), it is essential to identify the processes through which members of society and consumers judge media features in environmental advertising.

The aims of this paper are the following: i) test whether different brain areas are activated in response to future vs. past frames, ii) identify whether different brain areas are activated in response to young vs. old voices, iii) assess whether brain activations in response to future vs. past frame and young vs. old voice contrasts are linked to the attitude toward the messages.

To attain these aims, this study resorted to functional Magnetic Resonance Imaging (fMRI), a technique that provides indirect measurements of brain activation (Poldrack et al., 2017; Solnais, Andreu, Sánchez-Fernández, Andreu Joan, 2013). The study of the frame and voice data also offers a precise blueprint of the fMRI's ability to detect differences in brain activity.

2. Research and propositions

2.1. Future vs. past framing

Communication research literature is relatively unanimous regarding the effects of different message frames. Several studies (Martínez-Fiestas et al., 2015), for example, advance that messages designed with an emphasis on the positive (vs. negative) consequences of environmental responsibility generate higher persuasion. Less attention, however, is paid to temporal framing. Most communication research analyzes temporal framed messages from the standpoint of the Construal Level Theory (Trope, Yaacov and Liberman, 2010). According to this model, the more (vs. less) distant the framing of an event, the more likely it is represented in abstract (vs. concrete) terms. This suggests that altering the framing of a message's temporal distance could systematically affect the way future events (e.g. energy savings) are construed and thus, influence evaluation, processing and decision making (Trope and Liberman, 2003; Xu et al., 2015).

As in the case of high temporal distance messages, future- (vs. past-) framed messages are more abstract and impersonal, and thought to facilitate a greater amount of active analysis in imaging how the environmental event could potentially take place (Antes and Mumford, 2009). Designing environmental messages focused on the past, in turn, triggers subjective and experiential thoughts which maximize a potential self-threat associated with past behavior. Based on this reasoning, most studies conclude that future, messages may be more persuasive. The argument is that they lead to a better execution of strategy because they facilitate a more balanced contemplation of the reflected-upon situation, they lead people to apply broader categorization schemes and simpler structures, and they relate to future personal goals (Liberman et al., 2002; Martin et al., 2011). However, some studies of creative problem solving (Atance and O'Neill, 2001; Scott et al., 2005) find that past contexts provoke better solutions in participants due to the guidelines that their past experiences afford when encountering similar situations. Other research posits that future-framed messages, which fail to consider contextual information, may not be as persuasive in solving ethical/environmental problems as past-framed messages (Nokes and Ohlsson, 2005).

Neural activation during future and past-framed messages is an issue that also remains unclear (Addis et al., 2007). Wang et al. (2010) deduce that the degree of concrete processing evoked by the neural processing of factual (past and present) phrases differs from that of hypothetical (future) phrases. Most researchers agree with this reasoning and find that processing future (vs. past) messages is specifically associated with activation of the medial frontal cortex, lateral superior temporal gyri and other areas linked to imagery/simulation processes such as the lingual and calcarine areas (Gilead et al., 2013; Okuda et al., 2003; Szpunar et al., 2007). Other studies, on the contrary, identify specific brain areas when evoking the past (Okuda et al., 2003; Viard et al., 2011) such as the precuneus, middle and inferior temporal gyri, angular gyrus and hippocampus.

Other research in the language processing field has gone further and identified an overlap in brain activity when exposed to both future and past phrases by both the left (L) lateral superior temporal, medial prefrontal and superior occipital areas (Demblon, Bahri, and D'Argembeau, 2016) and the medial temporal and parietal regions (Okuda et al., 2003; Schacter and Addis, 2009). This discrepancy could be due to differences in the nature of the stimulation. Gilead, Liberman, and Maril (2013), for example, when attempting to pinpoint neural differences in future vs. past thoughts, reverted to concrete and abstract phrases made up of a transitive verb in the third-person, male, singular form, while Schacter and Addis (2009) and Addis et al. (2007) urged participants to remember or imagine personal (not external or impersonal) events of the past or future. Therein lies the interest in clarifying the neural mechanisms of past and future-framed messages when using third-person impersonal sentences characteristic of environmental messages.

2.2. Young vs. old voices

The voice conveying the message is the main communication tool and can influence attitudes, intentions and behaviors (Montoya, 2000). Communication literature analyzing the media effects of certain characteristics of the voice such as gender arrive at a relatively unanimous conclusion: the male voice generates higher credibility, confidence and expertise power and, consequently, appears to be more persuasive than the female voice (Martín-Santana et al., 2015). However, no research to date has delved into the question of the media effects (e.g. attitudes toward advertisements) of voice age (Zäske and Schweinberger, 2011). To better understand media effects generated by young vs. old voices it is necessary to turn to phonetics and social psychology studies focusing on biological differences. Specifically, young voices share a higher speaking rate, intensity and projection (Harnsberger et al., 2008), a higher variability of fundamental frequency (Glaze et al.,

1988) and a higher pitch (Weger et al., 2007). These natural, age-linked characteristics may have relevant effects in terms of affective variations of voice quality as high-pitch tones (e.g. young voices) are commonly associated with positive emotional reactions, whereas low-pitch tones (e.g. old voices) are linked to negative responses (Rodero et al., 2013). Other research findings indicate an increase in working memory among participants listening to the young vs. old voice (Mammarella et al., 2013). Despite these advances, the media effects such as attitudes toward persuasive messages pronounced by these different voices still remain unclear (Zäske et al., 2013).

Neither has there been a development of research directly on the neural correlates of young and old voices. Studies undertaken on neural mechanisms of high/low timbre or high/low pitch voices such as Hölig et al. (2014), for instance, conclude that the superior temporal sulcus responds to acoustic differences in speech such as timbre (e.g. high timbre: young voice; low timbre: old voice). Similarly, Lattner et al. (2005) record a strong response to high-pitched voices (e.g. young or female) in the right (R) superior/anterior temporal lobe and in the Heschl's gyrus and a stronger activation in response to low-pitched voices (e.g. old or male) in the subcallosal and inferior frontal gyri. Wiethoff et al. (2008) also point out that the (para)hippocampus and the middle frontal gyri are positively associated with voice intensity (e.g. higher activation of young voices).

2.3. Combination of temporal frame and voice age

Different voices (e.g. old and young voices) in a typical ecological media campaign pronounce environmental messages evoking the past or future. For example, Greenpeace recently resorted to young and old male voices for the following advertisements: “By changing normal bulbs for LED bulbs, you will save more than 85% of energy” (future-framed message) and “Last year we cleaned beaches and rivers to report plastic pollution” (past-framed message). Given the conjoint presentation of the media features, it is logical to analyze the media effects created by the combination of voice age and temporal frame. Furthermore, language processing literature suggests that it is not only important to analyze how listeners process the “what” (e.g. future/past-framed) of messages, but also how they process the “who” relaying the message (Belin et al., 2004). In that sense, this study aims to explore the behavioral and neural mechanisms through which participants process the combination of future vs. past frames (FF vs. PF) and young vs. old voices (YV vs. OV).

Based on the main currents advanced by the literature, we formally propose:

Proposition 1. *Areas in the brain linked to hypothetical thinking and imagery processing, namely the superior temporal gyrus, lingual and calcarine zones, are activated when contrasting future (FF x YV + FF x OV) vs. (PF x YV + PF x OV) past-framed messages. Areas included within the episodic system, such as the superior and middle temporal gyri, cuneus, angular gyrus and precuneus are activated, by contrast, when comparing past-framed (PF x YV + PF x OV) vs. future-framed (FF x YV + FF x OV) messages.*

Proposition 2. *The superior temporal sulcus, superior/anterior temporal lobe, Heschl's gyrus, (para)hippocampus and the middle frontal gyri, areas linked to high timbre, high-pitched voices and high-intensity processing, are strongly activated when comparing young (YV x FF + YV x PF) vs. old voices (OV x FF + OV x PF). In turn, areas related to low-pitched voices processing, such as the subcallosal and inferior frontal gyri, are activated when comparing old (OV x FF + OV x PF) vs. young voices (YV x FF + YV x PF).*

*Furthermore, given the importance from the behavioral perspective of understanding how specific brain areas can predict self-report responses (such as attitudes toward advertisements), this study also tested which brain regions activated during listening to future-past advertisements covary with individual differences in self-reported attitudes toward advertisements referring to future-past framing. Similarly, the study evaluates whether brain activations in response to young (vs. old) voices covary with the differences in attitudes toward advertisements presented by young and old voices. As in the case of previous research, we expected activation to covary in the areas most commonly linked to value such as the thalamus (*Clithero and Rangel, 2014*) or anterior cingulate cortex –ACC– (*Bartra et al., 2013*).*

3. Materials and methods

3.1. Participants

Thirty heterosexual right-handed subjects (15 women and 15 men) averaging 29.90 (SD: 9.21) years of age were selected to participate in the experiment via social networks and the institutional website of XXX University (March–May 2016). The initial survey enquired about intentions toward the purchase of environmentally friendly products by means of a seven-point Likert scale (1 = never; 7 = very often), a method that has served in other research to measure environmental behavior (Leiserowitz, Maibach, Roser Renouf, and Smith, 2011). Among the initial sampling, only the participants showing medium to high intentions toward ecological consumption ($M = 5.37$, SD = 1.43) were retained for reasons of control. All participants also were required to be in good health, medication-free, not afflicted by any neurological disease, not abuse drugs, and have normal (or corrected) vision and hearing. The sampling adhered to other common fMRI exclusion criteria (e.g. claustrophobia, pregnancy and metal implants in the body).

To access private medical information, the authors secured a written form from each participant following the ethical commitment consent. Before the outset of the project, the obtention of the consent, as well as the research in general, was reviewed and approved by the Vice-rector for Research and Transfer of XXX University (through the Ethics Committee of Human Research) following the protocol of the World Medical Association Declaration of Helsinki (2013).

3.2. Procedure

The study consisted of one session. Participants arrived at the laboratory 1 h prior to the start of the fMRI task. After instruction and verification that all the study procedures were understood, the participants completed the informed consent through a questionnaire. Subjects then underwent a series of fMRI scans, including two localizer scans, a structural scan, and functional scans. Over the course of the functional scans, the participants performed a passive-viewing task asking them to pay attention to some stimuli. After leaving the scanner, participants evaluated a survey with a set of messages that differed in temporal frame and age of voice. At the end of the session, participants were thanked and reimbursed.

3.3. Experimental design

The main objective of the experimental design was to put to test persuasive ecological audio messages in the past or future tense pronounced by young or old voices. To carry this out, the authors developed a 2 × 2 design with two independent variables (Temporal Frame and Voice Age), each containing two levels (Future Frame/Past Frame and Young Voice/Old Voice).

Future frame (FF) messages highlight the positive consequences of future environmentally responsible behavior (e.g. "If renewable energies are used, reserves of natural energy sources will increase"). Past frame (PF) sentences, by contrast, emphasize the positive consequences of being environmentally responsible (e.g. "If society had acted correctly, climate change effects would be lower"). It is worth noting that only the gain- (vs. loss-) framed messages were chosen for reasons of control and persuasiveness (Martínez Fiestas et al., 2015). Furthermore, all the (gain) future or past-framed messages were controlled in a pretest to refer to positive future and past frames.

The well-established higher credibility and persuasiveness of the male voice (Martín-Santana et al., 2015) led us to choose two male voices with a neutral Spanish accent: a ten-year-old (YV) and a forty-year-old (OV). The voices were recorded digitally via Adobe Audition 3.0 software at 44 100 Hz, 16 Bit-Stereo. The average fundamental frequency of each speaker was arranged to compare the voices (child voice pitch: 250 Hz; adult voice pitch 120 Hz). The recordings were then equalized with the PSOLA re-synthesis function of the PRAAT speech editing software. Intensities were normalized using the Cool Edit Speech editing software. Furthermore, all auditory stimuli were filtered for ambient noise and standardized for the average root mean square (RMS) power. Then, a sound pressure level (SPL) sensation of 70 dB on an average was applied to assure comfort, intelligibility and audibility given the background noise of the scanner. Stimuli were presented via an MRI compatible sound system by electrostatic headphones with E-Prime Version 2 Professional software.

The experimental design therefore had four conditions arising from the combination of the four levels of the factors (FF x YV, FF x OV, PF x YV, PF x OV). Each condition corresponded to one future/past message pronounced by a young/old voice (between 13 and 15 Spanish words each). During scanning, the subjects were subject to a total of forty 6 s messages randomly repeated three times each (with a black cross-hair on a homogenous black background screening). The messages were kept short as longer sequences are ill-advised in fMRI-hemodynamic response techniques (Schmälzle et al., 2015). Each participant was exposed to exactly 35 messages of each category. Moreover, 61 inter-stimuli intervals (ISI; same fixation point) of the same duration were randomly intercepted between messages. Two additional 12 s baseline periods with the same fixation point were presented at the beginning and end of the task. The total paradigm duration was 20.5 min. All the messages and the experimental fMRI task can be consulted in Appendix A and Appendix B.

3.4. Self-report measures

Five minutes after the scan, the participants took part in a behavioral task where they evaluated the messages under each of the four conditions. To carry this out, they were presented with the four 6 s messages viewed previously during the scanning: 1) FF x YV, 2) FF x OV, 3) PF x YV, and 4) PF x OV. All were presented in a pseudorandom order (Dale, 1999) with the variable ISIs ranging from 15 to 12 s. The total duration of the task was 1 min and 10 s.

After each message, the subject recorded his/her opinion on a semantic differential scale using the following five pairs of adjectives: a) non-arousing/arousing, b) non-informative/informative, c) irrelevant/relevant, d) dislike/like, and e) discourages/encourages responsible behavior. Since the preceding pairs of adjectives (except the latter) define the attitude toward an ad (Venkatraman et al., 2015), the study attempted to identify which voice ages and temporal frames generated a better attitude. The internal consistency (Cronbach's alpha) of the attitude toward the four messages measured by the five pairs of adjectives was acceptable in all cases.

Statistical analyses were performed using the IBM Statistical Package of the Social Science (IBM SPSS Version 20). Paired-Samples t-tests were set to determine whether participants showed higher attitudes toward advertisements presenting future vs. past messages, and young vs. old voices.

3.5. Image acquisition and preprocessing

Scanning was carried out with a Siemens Trio 3T MRI by descending slice acquisition and using a standard birdcage coil. Anatomical scans (T1 images) were acquired by a 3D MP-RAGE sequence using a sagittal orientation with 1 mm × 1 mm x 1 mm voxel size. Functional scans used a T2*-weighted gradient echo-planar imaging (EPI) sequence sensitive to the BOLD signal, TR = 2000 ms, TE = 25 ms, Flip Angle 90°, and a plane reduction of 3.5 × 3.5 × 3.5 mm corresponding the slice thickness. The distance factor of 20% resulted in a total of 680 slices, a slice matrix of 64 × 64 mm, and a Field of View of 238 mm with an axial orientation.

Functional data were pre-processed and analyzed using Statistical Parametric Mapping (SPM12, http://www.fil.ion.ucl.ac.uk/spm/software/spm12/) and implemented in MATLAB 2010b (Mathworks, Sherborn, MA). To avoid magnetic field saturation effects, image acquisition was preceded by seven volumes which were discarded before preprocessing. Corrections were then applied by means of interpolation with respect to the differences in the time of slice acquisition with the initial slice serving as the reference. The data in the first functional image were then realigned before the authors co-registered the functional and structural images. Next, the data were normalized according to the Montreal Neurological Institute (MNI) template using parameters defined for anatomic images. Finally, functional images were smoothed with the Gaussian kernel (7 mm FWHM). The mean functional images were visually inspected for artifacts. Furthermore, the realignment parameters of all subjects were examined. The Volume Artifact tool from ArtRepair (http://cibsr.stanford.edu/tools/human-brain-project/artrepair-software.html) then served to detect and repair anomalously noisy volumes. Volumes displaced more than .5 mm/TR were repaired. Based on these measures, two (female) participants were excluded from the analysis because too many volumes (>30%) required repair.

3.6. Analysis of the fMRI data

The following conditions were modeled using a canonical hemodynamic response function: future frame x young voice (FF x YV), future frame x old voice (FF x OV), past frame x young voice (PF x YV), and past frame x old voice (PF x OV). The rest periods (fixation points) were treated as the baseline. Six rigid body motion correction parameters were also included as nuisance covariates in the General Linear Model (GLM) implemented in SPM12. Data were high-pass filtered with a cutoff of 128 s.

3.6.1. Whole-brain analysis

On the first level (single subject analysis), the following contrasts were generated: i) future (FF x YV + FF x OV) vs. past (PF x YV + PF x OV) frames, and the reverse, and ii) young (YV x FF + YV x PF) vs. old (OV x FF + OV x PF) voices, and the reverse. On a second level, one-sample t-tests were carried out to examine the significant brain activation of the group during the contrasts mentioned above. The cp_cluster_Pthresh (https://goo.gl/kjVydz) tool was used to set the cluster extent threshold at a meaningful value. This tool offers a non-arbitrary, uncorrected threshold and cluster extent equal to a $p < 0.05$ corrected for multiple comparisons (FEW) across the whole brain. In this case, the threshold resulted in values of p < .001 with a cluster (*k*) 40. A more liberal threshold was applied given the exploratory nature of the analysis, as well as for completeness and future meta-analyses with a threshold of p < 0.001 uncorrected with a cluster extent of 5 and 10 voxels. Interaction effects between temporal frames and voice ages (e.g. FF x YV vs. FF x OV) were not modeled since the resulting brain activations only refer to the different condition (e.g. a contrast that would be similar to YV vs. OV).

3.6.2. Covariate analysis

To explore the brain regions where future framing activation is linked to the rating of attitudes toward future (vs. past) combinations, the contrast image of the future (FF x YV + FF x OV) vs. past (PF x YV + PF x OV) was entered into a one-sample *t*-test and the difference between the rating of attitude of future framing combinations (At future), and the scores given to the past framing (At past) combinations serving as a covariate. We proceeded in similar fashion to assess if brain regions related to young vs. old voices covaried with the difference of the rating between young voice combinations (At young) and the ratings of the old voice (At old) combinations.

4. Results

4.1. Self-report results

A paired-samples *t*-test showed significantly higher attitudes toward advertisements presenting future (FF x YV + FF x OV) as opposed to past (PF x YV + PF x OV) frames (t (1, 28) = 2.76, $p = 0.01$), as well as those pronounced by young (YV x FF + YV x PF) compared to old (OV x FF + OV x PF) voices (t (1, 27) = 3.95, $p = 0.001$) (see Fig. 1).

4.2. Functional imaging results

4.2.1. Future and past frame contrasts

Clusters in the bilateral superior temporal gyri, R lingual gyrus, L calcarine, L thalamus and R middle frontal gyrus were more strongly activated when comparing future-framed (FF x YV + FF x OV) vs. past-framed (PF x YV + PF x OV) advertisement messages. Conversely, the bilateral middle temporal gyri, the R pre(cuneus) and the L angular gyrus were activated more significantly by past rather than future messages. All results were thresholded at $p = 0.001$ uncorrected. See the results in Fig. 2 and peak coordinates in Table 1.

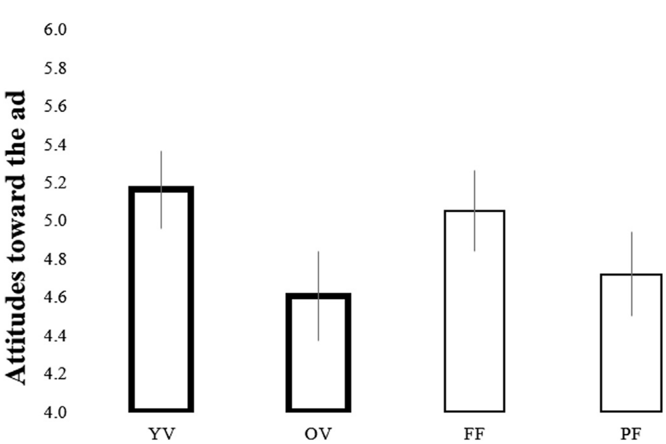

Fig. 1. Results of the paired samples t-tests. y-axis: Attitude toward the persuasive advertisements; x-axis: young voice (YV), old voice (OV), future frame (FF) and past frame (PF) combinations. Advertisements pronounced by young voices generated higher attitudes than old voices (t (1,27) = 3.95, $p = 0.001$). Advertisements presenting future-framed messages also yielded higher attitudes compared to the past-framed advertisements (t (1,27) = 2.76, $p = 0.01$). Standard Deviation is presented.

4.2.2. Young and old voice contrasts

The findings indicate, on an average, that the superior temporal, R Heschl's gyrus, L parahippocampus, L medial superior frontal, R anterior cingulum cortex, postcentral, hypoccampus and amygdala areas are significantly more active while subject to ecological messages conveyed by young (YV x FF + YV x PF) as opposed to old voices (OV x FF + OV x FF). The R precentral, L cerebellum and R inferior frontal triangulum gyri, by contrast, are strongly activated by old (vs. young) voices pronouncing environmental messages. All results are thresholded at $p = 0.001$ uncorrected. See results in Figs. 3 and 4 and peak coordinates in Table 2.

4.2.3. Association between neural responses and attitudes toward advertisements

The difference between the scores of attitudes toward future and past-framed messages covary significantly as evidenced with the activation of the R cerebellum ($r = 0.593$, $p = 0.001$), L cerebellum ($r = 0.617$, $p < .001$), R fusiform ($r = 0.545$, p = 0.003), R thalamus ($r = 0.535$, $p = 0.003$) and L middle occipital areas ($r = 0.539$, $p = 0.003$). Thus, participants who give higher ratings to future-framed messages show significantly stronger activation in these areas during future (vs. past) periods. Similarly, activation in the inferior ($r = 0.348$, $p = 0.069$) and middle ($r = 0.467$, $p = 0.012$) temporal gyri, as well as the ACC areas ($r = 0.422$, $p = 0.025$), are strongly (positively) associated with the differences in scores between attitudes toward messages pronounced by young and old voices. Therefore, participants who give the young voice a higher rating revealed more activation in those regions during young vs. old voice contrasts. See the main results plotted in Fig. 5 and Appendix C for all MNI peak coordinates.

5. Conclusions

This is the first study linking brain activation and self-report responses to persuasive ecological advertisements applying temporal framing and the age of the voice conveying the message. At the behavioral level, the findings clear up the discrepancy regarding the media effects generated by temporal framing and voice ages, and point to higher attitudes toward environmental advertisements with future framing pronounced by the young voice. At the brain level, the study characterizes a different set of regions in the brain activated by future as opposed to past-framed messages, and young as opposed to old voices and indicate that these are elements that are critical in processing persuasive ecological messages. Furthermore, the study identifies a link between neural and behavioral responses indicating that certain brain activations in response to future-framed messages or young voices covary, respectively, with attitudes toward future and young voice advertisements.

As regards the self-report responses, the current work infers higher attitudes toward advertisements with future-framed messages pronounced by young voices. These findings support the conclusions of other studies (Liberman et al., 2002; Martin et al., 2011) and point to a higher effectivity of ecological messages when designed with an emphasis on the future (vs. past) repercussions of being environmentally responsible. Moreover, this study makes headway in this field of research by evidencing that young voices are more persuasive than old ones in ecological advertising as they do not only provoke a higher working memory (Mammarella et al., 2013), but generate higher attitudes toward the messages.

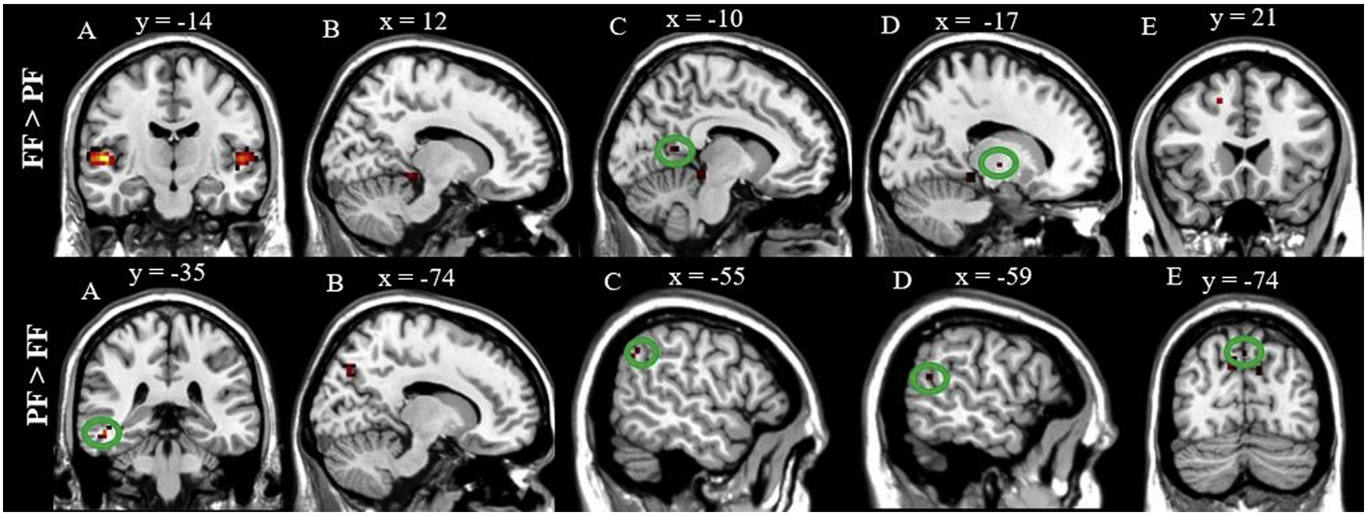

Fig. 2. Brain regions activated more strongly in response to future-framed vs. past-framed messages (FF > PF) and past-framed vs. future-framed messages (PF > FF). The upper part of the figure shows a T-map thresholded at $p < .001$ uncorrected for multiple comparisons ($T > 3.6$), superimposed on the mean anatomical image of all subjects (MNI-space). A: R and L superior temporal gyri; B: R lingual; C: L calcarine; D: L thalamus; E: R middle frontal gyrus. The lower part shows a T-map thresholded at $p < .001$ uncorrected for multiple comparisons ($T > 3.7$), superimposed on the mean anatomical image of all subjects (MNI-space). A: R middle temporal gyrus; B: R cuneus; C: L angular; D: L middle temporal gyrus; E: R precuneus. See corresponding peak coordinates in Table 1.

Table 1
Brain regions with stronger activation in response to future-framed (FF x YV + FF x OV) vs. past-framed (PF x YV + PF x OV) messages. Brain regions are activated differently in response to past-framed (PF x YV + PF x OV) vs. future-framed messages (FF x YV + FF x OV).

Brain region	Peak MNI-coordinates (mm)			Z	T	Effect Size [d]
	x[b]	y[b]	z[b]			
FF vs. P F						
R superior temporal [a]	50	−14	4	5.50	7.57	1.04
L superior temporal [a]	−48	−21	4	4.87	6.24	.92
R lingual [b]	12	−35	−7	3.85	4.49	.73
L calcarine [b]	−10	−56	11	3.47	3.94	.66
L thalamus [b]	−17	−11	0	3.33	3.75	.63
R middle frontal [b]	19	21	46	3.22	3.59	0.61
PF vs. FF						
R middle temporal [c]	50	−35	−11	4.02	4.76	0.76
R posterior cuneus [c]	12	−74	39	3.60	4.13	0.68
R posterior precuneus [c]	1	−74	46	3.16	5.51	.60
L angular [b]	−55	−60	35	3.48	3.95	.66
L middle temporal [b]	−59	−53	18	3.31	3.71	.63

[a] Peak of clusters significant at $p < .001$ uncorrected, $k \geq 40$ voxels are reported.
[b] No clusters survived at $p < .001$, $k \geq 40$. Peak of clusters significant at $p < .001$, $k \geq 5$ voxels are reported.
[c] No clusters survived at $p < .001$, $k \geq 40$. Peak of clusters significant at $p < .001$, $k \geq 10$ voxels are reported.
[d] Effect Size $= Z/\sqrt{N}$.

At the neural level, brain regions eliciting stronger activation during future-vs. past-framed messages include the middle frontal gyrus and bilateral superior temporal areas, the thalamus, and certain areas linked to visual processing. The middle frontal gyrus is thought to play a key role in temporal frame processing as a number of studies have pointed to an increase in activation of this area during the construction of both potential future scenarios and recollection of past events (Addis et al., 2007; Benoit et al., 2014; Demblon et al., 2016; Szpunar et al., 2009; Szpunar et al., 2007). Others, nonetheless, associate activation of this region with prospective memory where the intended action to be remembered occurs in the future (Burgess et al., 2003). In that line, certain studies point to activation of the middle frontal gyrus in the processing of hypothetical sentences (Gilead et al., 2013) and thinking of the future (Fellows and Farah, 2005; Okuda et al., 2003). The findings of this paper support this last reasoning and reveal a specialization of the middle frontal gyrus not only in imaging the future, but also in processing persuasive messages encouraging future sustainable behavior.

Although bilateral superior temporal activations are observed during both remembrance of the past and pondering the future (Addis et al., 2007; Okuda et al., 2003), Burgess et al. (2011) identify a specific co-activation of this area by the middle (pre)frontal gyrus when imaging the future. In the current study, nonetheless, activation of the bilateral superior temporal gyri only occurs during future- (vs. past-) framed messages. This finding supports the notion that this area, together with the middle frontal gyrus, is involved in prospective memory and future-framed message processing.

The thalamus is widely considered an area within the episodic system (Aggleton, and Brown, 2006; Carlesimo et al., 2011) responsible for memories of past personal events. In this current study, unexpected thalamic responses to future (vs. past) phrases could reveal a contribution of the episodic system (imaging responsible past behaviors, for example) in the processing of persuasive future messages, in line with the work of Addis et al. (2007). This suggests an influence of past behavior and memories when processing messages aimed at encouraging responsible future behavior, which means that how responsible society was in caring environment in past influences processing of persuasive future messages. The current study also singles out activation in the calcarine and lingual gyri in the comparison of the future vs. the past. These areas are most commonly associated with visual imagery (Ishai,2002; Lang et al., 1998; Rosenbaum et al., 2008). Its activation while exposed to future- (vs. past-) framed advertisements concurs with other studies (Gilead et al., 2013; Szpunar et al., 2009) and could highlight a higher tendency to imagine when thinking about the future in relation to past events.

Contrary to the conclusions of some studies that identify a common set of regions in past and future message processing (Demblon et al., 2016; Schacter and Addis, 2009), the current findings reveal specific brain responses to past vs. future advertisements in the bilateral middle temporal gyri, cuneus, precuneus and angular gyri. Together with the thalamus, the middle temporal

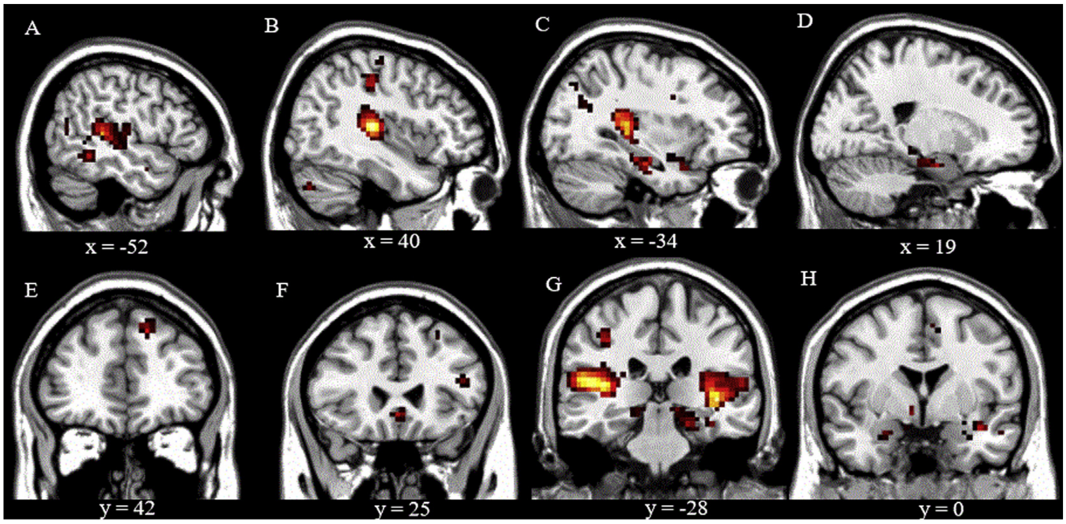

Fig. 3. Brain regions with stronger activation in response to YV vs. OV. T-map thresholded at $p < .001$ uncorrected for multiple comparisons ($T > 4.2$), superimposed on the mean anatomical image of all subjects (MNI-space). A: L superior temporal gyrus; B: Heschl's gyrus; C: L parahippocampus; D: R hippocampus; E: L medial superior frontal; F: R anterior cingulum; G: R postcentral gyrus; H: R amygdala; See corresponding peak coordinates in Table 2.

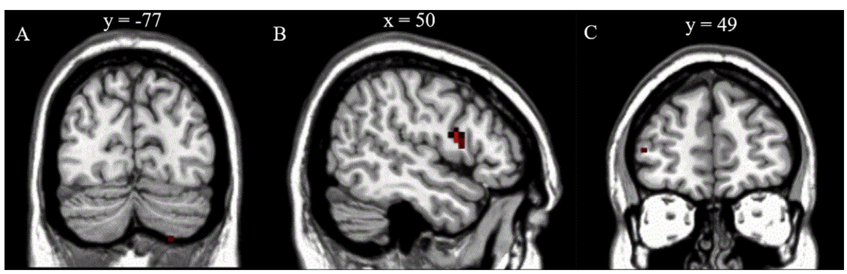

Fig. 4. Brain regions with stronger activation in response to OV vs. YV. T-map thresholded at $p < .001$ uncorrected for multiple comparisons ($T > 3.5$), superimposed on the mean anatomical image of all subjects (MNI-space). A: L cerebellum; B: R precentral; C: R inferior frontal triangulum. See corresponding peak coordinates in Table 2.

Table 2
Brain regions with stronger activation in response to a young voice (YV x FF + YV x PF) vs. an old voice (OV x FF x OV x PF). Brain regions are activated differently in response to the old voice (OV x FF x OV x PF) vs. the young voice (YV x FF + YV x PF).

Brain region	Peak MNI-coordinates (mm)			Z	T	Effect Size [c]
	x[b]	y[b]	z[b]			
YV vs OV [a]						
L superior temporal gyrus	−52	−35	7	4.94	6.37	.93
R Heschl' s area	40	−25	11	5.56	7.70	1.05
L parahippocapus	−34	−18	−21	4.44	5.45	.84
L medial superior frontal	−13	42	42	4.18	5.02	.79
R anterior cingulum	1	25	−7	4.13	4.93	.78
R postcentral gyrus	36	−28	42	4.12	4.92	.78
R hippocampus	19	−7	−21	4.10	4.89	.77
R amygdala	26	0	−21	3.70	4.27	.70
OV vs YV [b]						
R precentral	50	7	18	4.01	4.74	.76
L cerebellum	−24	−77	−53	3.32	3.73	.63
R inferior frontal triangulum	47	49	7	3.21	3.58	.61

[a] Peak of clusters significant at $p < .001$ uncorrected, $k \geq 40$ voxels are reported.
[b] No clusters survived at $p < .001$, $k \geq 40$. Peak of clusters significant at $p < .001$, $k \geq 5$ voxels are reported.
[c] Effect Size $= Z/\sqrt{N}$.

gyrus and the posterior (pre)cuneus areas play a critical role in encoding episodic (counterfactual) thinking (De Brigard, Addis, Schacter, and Giovanello, 2013; Haut et al., 2015). Furthermore, Okuda et al. (2003) identify such activations when analyzing recall of past (vs. future) events. The current findings also agree with previous studies (Abraham et al., 2008; Sestieri2011) indicating a strong link between angular gyrus activation and episodic memories. Taken together, the results of this paper bolster Proposition 1 and suggest the involvement of the episodic system not only in imaging future behaviors (through the thalamus), but in processing past ecological messages (through the middle temporal gyrus, cuneus and angular areas).

Different clusters of activation, in line with Proposition 2, are observed in the contrasts between young vs. old voices and old vs. young voices. Specifically, in the first case, the superior temporal gyrus, (para)hippocampus areas, Heschl's gyrus, medial superior frontal gyrus, postcentral gyrus, ACC and amygdala are strongly activated. Superior temporal and Heschl's gyrus areas are associated with high-timbre and high-pitched voices, as in the case of young voices (Lattner et al., 2005), while (para)hippocampal and middle frontal regions are positively correlated with voice intensity (e.g. young voices, Wiethoff et al., 2008). Therefore, activations of these areas while the subject listens to young (vs. old) voices strongly supports the involvement of those regions in processing high-timbre, high-pitched and high-intensity voices.

Contrary to expectations, activations in the postcentral, ACC and amygdala areas are recorded when comparing young vs. old voices. On the one hand, some fMRI studies analyzing emotional speech found postcentral activations when comparing female vs. male voices (Weston et al., 2015). Since female voices (like young voices) have a higher timbre and pitch than male voices (like old voices), it

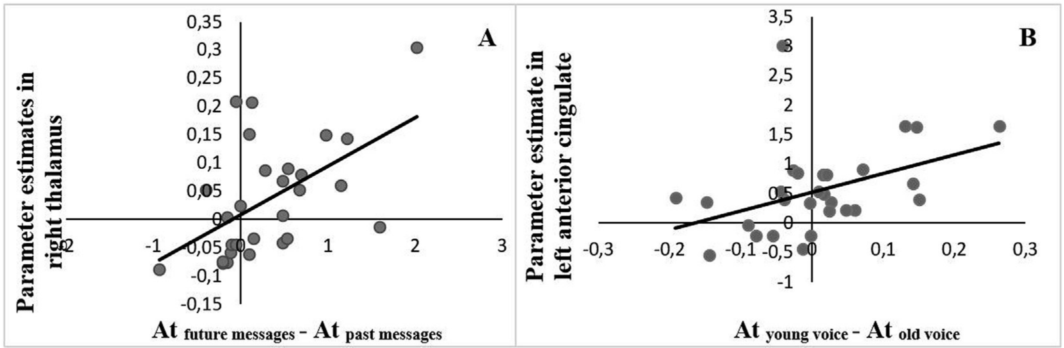

Fig. 5. Covariation between neural activation and attitudes toward advertisements. (A) Plot showing the correlation between parameter estimate future-vs. past-framed messages in the right thalamus cluster and the attitude toward advertisements that present future (vs. past) messages. (B) Plot showing correlation between the parameter of young vs. old voices in the left anterior cingulate cluster and the attitude toward advertisements pronounced by a young (vs. old) voice.

is reasonable to identify activation of the postcentral gyrus in young vs. old voices. On the other hand, a large amount of neuroimaging literature provides invaluable insight into the roles of the ACC and amygdala in assessing the salience of emotional and motivational information and the regulation of emotional responses (Drevets and Raichle, 1998; Vogt et al., 1992). Although it is necessary to remain prudent when arriving at inverse inference conclusions (Poldrack et al., 2017), activations of the ACC and the amygdala could reflect a higher relevance of ecological messages conveyed by young as opposed to old voices.

Furthermore, contrasts of the old vs. young voice result in the strong activation of areas in the brain including the inferior frontal gyrus, precentral and cerebellum. These results partially support the findings of Lattner et al. (2005) indicating that low-pitched voices (male or old) are processed in the inferior frontal gyrus. The cerebellum and precentral areas have previously been associated with voice gender perception (Joassin et al., 2011; Pulvermüller et al., 2006). Taken together, our findings indicate that these areas are also responsible for encoding the differences of age of the voice, revealing a higher activity linked to old as opposed to young voices.

The final goals of this paper are to determine the brain regions where future messages and young voice activation predicts attitudes toward future (vs. past) and young (vs. old) combinations. The current findings reveal that participants conferring higher scores to the advertisements that present future messages show stronger activation during future (vs. past) periods in some regions of the brain including the bilateral cerebellum, R fusiform, R thalamus and L middle occipital gyrus. Interestingly, the R thalamus is included as an area within the "valuation system" and, therefore, is responsible for encoding the subjective value signal and potentially contributing to value-based decision making (Bartra et al., 2013; Clithero and Rangel, 2014). Moreover, this area is shown to correlate with choices leading to later rewards (Sripada et al., 2011) and relevant phrase evaluations (Schiller et al., 2009). The stronger right thalamus activation in this study may reflect a higher subjective value and preference for future- (vs. past-) framed ecological advertisements, thus revealing the significance of these messages on increasing attitudes toward ecological messages.

Similarly, the higher ratings given to messages pronounced by young voices and the higher activation in the R inferior temporal, L ACC and R middle temporal gyri are in line with the expectations of Proposition 2. Interestingly, the ACC is associated with computing the subjective value (Bartra et al., 2013) and encoding predictive reward value (Kennerley et al., 2011). In fact, several studies link ACC activation with i) choices involving large gains and rewards (Rogers et al., 2004) and ii) the degree of reward expectancy (Brembs et al., 2002). Altogether, the higher ACC activation could well be related to higher rewards and subjective values generated by young (vs. old) voices conveying persuasive ecological messages.

It is noteworthy that participants while inside the scanner did not take part in any specific task besides paying attention to the stimuli. To better understand the neural correlates linked to processing audiovisual advertisements, it is advisable to examine neural activation as participants come to active decisions during scanning about future/past ecological advertisements conveyed by either young or old voices. Secondly, the findings indicate links between neural brain activation and attitudes toward the advertisements. Although it is widely accepted that increasing the attitudes toward messages may be a precursor of higher intentions to act according to the advertised behaviors (Ajzen, 1991), future research should link neural responses to intentions or actual responsible behaviors to better understand which brain areas predict actual behaviors or preferences. Thirdly, the findings of this paper should be taken with caution because of a participation limited only to subjects with medium to high intentions toward ecological consumption.

Despite these limitations, this study constitutes a preliminary step in advancing the understanding of consumers' neural and self-report responses to persuasive future/past-framed messages pronounced by young/old voices. In line with other research, the current findings reveal that young voices and future-framed messages increase attitudes toward environmental advertisements. This project is the first to shed light on neural responses to temporal-framed messages combined with voice age in ecological messages. The findings are the following: i) areas of the brain related to imagery, prospective memories and episodic events are strongly activated when subject to future- (vs. past-) framed messages, ii) past (vs. future) messages elicit activations within the episodic system; iii) young voices (YV) elicit stronger activation in areas linked to processing high-timbre, high-pitched and high-intensity voices; iv) areas previously associated with low-pitched voices and voice gender perception are strongly elicited by messages pronounced by older voices (OV). Furthermore, this study singles out that both the right thalamus response to future-framed messages and the ACC response to young voices reflect more positive attitudes toward environmental advertisements. Finally, future fMRI studies could attempt to make sense of unresolved problems in environmental advertising literature such as the proper level of assertiveness (Baek et al., 2015; O'Keefe, 1997) or degree of specificity (Leonidou et al., 2011; Mendleson and Polonksy, 1995) of messages.

Theoretically, our findings contribute to the literature of the challenges to create persuasive messages or public service announcements (PSAs) to discourage undesirable behaviors such as residential energy waste (Xu et al., 2015) or avoiding purchase of unsustainable food (Hanss, and Böhm, 2013; Miranda-Ackerman and Azzaro-Pantel, 2017) and cigarettes (Fish et al., 2017). This study clarifies the conjoint effects of very common elements in messages aiming to encourage environmental and planet care in future such as temporal framing and voice age. Furthermore, it constitutes a new step in the application of neurological tools to analyze processing environmental messages. Previous fMRI research has compared the neural effects of pro-environmental and non-environmental advertisements (Vezich et al., 2017) and analyzed the neural correlates of gain/loss frame (Vezich et al., 2016). This research goes further and sheds light on the neural responses to new (and little studied) environmental advertising elements of great potential such as temporal frame and voice age, which, furthermore, are very common to find together in practice. Finally, this paper also clears up previous inconsistent results regarding brain activity when exposed to both future and past messages (Okuda et al., 2003; Schacter and Addis, 2009). By controlling the type of sentence (third-person impersonal sentences), this research identifies different brain mechanisms toward future and past messages. Furthermore, this research confirms for the first time that young voices are indeed processed as more pitched, with higher intensity and more emotion than old ones.

The findings of this paper have remarkable managerial implications as they suggest that environmental messages relative to the future (and not the past) pronounced by young voices (not old) not only increase attitudes toward advertisements, but gain more subconscious relevance and appear to be more emotional. Higher subconscious emotions, relevance and attitudes toward ecological advertisements could be further translated into higher responsible attitudes or behaviors. Therefore, professionals of companies that market environmentally responsible products/ideas, as well as governments or environmental associations, should design their advertising campaigns evoking the future with messages pronounced by young voices.

Acknowledgements

This work was supported by an Excellence Project awarded by the Junta de Andalusia [REF: P12-SEJ-1980]; and a FPU (Formación Profesor Universitario) contract awarded by the Ministry of Education, Culture and Sports of Spain. [REF: FPU14/04736].

Appendix A

Table 1A
List of messages presented during the fMRI task.

Future framing
If society does not act now, the effects of climate change will soon become real.
If contamination of the ecosystems is halted, many species of the Arctic will return to their home.
Reducing levels of toxicity will significantly improve water and air quality.
Using fewer disposable products will reduce the need for new landfills.
Pamper the planet responsibly is the guarantee of it sustainability for future generations.
Reserves of natural energy sources will increase if renewable energies are used.
Children will breathe and drink more healthily if public transport is used.
Humans will reduce the holes in the ozone if less carbon dioxide is emitted
Turning of the switches off during sleep will reduce the intensity and frequency of fires.
Oceans of the future will be more vivid and clean if canned beverages are avoided.
Disposing trash in appropriate containers will improve the planet's fauna and flora.
If companies act responsibly they will reduce sub-tropical diseases.
The intensity of heat waves will be significantly reduced if LED bulbs are used.
Using water treatment plants will reduce the variability of the supply of water resources.
The creation of environmental awareness will reduce desertification and global salinization.
Halting the use of phytosanitary products will make the world a less harmful place.
2 million more children will live annually if the use of non-rechargeable batteries is minimized.
Refilling more biodiesel and less diesel will decrease the number of circulatory diseases.
Using recycled clothing will reduce the number of pollutant emissions into the atmosphere
A rational use of water will assure its supply in the coming decades.
Past framing
If society had acted, the current effects of climate change would be lower.
If recycled paper had been used, there would be 13 million more hectares of forest.
A multitude of species would have been preserved if garbage had not been thrown into public areas.
In the world, there would be more forests if there had been more environmental awareness.
If ecosystems had been cared for, migrations would have followed their biological course.
Today's sea level would be stable if toxic emission had been lower.
Consuming fewer transgenic organisms would have reduced diseases and epidemics.
Natural resources would not have been depleted if there had been investment in ecological education.
Being responsible would have saved 1 kilo of toxic gas for every 3 km of bike.
Cultivating the land with natural fertilizer would not have reduced the profitability of the herds.
There would be fewer respiratory illnesses if more public transport had been used.
There would be fewer hurricanes and tornadoes if biodiversity had been protected.
Fair business practices would not have increased the intensity and frequency of rains.
The current quality of life would be higher if renewable energy had been chosen
The reduction of toxic emissions would have slowed the melting of polar glaciers.
If more recycled paper had been used, many gallons of oil would have been saved.
The use of LED bulbs would have produced annual electrical savings in families.
Greater social ecological awareness would have increased recycling and reuse.
A greater purchase of organic products would have improved health.
Preserving biodiversity in the past would have maintained indigenous species.

Appendix B

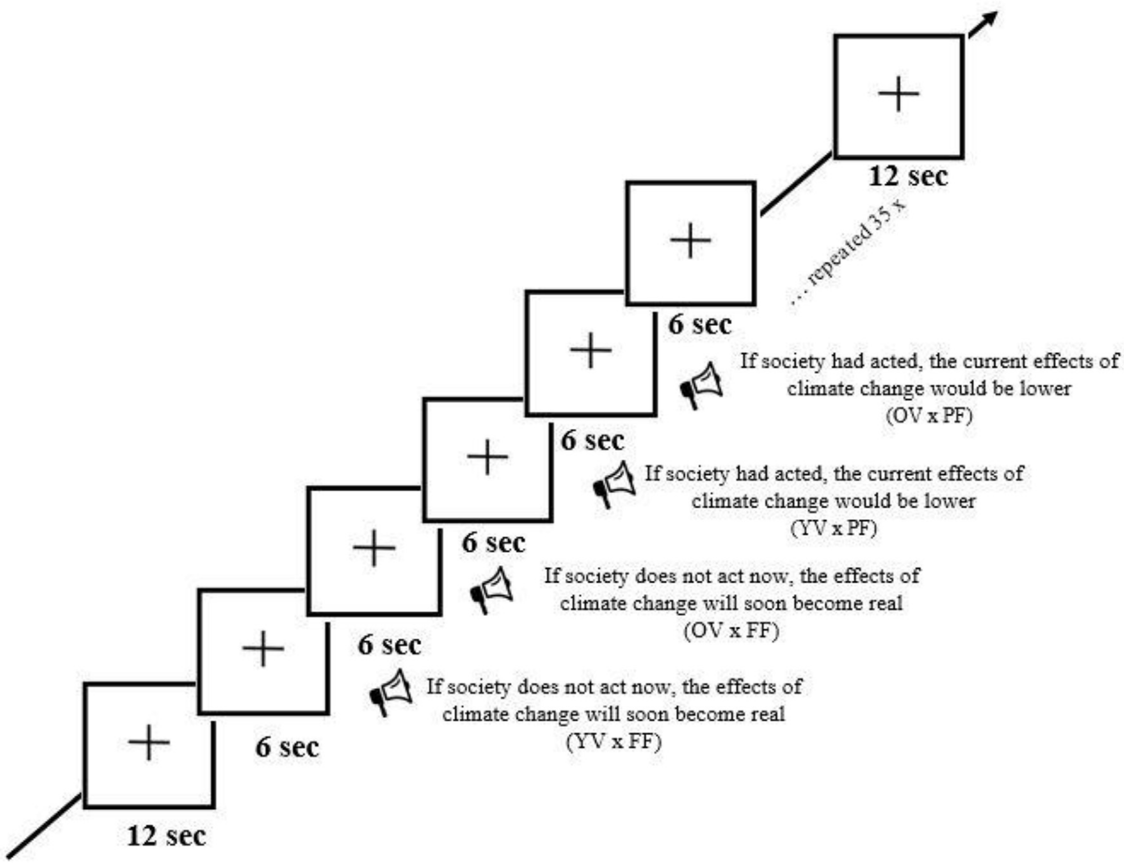

Fig. 1B. Representation of the experimental design during the fMRI task. The order corresponds to the first group of four trials. The conditions (FF x YV, FF x OV, PF x YV and PF x OV) are presented in random order in the subsequent 34 repetitions.

Appendix C

Table 1C
Main peak activation in covariation analysis. (1) Brain regions in which activation covaries greatly in attitudes toward future- (FF x YV + FF x OV) and past-framed (PF x YV + PF x OV) messages. (2) Brain regions in which activation covaries greatly in attitudes toward messages presented by young (YV x FF + YV x PF) and old (OV x FF + OV x PF) voices.

Brain region	Peak MNI-coordinates (mm)			Z	T	Effect Size[c]
	x[b]	y[b]	z[b]			
(1) FF vs PF[a]						
R cerebellum	8	−74	−11	4.65	5.89	.88
L cerebellum	−10	−53	−18	4.62	5.83	.88
R fusiform	33	−63	−7	4.07	4.88	.80
R thalamus	22	−18	0	3.77	4.40	0.71
L middle occipital gyrus	−38	−81	4	3.55	4.07	0.67
(2) YV vs OV[b]						
R inferior temporal gyrus	40	−11	−21	3.36	3.81	0.63
L anterior cingulum gyrus	−17	35	25	3.23	3.63	0.61
R middle temporal gyrus	50	−46	7	3.21	3.59	0.61

[a] Peak of clusters significant at $p < .001$ uncorrected, $k \geq 20$ voxels are reported.
[b] No clusters survived at $p < .001$, $k \geq 20$. Peak of clusters significant at $p < .001$, voxel level are reported.
[c] Size effect $= Z/\sqrt{N}$.

References

Abraham, Anna, Schubotz, Ricarda I., von Cramon, D. Yves, 2008. Thinking about the future versus the past in personal and non-personal contexts. Brain Res. 1233, 106–119. https://doi.org/10.1016/j.brainres.2008.07.084 (October).

Addis, Donna Rose, Wong, Alana T., Schacter, Daniel L., 2007. Remembering the past and imagining the future: common and distinct neural substrates during event construction and elaboration. Neuropsychologia 45 (7), 1363–1377. https://doi.org/10.1016/j.neuropsychologia.2006.10.016.

Aggleton, John P., Brown, Malcolm W., 2006. Interleaving brain systems for episodic and recognition memory. Trends Cognit. Sci. 10 (10), 455–463. https://doi.org/10.1016/j.tics.2006.08.003.

Ajzen, Icek, 1991. The theory of planned behavior. Organ. Behav. Hum. Decis. Process. 50 (2), 179–211. https://doi.org/10.1016/0749-5978(91)90020-T.

Antes, Alison L., Mumford, Michael D., 2009. Effects of time frame on creative thought: process versus problem-solving effects. Creativ. Res. J. 21 (2–3), 166–182. https://doi.org/10.1080/10400410902855267.

Atance, Cristina M., O'Neill, Daniela, 2001. Episodic future thinking. Trends Cognit. Sci. 5, 533–539. https://doi.org/10.1016/S1364-6613(00)01804-0.

Martínez-Fiestas, M., Isabel Viedma del Jesus, M., Sánchez-Fernández, J., Montoro-Ríos, F., 2015. A psychophysiological approach for measuring response to messaging: how consumers emotionally process green advertising. J. Advert. Res. 55 (2), 192. https://doi.org/10.2501/JAR-55-2-192-205.

Baek, T.H., Yoon, S., Kim, S., 2015. When environmental messages should be assertive: examining the moderating role of effort investment. Int. J. Advert. 34 (1), 135–157. https://doi.org/10.1080/02650487.2014.993513.

Bartra, O., McGuire, J.T., Kable, J.W., 2013. The valuation system: a coordinate-based meta-analysis of BOLD fMRI experiments examining neural correlates of subjective value. Neuroimage 76, 412–427. https://doi.org/10.1016/j.neuroimage.2013.02.063.

Belin, P., Fecteau, S., Bédard, C., 2004. Thinking the voice: neural correlates of voice perception. Trends Cognit. Sci. 8 (3), 129–135. https://doi.org/10.1016/j.tics.2004.01.008.

Benoit, R.G., Szpunar, K.K., Schacter, D.L., 2014. Ventromedial prefrontal cortex supports affective future simulation by integrating distributed knowledge. Proc. Natl. Acad. Sci. Unit. States Am. 111 (46), 16550–16555. https://doi.org/10.1073/pnas.1419274111.

Brembs, B., Lorenzetti, F.D., Reyes, F.D., Baxter, D.A., Byrne, J.H., 2002. Operant reward learning in Aplysia: neuronal correlates and mechanisms. Science 296 (5573), 1706–1709. https://doi.org/10.1126/science.1069434.

Brunson, M.W., Reiter, D.K., 1996. Effects of ecological information on judgments about scenic impacts of timber harvest. J. Environ. Manag. 46 (1), 31–41.

Burgess, P.W., Gonen-Yaacovi, G., Volle, E., 2011. Functional neuroimaging studies of prospective memory: what have we learnt so far? Neuropsychologia 49 (8), 2246–2257. https://doi.org/10.1016/j.neuropsychologia.2011.02.014.

Burgess, P.W., Scott, S.K., Frith, C.D., 2003. The role of the rostral frontal cortex (area 10) in prospective memory: a lateral versus medial dissociation. Neuropsychologia 41 (8), 906–918. https://doi.org/10.1016/S0028-3932(02)00327-5.

Carlesimo, G.A., Costa, A., Serra, L., Bozzali, M., Fadda, L., Caltagirone, C., 2011. Prospective memory in thalamic amnesia. Neuropsychologia 49 (8), 2199–2208. https://doi.org/10.1016/j.neuropsychologia.2010.11.013.

Chandran, Sucharita, Geeta, Menon, 2004. When a day means more than a year: effects of temporal framing on judgments of health risk. J. Consum. Res. 31, 375–389. https://doi.org/10.1086/422116.

Clithero, J.A., Rangel, A., 2014. Informatic parcellation of the network involved in the computation of subjective value. Soc. Cognit. Affect Neurosci. 9 (9), 1289–1302. https://doi.org/10.1093/scan/nst106.

Connell, P.M., Brucks, M., Nielsen, J.H., 2014. How childhood advertising exposure can create biased product evaluations that persist into adulthoo d. J. Consum. Res. 41 (1), 119–134. https://doi.org/10.1086/675218.

Dale, Anders M., 1999. Optimal experimental design for event-related fMRI. Hum. Brain Mapp. 8, 109–114. https://doi.org/10.1002/(SICI)1097-0193(1999)8, 2/3<109::AID-HBM7>3.0.CO;2-W.

De Brigard, F., Addis, D.R., Ford, J.H., Schacter, D.L., Giovanello, K.S., 2013. Remembering what could have happened: neural correlates of episodic counterfactual thinking. Neuropsychologia 51 (12), 2401–2414. https://doi.org/10.1016/j.neuropsychologia.2013.01.015.

Demblon, J., Bahri, M.A., D'Argembeau, A., 2016. Neural correlates of event clusters in past and future thoughts: how the brain integrates specific episodes with autobiographical knowledge. Neuroimage 127, 257–266. https://doi.org/10.1016/j.neuroimage.2015.11.062.

Drevets, W.C., Raichle, M.E., 1998. Suppression of regional cerebral blood during emotional versus higher cognitive implications for interactions between emotion and cognition. Cognit. Emot. 12 (3), 353–385. https://doi.org/10.1080/026999398379664.

Fellows, L.K., Farah, M.J., 2005. Dissociable elements of human foresight: a role for the ventromedial frontal lobes in framing the future, but not in discounting future rewards. Neuropsychologia 43 (8), 1214–1221. https://doi.org/10.1016/j.neuropsychologia.2004.07.018.

Fish, J.A., Peters, M.D.J., Ramsey, I., Sharplin, G., Corsini, N., Eckert, M., 2017. Effectiveness of public health messaging and communication channels during smoke events: a rapid systematic review. J. Environ. Manag. 193, 247–256. https://doi.org/10.1016/j.jenvman.2017.02.012.

Fraj-Andrés, E., Martínez-Salinas, E., 2007. Impact of environmental knowledge on ecological consumer behaviour. J. Int. Consum. Market. 19 (3), 73–102. https://doi.org/10.1300/J046v19n03_05.

Gilead, M., Liberman, N., Maril, A., 2013. The language of future-thought: an fMRI study of embodiment and tense processing. Neuroimage 65, 267–279. https://doi.org/10.1016/j.neuroimage.2012.09.073.

Glaze, Leslie, Bless, Diane, Milenkovic, Paul, Susser, Robin, 1988. Acoustic characteristics of Children's voice. J. Voice 2 (4), 312–319. https://doi.org/10.1016/S0892-1997(88)80023-7.

Han, H., Hsu, L.-T., Jane, Sheu, C., 2010. Application of the Theory of Planned Behavior to green hotel choice: testing the effect of environmental friendly activities. Tourism Manag. 31 (3), 325–334. https://doi.org/10.1016/j.tourman.2009.03.013.

Hanss, D., Böhm, G., 2013. Promoting purchases of sustainable groceries: an intervention study. J. Environ. Psychol. 33, 53–67. https://doi.org/10.1016/j.jenvp.2012.10.002.

Harnsberger, J.D., Shrivastav, R., Brown, W.S., Rothman, H., Hollien, H., 2008. Speaking rate and fundamental frequency as speech cues to perceived age. J. Voice 22 (1), 58–69. https://doi.org/10.1016/j.jvoice.2006.07.004.

Haut, K.M., van Erp, T.G.M., Knowlton, B., Bearden, C.E., Subotnik, K., Ventura, J., Cannon, T.D., 2015. Contributions of feature binding during encoding and functional connectivity of the medial temporal lobe structures to episodic memory deficits across the prodromal and first-episode phases of Schizophrenia. Clin. Psychol. Sci. 3 (2), 159–174. https://doi.org/10.1177/2167702614533949.

Hölig, C., Föcker, J., Best, A., Röder, B., Büchel, C., 2014. Brain systems mediating voice identity processing in blind humans: voice Identity Processing in Blind Humans. Hum. Brain Mapp. 35 (9), 4607–4619. https://doi.org/10.1002/hbm.22498.

Ishai, A., 2002. Visual imagery of famous faces: effects of memory and attention revealed by fMRI. Neuroimage 17 (4), 1729–1741. https://doi.org/10.1006/nimg.2002.1330.

Joassin, F., Maurage, P., Campanella, S., 2011. The neural network sustaining the crossmodal processing of human gender from faces and voices: an fMRI study. Neuroimage 54 (2), 1654–1661. https://doi.org/10.1016/j.neuroimage.2010.08.073.

Kees, J., 2011. Advertising framing effects and consideration of future consequences. J. Consum. Aff. 45 (1), 7–32. https://doi.org/10.1111/j.1745-6606.2010.01190.x.

Kennerley, S.W., Behrens, T.E.J., Wallis, J.D., 2011. Double dissociation of value computations in orbitofrontal and anterior cingulate neurons. Nat. Neurosci. 14 (12), 1581–1589. https://doi.org/10.1038/nn.2961.

Lang, P.J., Bradley, M.M., Fitzsimmons, J.R., Cuthbert, B.N., Scott, J.D., Moulder, B., Nangia, V., 1998. Emotional arousal and activation of the visual cortex: an fMRI analysis. Psychophysiology 35 (2), 199–210. https://doi.org/10.1111/1469-8986.3520199.

Lattner, S., Meyer, M.E., Friederici, A.D., 2005. Voice perception: sex, pitch, and the right hemisphere. Hum. Brain Mapp. 24 (1), 11–20. https://doi.org/10.1002/hbm.20065.

Leiserowitz, Anthony, Maibach, Edward, Roser-Renouf, Connie, Smith, Nicholas, 2011. Global Warming's Six Americas, May 2011. Yale University and George Mason University. http://www.earthtosky.org/content/course-content/2012-mini-course/Knowledege_of_Audience/SixAmericasMay2011.pdf.

Leonidou, L.C., Leonidou, C.N., Palihawadana, D., Hultman, M., 2011. Evaluating the green advertising practices of international firms: a trend analysis. Int. Market. Rev. 28 (1), 6–33. https://doi.org/10.1108/02651331111107080.

Liberman, N., Sagristano, M.D., Trope, Y., 2002. The effect of temporal distance on level of mental construal. J. Exp. Soc. Psychol. 38 (6), 523–534.

Mammarella, N., Fairfield, B., Frisullo, E., Domenico, A.D., 2013. Saying it with a natural child's voice! when affective auditory manipulations increase working memory in aging. Aging Ment. Health 17 (7), 853–862. https://doi.org/10.1080/13607863.2013.790929.

Martin, L.E., Stenmark, C.K., Thiel, C.E., Antes, A.L., Mumford, M.D., Connelly, S., Devenport, L.D., 2011. The influence of temporal orientation and affective frame on use of ethical decision-making strategies. Ethics Behav. 21 (2), 127–146. https://doi.org/10.1080/10508422.2011.551470.

Martín-Santana, J.D., Muela-Molina, C., Reinares-Lara, E., Rodríguez-Guerra, M., 2015. Effectiveness of radio spokesperson's gender, vocal pitch and accent and the use of music in radio advertising. BRQ Business Research Quarterly 18 (3), 143–160. https://doi.org/10.1016/j.brq.2014.06.001.

Mckenzie-Mohr, D., 2000. New ways to promote proenvironmental behavior: promoting sustainable behavior: an introduction to community-based social marketing. J. Soc. Issues 56 (3), 543–554. https://doi.org/10.1111/0022-4537.00183.

Mendleson, N., Polonsky, M.J., 1995. Using strategic alliances to develop credible green marketing. J. Consum. Market. 12 (2), 4–18. https://doi.org/10.1108/07363769510084867.

Micu, A.C., Plummer, J.T., 2010. Measurable emotions: how television advertisements really work – patterns of reactions to commercials can demonstrate advertising effectiveness. J. Advert. Res. 50 (2), 137. https://doi.org/10.2501/S0021849910091300.

Miranda-Ackerman, M.A., Azzaro-Pantel, C., 2017. Extending the scope of eco-labelling in the food industry to drive change beyond sustainable agriculture practices. J. Environ. Manag. Retrieved from http://www.sciencedirect.com/science/article/pii/S0301479717304863.

Montoya, Norminanda, 2000. The voice in the audiovisual publicity addressed to children and its persuading effectiveness [La voz de los anuncios y su eficacia persuasive en los niños]. Zer 8, 161–177.

Nokes, Timothy J., Ohlsson, Stellan, 2005. Comparing multiple paths to mastery: what is learned? Cogn. Sci. : A Multidiscipl. J. 29, 769–796. https://doi.org/10.1207/s15516709cog0000_32.

O'Keefe, D.J., 1997. Standpoint explicitness and persuasive effect: a meta-analytic review of the effects of varying conclusion articulation in persuasive messages. Argumentation Advocacy 34 (1), 1–12. https://www.scholars.northwestern.edu/en/publications/standpoint-explicitness-and-persuasive-effect-a-meta-analytic-rev.

Okuda, J., Fujii, T., Ohtake, H., Tsukiura, T., Tanji, K., Suzuki, K., Yamadori, A., 2003. Thinking of the future and past: the roles of the frontal pole and the medial temporal lobes. Neuroimage 19 (4), 1369–1380. https://doi.org/10.1016/S1053-8119(03)00179-4.

Poldrack, R.A., Baker, C.I., Durnez, J., Gorgolewski, K.J., Matthews, P.M., Munafò, M.R., Yarkoni, T., 2017. Scanning the horizon: towards transparent and reproducible neuroimaging research. Nat. Rev. Neurosci. https://doi.org/10.1038/nrn.2016.167.

Pulvermuller, F., Huss, M., Kherif, F., Moscoso del Prado Martin, F., Hauk, O., Shtyrov, Y., 2006. Motor cortex maps articulatory features of speech sounds. Proc. Natl. Acad. Sci. Unit. States Am. 103 (20), 7865–7870. https://doi.org/10.1073/pnas.0509989103.

Rodero, E., Larrea, O., Vázquez, M., 2013. Male and female voices in commercials: analysis of effectiveness, adequacy for the product, attention and recall. Sex. Roles 68 (5–6), 349–362. https://doi.org/10.1007/s11199-012-0247-y.

Rogers, R.D., Ramnani, N., Mackay, C., Wilson, J.L., Jezzard, P., Carter, C.S., Smith, S.M., 2004. Distinct portions of anterior cingulate cortex and medial prefrontal cortex are activated by reward processing in separable phases of decision-making cognition. Biol. Psychiatr. 55 (6), 594–602. https://doi.org/10.1016/j.biopsych.2003.11.012.

Rosenbaum, M., Sy, M., Pavlovich, K., Leibel, R.L., Hirsch, J., 2008. Leptin reverses weight loss–induced changes in regional neural activity responses to visual

food stimuli. J. Clin. Investig. 118 (7), 2583–2591. https://doi.org/10.1172/JCI35055.
Schacter, D.L., Addis, D.R., 2009. Remembering the past to imagine the future: a cognitive neuroscience perspective. Mil. Psychol. 21 (Suppl. 1), S108–S112. https://doi.org/10.1080/08995600802554748.
Schiller, D., Freeman, J.B., Mitchell, J.P., Uleman, J.S., Phelps, E.A., 2009. A neural mechanism of first impressions. Nat. Neurosci. 12 (4), 508–514. https://doi.org/10.1038/nn.2278.
Scott, Ginamarie, Lonergan, Devin, Mumford, Michael, 2005. Conceptual combination: alternative knowledge structures, alternative heuristics. Creativ. Res. J. 17, 21–36. https://doi.org/10.1207/s15326934crj1701_7.
Sestieri, Carlo, Corbetta, Maurizio, Romani, Gian, Shulman, Gordon, 2011. Episodic memory retrieval, parietal cortex, and the default mode network: functional and topographic analyses. J. Neurosci. 31 (12), 4407–4420. https://doi.org/10.1523/JNEUROSCI.3335-10.2011.
Schmälzle, R., Häcker, F.E.K., Honey, C.J., Hasson, U., 2015. Engaged listeners: shared neural processing of powerful political speeches. Soc. Cognit. Affect Neurosci. 10 (8), 1137–1143. https://doi.org/10.1093/scan/nsu168.
Solnais, C., Andreu-Perez, J., Sánchez-Fernández, J., Andréu-Abela, J., 2013. The contribution of neuroscience to consumer research: a conceptual framework and empirical review. J. Econ. Psychol. 36, 68–81. https://doi.org/10.1016/j.joep.2013.02.011.
Sripada, C.S., Gonzalez, R., Luan Phan, K., Liberzon, I., 2011. The neural correlates of intertemporal decision-making: contributions of subjective value, stimulus type, and trait impulsivity: neural Correlates of Intertemporal Decision-Making. Hum. Brain Mapp. 32 (10), 1637–1648. https://doi.org/10.1002/hbm.21136.
Szpunar, K.K., Chan, J.C.K., McDermott, K.B., 2009. Contextual processing in episodic future thought. Cerebr. Cortex 19 (7), 1539–1548. https://doi.org/10.1093/cercor/bhn191.
Szpunar, K.K., Watson, J.M., McDermott, K.B., 2007. Neural substrates of envisioning the future. Proc. Natl. Acad. Sci. Unit. States Am. 104 (2), 642–647.
Trope, Y., Liberman, N., 2003. Temporal construal. Psychol. Rev. 110 (3), 403–421. https://doi.org/10.1037/0033-295X.110.3.403.
Trope, Y., Liberman, Nira, 2010. Construal-level theory of psychological distance. Psychol. Rev. 117 (2), 440–463, 10.1037.
Tu, J.-C., Kao, T.-F., Tu, Y.-C., 2013. Influences of framing effect and green message on advertising effect. Soc. Behav. Person. Int. J. 41 (7), 1083–1098. https://doi.org/10.2224/sbp.2013.41.7.1083.
VanDyke, M., Tedesco, J., 2016. Understanding green content strategies: an analysis of environmental advertising frames from 1990 to 2010. Int. J. Strat. Comm. 10 (1), 36–50. https://doi.org/10.1080/1553118X.2015.1066379.
Venkatraman, V., Dimoka, A., Pavlou, P.A., Vo, K., Hampton, W., Bollinger, B., Winer, R.S., 2015. Predicting advertising Success beyond traditional measures: new insights from neurophysiological methods and market response modeling. J. Market. Res. 52 (4), 436–452. https://doi.org/10.1509/jmr.13.0593.
Vezich, S., Gunter, B., Lieberman, M., 2017. The mere green effect: an fMRI study of pro-environmental advertisements. Soc. Neurosci. 12 (4), 400–408. https://doi.org/10.1080/17470919.2016.1182587.
Vezich, I.S., Katzman, P.L., Ames, D.L., Falk, E.B., Lieberman, M.D., 2016. Modulating the neural bases of persuasion: why/how, gain/loss, and users/non-users. Soc. Cogn. Affect.Neurosci. https://doi.org/10.1093/scan/nsw113 nsw113.
Viard, Armelle, Chételat, Gaël, Lebreton, Karine, Desgranges, Béatrice, Landeau, Brigitte, Sayette, Vincent de La, Eustache, Francis, Piolin, Pascale, 2011. Mental time travel into the past and the future in healthy aged adults: an fMRI study. Brain Cognit. 75 (1), 1–9. https://doi.org/10.1016/j.bandc.2010.10.009.
Vogt, Brent, Finch, David, Olson, Carl, 1992. Functional heterogeneity in cingulate cortex: the anterior executive and posterior evaluative regions. Cerebr. Cortex 2, 435–443. https://doi.org/10.1093/cercor/2.6.435-a.
Wang, J., Conder, J.A., Blitzer, D.N., Shinkareva, S.V., 2010. Neural representation of abstract and concrete concepts: a meta-analysis of neuroimaging studies. Hum. Brain Mapp. 31 (10), 1459–1468. https://doi.org/10.1002/hbm.20950.
Weber, R., Mangus, J.M., Huskey, R., 2015. Brain imaging in communication research: a practical guide to understanding and evaluating fMRI studies. Commun. Methods Meas. 9 (1–2), 5–29. https://doi.org/10.1080/19312458.2014.999754.
Weger, U.W., Meier, B.P., Robinson, M.D., Inhoff, A.W., 2007. Things are sounding up: affective influences on auditory tone perception. Psychonomic Bull. Rev. 14 (3), 517–521.
Weston, P.S.J., Hunter, M.D., Sokhi, D.S., Wilkinson, I.D., Woodruff, P.W.R., 2015. Discrimination of voice gender in the human auditory cortex. Neuroimage 105, 208–214. https://doi.org/10.1016/j.neuroimage.2014.10.056.
Wiethoff, S., Wildgruber, D., Kreifelts, B., Becker, H., Herbert, C., Grodd, W., Ethofer, T., 2008. Cerebral processing of emotional prosody—influence of acoustic parameters and arousal. Neuroimage 39 (2), 885–893. https://doi.org/10.1016/j.neuroimage.2007.09.028.
World Medical Association, 2013. Principios Éticos para las investigaciones médicas en seres humanos. 64º Asamblea General. Available from: http://www.wma.net/es/20activities/10ethics/10helsinki/index.html.pdf?print-media-type&footer-right=[page]/[toPage].
Xu, X., Arpan, L.M., Chen, C., 2015. The moderating role of individual differences in responses to benefit and temporal framing of messages promoting residential energy saving. J. Environ. Psychol. 44, 95–108. https://doi.org/10.1016/j.jenvp.2015.09.004.
Zäske, R., Schweinberger, S.R., 2011. You are only as old as you sound: auditory aftereffects in vocal age perception. Hear. Res. 282 (1–2), 283–288. https://doi.org/10.1016/j.heares.2011.06.008.
Zäske, R., Skuk, V.G., Kaufmann, J.M., Schweinberger, S.R., 2013. Perceiving vocal age and gender: an adaptation approach. Acta Psychol. 144 (3), 583–593. https://doi.org/10.1016/j.actpsy.2013.09.009.