A body of evidence : ‘feeling in seeing’ predicts realness judgments for photojournalistic images.

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Abstract

Photography and photojournalism frame our experience of the world, especially in a culture powered by images at an unprecedented level. Images in the digital age and the era of alternative facts mediate our relations to other human beings and make our negotiation between what is real or fake challenging. We investigated how our visceral responses, as the basis of subjective feelings, influence our relation and responses to the authenticity of photojournalistic images. Higher neurophysiological and affective arousal at the first perception of an image predicted the probability with which participants would judge that image as ‘real’ in a subsequent session. These findings highlight the crucial role that physiology plays in engaging us with imagery, beyond cognitive processing. ‘Feeling in seeing’ seems to be a salient signal that at least partly determines our beliefs in a culture powered by images. By considering at the same time the underlying neural, physiological and cognitive mechanisms that guide our responses to images as well as the contextual cultural effects on how these mechanisms are recruited, these findings contribute to long-standing but still timely and multidisciplinary debates in visual culture.

“The work of the eyes is done.
Go now and do the heart-work on the images imprisoned within you.”
Rainer Maria Rilke

Introduction

Images in their many different forms, from paintings and icons to photography and beyond, have always been powerful cultural agents. Their performative power has been extensively discussed across disciplines, from art history¹ and the history of emotions² to media studies^{3,4}, and more recently in political sciences⁵. Images, and especially photographs, operate differently from words, as they appear to be truthful witnesses of reality⁶. In particular, the advent of photojournalism endowed photographs with substantial political power due to their capacity to *frame* reality with the help of the lens, and determine which subjects are made visible or not, and how. Nowadays, the power of images is further accentuated by their instantaneous dissemination in global digital media. In addition, the ‘democratisation’ of photojournalism has resulted in an unprecedented visualisation of our private lives as well as of social, political and cultural events⁵.

But now more than ever before, we are asked to judge the realness, truthfulness and trustworthiness of our social world. From mainstream news to social media posts, from edited photos to deep fake videos, from humans to bots, and from alternative facts to fake news⁷⁻⁹, we must judge the veracity of agents and the information they convey. Shortly after the inauguration of the 45th President of the United States of America, world audiences heard one of the President’s advisers using the term “alternative facts” to describe false statements made by the press secretary. The debate was about the attendance numbers of Trump’s inauguration. And while the images spoke for themselves, world audiences heard that there are “additional facts and alternative information”. Soon after, in April, Time magazine was asking on its cover page whether truth was dead. In our times where our understanding of major socio-political events is camera-mediated, our relations to images, the emotions they elicit in us and they we understand their authenticity are fundamental yet poorly understood aspects of our culture. Not only images are powerful cultural agents but they can also act as model instances of reality precisely because they come with the seductive belief that what we see in a photograph is an authentic representation of the world. Photographs are also emotive in more direct and immediate ways than language³. At the same time images can be manipulated and faked^{10,11}. Given the prominent and emotive role of images and their openness to manipulation, we set out to investigate the relation between physiological and emotional responses to images and the

judgments we make. In particular, we present a series of studies that employed a range of methods, from on-line experiments to lab-based peripheral psychophysiology and neuroimaging, to determine how physiological engagement with imagery how the physiological and emotional changes elicited when we look at photographs of human suffering may influence the judgments we make about their realness and authenticity.

Across all studies, participants only received partial information about the experiment when they sign up. In particular, upon admission to the experiment, participants were informed only about the first part of the experiment, and were told that this is an experiment where we study people's intensity of feeling when they look at photojournalistic images (Figure 1). Once they had completed that first part of the experiment during which they either provided self-reported measures of arousal or we recorded physiological changes (Study 2), they were informed about the second part of the experiment. At that point participants were informed that they must see all the images again, in a new random order, and judge whether each image is real or fake.

Figure 1: The design of Study 1 and its two parts. Participants first completed Part 1m during which they were only asked to rate the intensity of their feelings when viewing different images. At that time, participants were unaware that they would later be asked to judge the realness of these same images, a task that took place in Part 2.

Participants were given the following definitions: *Real* images were defined as photos depicting an “event as it happened when it happened. It was not staged in any way and the emotions and actions shown are genuine”. *Fake* images were defined as photos that appeared to show an “event that was staged or pictures that may have been manipulated in a way that alters the nature and/or the content of the event” (e.g. pictures taken from movies, created in a studio setting or digitally). Edited photos with adjustments of colour or luminosity were not

considered as ‘faking’ the original depiction of the moment. Thus, their response should be based on whether they judged the moment as authentic or not. Each participant first rated each photo in terms of arousal (i.e. how intense is the feeling that the image triggers in you; 1-100 scale) and, in the surprise second part task, provided a real or fake judgment followed a confidence rating on their evaluation, on a slider ranging from 1(not at all) to 50,(very confident). Binary judgments of “real” or “fake” were combined with confidence ratings to provide an index of “probability of realness” ranging from 1 (very likely to be fake) to 100 (very likely to be real) for each photo. Specifically, the confidence rating was incremented by 50 when the photo was judged as real and subtracted from 51 (i.e. $51 - \text{confidence rating}$) when judged as fake.

Results

Study 1(n= 80; online) used an online within-subject design (Figure 1) to test whether participant’s self-reported arousal during passive exposure to photojournalistic images would subsequently predict the judgments they make on whether each image is real or not. In our first model (further details see **Methods**), *Arousal ratings* significantly predicted the probability of judging an image as real ($\chi^2 = 21.26, p < 0.001$): the higher participants rated an image in terms of felt arousal in the first part of the experiment, the more likely they were to judge it as being real, in the second part of the experiment. The same effect of arousal was present in the second model ($\chi^2 = 21.53, p < 0.001$) when including the covariates of interest (*TAS*, *Political orientation*, *Gender* and *age*) (further details see **Methods**). Only, the age of participants was found to be a trend predictor of judging an image as real ($\chi^2 = 3.62, p = 0.052$) with younger participants more likely to judge images as real than older participants. Taken together, these results indicate that our self-reported arousal elicited when looking at negatively valenced images, informs our understanding of what we consider to be real. Older participants were less likely in considering a photojournalistic image to be real.

Figure 2: In Study 1, the tendency of saying that an image was real was predicted using a linear mixed-model analysis. The fixed-effects predictors of interests were Arousal, Age, Political Orientation, TAS, Gender, and the interactions between Arousal and the other predictors. The Participant ID was included as random-effects predictor so that the intercept could vary across participants with Arousal allowed to randomly vary across participants (i.e. random slope). The Picture ID was also included as random-effects predictor with Age allowed to randomly vary across participants. Panel A) and B) depict how the tendency of saying that an image was real is modulated by the Arousal and Age, respectively. More specifically, larger reported arousal predicted increased tendency to say that an image was real; The opposite pattern was observed for Age. Panel C) shows the (normalised) parameter estimates with their confidence intervals. When the zero is not included in the interval, the estimate can be considered significantly different than zero, i.e. it significantly explain variation of the dependent variable.

In **Study 2** ($n = 41$) we adapted the online-design of Study 1 to a laboratory setting (see **Methods**) to go beyond subjective appraisal of arousal and understand if the actual physiological reactivity to images predicts later judgements of realness. Now, participants were simply asked to passively observe each image while we recorded their cardiac activity and skin conductance (see Supplementary Material). Once again, they were only informed that they would be asked to provide judgments about the realness of each image at the end of the first part. Cardiac responses to emotional stimuli typically follow a biphasic pattern with an initial cardiac deceleration within the first ~3 seconds after stimuli onset – reflecting the fast engagement of the parasympathetic system and the allocation of attentional resources – followed by a subsequent cardiac acceleration marked by sympathetic dominance and higher levels of motivational and emotional intensity¹². To test how these different indices of physiological arousal predict “probability of realness”, we built separate models with either *initial heart deceleration* (i.e. inter-beat interval changes within the first 3 seconds), *final heart acceleration* (i.e. inter-beat interval changes within 3 and 7 seconds after stimulus onset) or

skin conductance (see results in SM) as dependent variables with the orders of photo presentation both in the first part (*Trial 1*) and in the second part (*Trial 2*) of the study entered as covariates of no interest (see further details in **Methods**). Results revealed that both initial heart deceleration ($Chisq = 5.26, p = 0.022$) and final heart acceleration ($Chisq = 7.60, p = 0.0058$) significantly predicted later judgments of realness. Specifically, smaller heart decelerations and larger heart accelerations were associated with increased probability judging an image as being real, a pattern that suggests the importance of sympathetic activation in shaping subjective believes of photo authenticity. In both models, Trial 1 ($Chisqs > 8.42, ps < 0.0038$) and Trial2 ($Chisqs > 4.95, ps < 0.027$) were found to be significant negative predictors, i.e. photos presented later in the task tended to be judged as less likely to be real. When adding the covariates to the model, both initial heart deceleration ($Chisq = 4.18, p = 0.041$) and final heart acceleration ($Chisq = 4.05, p = 0.044$) remained significant predictors. Interestingly, participants' level of alexithymia was found to be a significant predictor ($Chisq = 6.76, p = 0.0093$) as participants with high scores were more likely to judge images as fake, suggesting that those experiencing greater difficulties in identifying and understanding own emotions are also more distrustful of the authenticity of photojournalistic images.

Figure 3. HR findings in Study 2. Descriptive plots of the tendency of judging an image as real as a function of heartbeat change **A)** within 3 seconds after picture onset and **B)** 3 seconds after picture onset. For each participant, heartbeat changes were divided in an equal number of bins ($n=20$ bins) and the probability was then averaged across participants. Higher Inter Beat Interval (IBI) values in the initial 3 seconds reflect enhanced heart deceleration and lower IBI values in the final 3 seconds reflect increased heart acceleration.

These results show that changes in cardiac activity, reflecting sympathetic activation in response to the images presented, predict judgments of image authenticity, and suggest that bodily arousal, in addition to subjectively reported arousal (see Study 1) may bias one's cognitive appraisal of realness.

In **Study 3 (n=20)** we investigated whether we could identify a cortical signature for the proposed influence of cardiac arousal on these subjective judgements. Specifically, we used electroencephalography (EEG; BrainVision 64-electrode system) to understand if the amplitude of the Heartbeat Evoked Potential (HEP) during image presentation predicts people's judgements about the realness or not of the images. Unlike standard ERPs which reflect neural responses to externally presented stimuli, the events of interest for HEPs are the heartbeats and therefore it is considered that this electrophysiological signal reflects the cortical representation of ongoing cardiac activity¹³. Accordingly, research has demonstrated that directing attention towards own interoceptive sensations^{13,14} and self-body processing^{15,16} modulates HEP magnitude. Moreover, while HEPs have also been found to be enhanced during the perception of emotional stimuli (Lutz et al, 2015; Couto et al, 2014) it is thought that they do not index autonomic arousal, such as sympathetic activation or increased heart rate, but rather reflect cardiac afferent signalling and its cortical processing (Gray et al, 2007; Schulz et al, 2013; Park and Blanke, 2019).

Employing a paradigm similar to that of previous studies, we predicted that images evoking higher HEP amplitude during the initial passive observation task would be more likely to be judged as real in the second part of the task. During the first part of the task, participants passively view all 80 images while their brain activity was monitored with an EEG. To allow an adequate number of heartbeats to occur during each picture presentation, photos were displayed for 6 seconds and were presented twice, in two different blocks, and in random order. The second part of the task was identical to that of Study 2.

For each participant, the events of interest, i.e. heartbeats occurring during each image presentation in part one, were classified as having high (*High Prob*) or low (*Low Prob*) probability of being real through a median split on the participant's individual probability judgments. Monte Carlo cluster-based permutations comparing brain activity during *High Prob* and *Low Prob* photos were run with FieldTrip toolbox (<http://www.fieldtriptoolbox.org/>) to identify, temporally and spatially (see *Methods*), HEPs with different amplitudes in the two conditions (Maris & Oostenveld, 2007). We observed a significant difference between images

with a *High Prob* and *Low Prob* to be judged as real: $t = 386$, $p = 0.0135$, between 495-560 ms (465-530 ms post R peak). The difference was most pronounced in the central region (FC3, FC2, FC4, C3, C1, C2, C3, CP1, CPz, CP2) (Figure 4; see **Methods**). These findings expand those of Studies 1-2 by showing that a neural index of heartbeat processing can predict judgements of photo authenticity, thus, providing important evidence in support of a direct neural link between bodily reactions and the perception of what's real.

Figure 4. The results of Study 3. Left panel: The average of High and Low probability trials plotted over significant electrodes (AFZ, Fz, F1, F2, F3, FC3, FC1, FCz, FC2, FC4, C3, C1, Cz, C2, C4, CP1, CPz, CP2). Right panel: Topography distribution of the difference in amplitude between High Prob and Low Prob conditions.

We next designed an implicit measure of the realness judgment. In **Study 4 (n=69; online)** we did not ask participants to make explicit judgments about the realness of the images. Instead, after obtaining their arousal ratings during Part 1 as in the previous studies, we then informed participants during Part 2, that the authenticity of each image had been determined by independent fact-checkers. We then showed them all images in a new randomised order together with a fictitious fact-checked label (i.e. real or fake) and asked participants to indicate to what extent they were surprised with the label.

Figure 5: Design of Study 4

We hypothesized that if images eliciting high arousal during the first presentation, and thus more affectively engaging, were fact-checked as “fake”, participants would report greater surprise. That measure of surprise could be thought of as a prediction error if arousal is indeed a key driver of people’s beliefs in the realness of the image. Consequently, the prediction error would be higher for images that were perceived as highly arousing and fact-checked as “fake”. Participants performed three parts of the experiment. In the first part, they rated their arousal after seeing each image, in the second part they were exposed to fact-checking information and had to rate how surprised they were to see the label –“real” or “fake”- associated to the image in question. In our first model (see **Methods**) *Arousal* ratings, fact-checked *Label* (*Real/Fake*) and their interaction as fixed effects were used to predict Surprise (see **Methods** for random effects structure). We found a significant interaction between *Label* with *Arousal* ($\chi^2 = 7.24, p = 0.0071$). This interaction shows that, in line with our prediction, participants were more surprised when learning that images that they had previously perceived as highly arousing were fact-checked as ‘fake’.

Figure 6: Descriptive plot of the Surprise provided by the participants in the second part of Study 4 as a function of Arousal and Label. For each participant, the Arousal values were divided in an equal number of bins ($n=20$ bins) and the Surprise was then averaged across participants. Error bars indicate standard error of the means.

Taken together our results highlight the predictive power of a bodily feeling state in form of arousal when this prediction is violated by ‘factual’ information about the nature of an image, indexed in this study as heightened surprise to images that were previously perceived as highly arousing and were subsequently fact-checked as ‘fake’. The fact that the other type of prediction error, namely cases where an image elicited low arousal but was subsequently fact-checked as “real” did not elicit high surprise suggests that it is the saliency of the affective experience when first encountering the image that increases the precision of the prediction which is subsequently violated by the “fake” label. Thus, it is not simply a prediction error driven by a purely cognitive dissonance as it would be the case for images for which affective saliency was low during the first encounter and that image was subsequently judged as “real”. This pattern supports the role that interoceptive predictions play in determining our beliefs about realness and truthiness.

Pictures do not simply tell a story. They also convey emotions. The induced emotional states can be quite different based on the situation depicted in the image. Do induced emotions influence the judgment of observers? In other words, do the type of emotional states associated with an image influence whether the image will be judged as real or not? In **Study 5** (see also Methods), we aimed at quantifying the participants' emotional states (i.e. pattern of emotions) associated to our set of images. In Part 1, each image was presented once for 3 seconds. Next, a new page appeared with a list of 15 emotions (Anger/Rage, Compassion, Disgust, Excitement, Fear, Guilt, Hope, Joy, Pain, Pleasure, Remorse, Sadness, Shame, Tenderness, or Nothing), and participants were instructed to the emotions that they felt most while seeing the previous image. After selecting the emotions, participants were presented with a slider bar for each selected emotion and were asked to use it to indicate the intensity of the selected emotion(s). Each slider was also associated to the label of the chosen emotion(s).

As with previous studies, after the end of Part 1, we asked participants to judge whether the image depicted real or fake (e.g. staged) situations. If specific emotions do not play a role in this kind of decisions, we should have observed a similar type of judgment across the different types of emotional states elicited by the various images. Using unsupervised methods (i.e. PCA and K-means), we investigated the five principal dimensions that best explained the variance of the emotional patterns and identified two clusters that we labelled *Violence* and *Suffering*. Subsequently, we used multiple regression analysis and the identified PCs as explanatory variables to explain the variance observed in the real judgment. Interestingly, we observed that the images depicting suffering situations that were more associated to compassion, tenderness and sadness were generally considered more real than those images depicting violence that were associated to anger, disgust, and fear

As expected, images elicited complex patterns of emotions and some of these emotional states were similar across some of the images, as shown in the correlation plot (see Figure XXX in supplementary materials). In order to reduce the number of dimensions (i.e. 14 emotions), we ran a principal component analysis (PCA). Based on the Scree plot of the resulting eigenvalues, we focused the subsequent analyses on the first 5 principal components that explained 76.45% of the total variance. The loadings of the components for each emotion are shown in Table 1 (see supplementary materials). We labelled the components based on the most prominent loadings (in absolute value) of the component except for component 2. For the first component, the largest positive loading was *Compassion* (0.9) and the largest negative loading was *Anger* (-0.63). We therefore labelled this component "*Anger/Compassion*". Other loadings larger than

0.3 were *Tenderness* and *Sadness* (positive values); and *Disgust*, *Fear*, *Excitement*, *Pleasure* (negative values). In other words, images with high scores in this component, were rated high in compassion, tenderness and sadness, and low in disgust fear, excitement, and pleasure. For the second component, the largest positive value was joy (0.86) followed by *Pleasure*, *Excitement*, and *Hope*; the largest negative was *Disgust* (-0.39) followed by *Anger* and *Sadness*. We therefore labelled this component “*Negative/Positive*”. For the third component, the largest loading was *Shame* (0.79) followed by *Guilt*, *Disgust*, *Pleasure*, and *Anger*; the largest negative was *Fear*(0.46). We therefore called this component “*Fear/Shame*”. For the fourth component, the largest loading was *Pain* (0.82) followed by *Remorse* and *Sadness*; the largest negative was *Hope* (-0.36) followed by *Shame*. We therefore called this component “*Hope/Pain*”. For the fifth component, the largest loading was *Hope* (0.6) followed by *Remorse*; the largest negative was *Guilt* (-0.17) followed by. We therefore called this component “*Guilt/Hope*”.

We then computed the (Pearson) correlation between each variable and the probability score variable (see Table 2 in Supplementary Materials). Only components 1 and 5 had a correlation significantly larger than zero (*Anger/Compassion*: $r=0.33$, $pval=0.003$, $ci=[0.12, - 0.51]$; *Guilt/Hope*: $r=0.34$, $pval=0.002$, $ci=[0.13, - 0.52]$). Figure 1 shows how the images were distributed according to these two components. The two axes have been labelled using the emotions associated to the components (X: *Anger/Compassion*; Y: *Guilt/Hope*). Most of the pictures on the left side of the plots depicted violence-related situation; the ones on the right side depicted suffering-related episodes. We then used a K-means analysis¹⁷ to clusterize the images in a unsupervised way. Based on the Silhouette method¹⁸, we used two clusters. Results are shown in the top-left subplot of Figure 1 when each dot corresponds to each image in the main plot. We labelled the yellow cluster “*Violence*” and the blue cluster “*Suffering*”. One image appeared to be an outlier (the soldier peacefully walking with the kids, a positive image) and in fact the Silhouette analysis revealed that this image had a negative silhouette width, suggesting that this image was not properly part of the cluster. The two group of images can be separately visualised in the supplementary materials.

To better quantify the relationship between the explanatory variables and probability score, we ran a multiple regression analysis (all variables were included). The model significantly fitted the data [$F(5, 74)= 5.12$, $pval<0.001$] and explained around 20% of the observed variance. The estimated significant coefficients were 1.943 for *Anger/Compassion* and 3.90 for *Guilt/Hope*. Therefore, for each unit increase in *Anger/Compassion*, the probability score of an image would increase of around 2 units and for each unit increase in *Guilt/Hope*, the probability score

would increase of almost 4 units. Figure 7 shows the scatterplots between each variable and the realness and the related (scaled) coefficient intervals.

Figure 7. Pictures PC 1 and 5. Pictures organized based on the principal components 1 (Anger/Compassion) and 5 (Guilt/Hope). The labels to the components were given based on the most prominent (in absolute value) loadings in the components. The subplot in the top-right indicate the clusters identified by the KMeans analysis. Each dot is a picture as represented in the main plot. We labelled the yellow cluster “Violence” as most of the images depicted violence-related episodes; and the blue cluster “Suffering”, as most of the images depicted suffering. The green dot appears to be an outlier (a soldier peacefully walking with kids, a positive image). The Kmeans analysis included this picture in the Violence group, but the Silhouette analysis revealed that it had a negative silhouette value, suggesting that it was not properly part of the cluster. We therefore removed this picture from the cluster.

Figure 8. Multiple regression analysis. The five principal components resulting from the PCA analysis were used as predictor for a multiple regression analysis to explain the probability scores (averaged across participants) variability of the pictures. Panels A-E show the partial plots of each dimension with the averaged probability score; Panel F show the Confidence Intervals of the estimated coefficients (in standard units).

In the previous studies the stimuli set consisted on authentic photojournalistic images depicting real life events. In **Study 6 (n=80 - online)**, we used “fake” photos with similar themes, e.g. security or emergency drill operations, to investigate if the observed effects are also present when judging the authenticity of “fake” photos (see **Methods** for details on stimuli selection process). Hence, we exposed participants to 40 images depicting real life emergency events matched to 40 images depicting drill scenarios (total n=80) and asked them, as before, to rate their felt arousal after each image. In a second part of the experiment, we asked participants, to indicate how much they believed an image was true, and how confident they were about their choice.

Figure 9. Descriptive plot of the tendency of saying that a picture was real in Study 6 as a function of Arousal and Label. For each participant, the Arousal values were divided in an equal number of bins ($n=20$ bins) and the Probability was then averaged across participants. Error bars indicate standard error of the means.

In our first model (see **Methods** for details), we replicated our standard *Arousal* ($Chisq = 8.47, p = 0.0036$) effect. and show that images depicting “fake”, i.e. drill, events were less likely to be rated as real ($Chisq = 25.28, p < 0.001$). Importantly however, the interaction between *Arousal* and image *Authenticity* ($Chisq = 1.41, p = 0.234$) confirming that perceived arousal predicts beliefs or realness independently of actual picture authenticity. When adding our covariates of interest to the model (*TAS, age, gender, political orientation*) the results remained unchanged. That is, image *Authenticity* ($Chisq = 7.62, p = 0.0058$) reported Arousal ($Chisq = 23.10, p < 0.001$) were found to be significant predictors but their interaction was not ($Chisq = 0.75, p = 0.39$). Interestingly, TAS was found once more to be a negative predictor of the likelihood of judging photos as real ($Chisq = 15.34, p < 0.001$). Finally, we also found an interaction between image *Authenticity* and *Gender* ($Chisq = 4.83, p = 0.028$) but post-hocs did not reveal consistent differences between genders in realness judgments as a function of image Authenticity ($ps > 0.05$). No other interaction was

significant. Taken together, we observed participants being fairly accurate in estimating the images' realness, as shown by the significant main effect of image condition. Further, we replicated in another stimuli-set our prior findings of arousal and alexithymia in estimating real images to be real.

Discussion

The question of the authenticity of images has a long history, from art forgeries to manipulated photographs in Stalin's Soviet Union to modern day deep fake technology. How we define, perceive, and relate to the authenticity of imagery becomes even more important when we consider the political capacity of images and their pervasive presence in social media. Images and in particular photojournalism are increasingly used to inform but also misinform audiences worldwide. It is not only the medium itself that inherently reflects a biased representation of reality but also its emotive use and technological manipulation that afford the spread of misinformation. Whether in isolation or alongside textual information, images enhance people's biases in believing the truthiness of information¹⁹. Central to our relations to images are the emotions that they elicit as images invite us to empathize or dissociate from the depictions of human condition. While factors relating to our cognitive style²⁰, framing and contextual effects²¹ and professional expertise²² influence the views we form about the images we look at, we here set out to understand how our physiological and affective engagement with images can influence the judgments we make about their authenticity.

Across six studies we consistently observed that indices of affective reactions to images, predicted the extent to which people perceived photojournalistic images of human suffering as real, rather than fake or staged. That was the case for the intensity of subjectively reported arousal (Study 1) to the magnitude of peripheral (Study 2) and central (Study 3) physiological reactivity and interoceptive signalling. In addition we further validated this relation in a set of images that contained both real and staged photographs (Study 5) and with the use of an implicit measure operationalized as a "surprise" or prediction error measure when subjective indices of arousal were violated by fact-checking (Study 4).

The observation that physiological signals play such a role in influencing our beliefs in the realness of images is consistent with current views in social-affective neuroscience about our embodied affective basis of self-awareness and social cognition. The seminal work of Damasio on somatic markers shows the importance of physiological states for cognition²³, and suggests that the ways in which we perceive our visceral states and become aware of our feelings are at

the core of self-awareness ^{23,24}, crucial for social cognition and behaviour. The body's physiological states also give rise to affect, that is, a mental representation of how we feel, a process that critically depends on social relations ^{25,26}. Interoceptive processes underlie the importance role that bodily states (e.g. changes in heart-rate) and their mentalization in terms of feelings (e.g. arousal) and emotions (e.g. anger, or fear, or surprise) play in cognition and in social relations ²⁷. Extending recent findings that highlight the role of interoceptive states for feelings of conscious presence in the world ²⁸ and derealization ²⁹, the present studies add to this growing literature whereby our emotions and their underlying interoceptive states are constructions, rather than mere reactions, to the world ³⁰. And going beyond the view of affective realism whereby “believing is seeing” as we are experiencing supposed facts about the world that are created in part by our feelings, we suggest that “feeling in seeing” is believing. As shown here, we use such interoceptive inferences to inform and shape our beliefs in the realness of a culture powered by images.

Methods

All online studies (Study 1, 4, 5) were designed and administered using the online platform ‘Qualtrics’ (www.qualtrics.com). Participants were recruited online through Mechanical Turk (<https://www.mturk.com/>) or Prolific (<https://www.prolific.ac/>) and compensated with ~£7/hour. Participants in the lab- based studies (Study 2, 3, 6) were tested at the School of Advanced Study, University of London, recruited through online advertisements and compensated with £8/hour. All studies were carried out according to the Helsinki declaration guidelines and approved by the Ethics committees of the School of Advanced Study and Royal Holloway, University of London. Participants gave their written informed consent before taking part and were debriefed on the purpose of the study after participation.

Stimuli

Our main stimuli set (all studies except Studies 5, 6) consisted in 80 photojournalistic images depicting a variety of events of negative valence selected from the web. The sources of all images, i.e. the photographer or journalistic agency, were identified and, to the best of our knowledge, all of them are genuine photojournalistic images depicting real-life events. The stimuli were selected to cover a wide range of subjects – such as war, violence, injury, (child) poverty, sadness – to promote both intra- and inter-participant variability in the quality and intensity of affective feelings and physiological reactions elicited, as we hypothesised that each participants would show unique patterns of affective reactions to the different stimuli. The high

inter-stimuli and inter-participant variability observed in subjective ratings and cardiac reactions confirmed this hypothesis. Two attention checks consisting in movie stills, depicting zombies (from Walking Dead) and several famous actors posing for a photo (The Expendables 2 promotion picture), were added to the stimuli set in the second part of the experiment only.

For studies 5 and 6, we first selected from the web 40 photographic images taken during emergency or security drills or from war exercises. Then, we matched these “fake” images with 40 new “real” photojournalistic images depicting genuine real life events with similar visuo-semantic and iconographic properties. The selection process was realized by three independent raters (see Supplementary Material for an index of all images used). Two attention checks in the form of high or low arousal answer instructions were included.

Study 1

Participants

Data was collected from 70 participants (29 females; mean age = 38.914, SD = 11.564)

Experimental procedure

The experiment was divided in two parts. In the first part, participants were asked to attend to photojournalistic images and to rate after each presentation, how much they felt aroused when looking at the image, i.e., how intense is the feeling, either positive or negative, the image triggers in you. Pictures were displayed, in randomized order, for 3 seconds and answers were given on a slider, ranging from low (1) to high arousal (100). The second part of the experiment was as a surprise task as participants remained were completely oblivious to it until the completion of the first part. In this task, participants were asked to judge whether each image was “real” or “fake”. *Real* images were defined as being images that showed events as they had happened; where expressions and actions can be read as genuine. *Fake* images were defined as images that appeared to show staged events or that appeared to have been manipulated in ways that alter the nature and/or the content of the event depicted (e.g. pictures taken from movies, created in a studio setting or digitally). Edited photos with adjustments of colour or luminosity were not considered as ‘faking’ the original depiction of the moment. After becoming familiar with the task in 2 practise trials, participants were exposed again to each image of the stimuli set (3 seconds) and asked to decide whether they believed the image to be “real” or “fake”. They were also asked to report on the confidence of their evaluation, on a slider ranging from 1-50, not at all to very confident. Stimuli were presented in a randomised order.

After completion, participants were requested to complete the *Toronto Alexithymia Scale*, demographical information *Age, Gender, race, Country of residence* (Free entry, see respective study for sample characteristics) and to report on their *Political Orientation* on a 7 point Likert Scale anchored by conservative (1) and liberal (7) labels.

Measures

Arousal Ratings of the intensity of felt arousal when looking at the image (stimuli n=80, attention checks n=2). Asked after the display of the stimuli and assessed on a scale ranging from 1-100. The variable was mean centred and scaled for the purpose of further modelling.

Probability of Realness. Probability of Realness index, ranging from 1-100. Values closer to 1 represent images that were more likely to be judged as fake and values closer to 100 represent images that were more likely to be judged as real. The index is composed of the choice *fake* (*fake*=0) or *real* (*real*=1) and the reported level of confidence, ranging from 1-50. For the answer 'real', confidence ratings were added to '50'; for the answer *fake*, confidence ratings were reversed, that is, 51 was subtracted from the confidence rating and the absolute value of the equation's outcome was used. For example, a *fake* image with '48' as level of confidence would receive a probability score of '3' and a *real* image with '50' as level of confidence, would receive a probability score of '100'.

Political Orientation Answers were given on a Likert scale ranging from 1-7, where 1 was very conservative and 7 very liberal. Participants could withhold the answer.

Toronto-Alexithymia Scale (TAS-20) 20-item, self-report scale assessing alexithymia, i.e., the relative inability to identify and/or describe their emotions, tend to minimize emotional experience and/or to focus their attention externally.. Answer to every item is given on a Likert scale ranging from strongly disagree-strongly agree (1-5). Scores for each item were added to an overall score.

Statistical Analysis

We were interested if and how arousal may predict the later judgment of an images' realness. Given the repeated-measures nature of the design, data was analysed with mixed-model regressions using the lme4 v1.1 -17 package available for R software (R Core Team, 2013). Mixed-model regressions preserve trial-by-trial information, account for inter-individual variance (e.g. participants' unique response style that is independent from the stimulus presented), and are therefore the preferred method to analyse repeated-measures designs ³¹. Due to confirmatory hypothesis testing, we adopted a maximal linear mixed model approach with a random slopes and intercept effects structure for item and subject ³². The random slope structure was simplified whenever model convergency or singularity issues were encountered

(see Supplementary Materials for the final models in each study). In a first step we fitted a linear mixed effects model with *Probability of Realness* as the outcome variable, *Arousal* as fixed effect with a random slope for *Arousal by Picture* and a random slope for *Arousal by Participant* as well as random intercepts for *Picture* and *Participant*. In a second step, we included as fixed effects to the model our covariates of interest, *Age*, *Political orientation*, *TAS* and *Gender* as fixed effects, and added to the random effects structure *Age* as a random slope to *Picture*.

All covariates were mean centred and scaled. Chis-sq and p-values for fixed-effect parameters were calculated with the *Anova()* function of the *Car* package in R.

Study 2

Participants Data was collected from a total of 49 participants. Data from 8 participants was excluded from analyses due to noisy physiological signal ($n = 2$), inability to pay attention ($n = 1$), high percentage ($>30\%$) of unanswered real-fake judgments ($n=2$) or failed attention checks ($n=3$). Data from the remaining 41 participants (25 females; mean age = 39.085; SD = 11.308) was analysed.

Stimuli as in Study 1.

Experimental procedure

The experimental procedure was identical to that of Study 1 with the exception that, in the first part, participants were only instructed to passively attend (i.e. not asked to provide subjective judgments) to the photojournalistic images whilst their cardiac activity and galvanic skin responses were monitored. As in Study 1, in the second part of the experiment, participants were instructed to judge each of the previously seen images regarding their realness and to rate the confidence in their decision. As in Study 1, participants were unaware that there would be a second part until completion of the first. All stimuli were displayed in a randomised order and participants were given a break between the two parts.

ECG-Recording Three disposable ECG electrodes were attached in a modified lead II chest configuration: two electrodes were positioned underneath the left and right collarbone and a third on the left side of the lower back. The signal was recorded with a Powerlab 8/35 and a Bio Amp FE132 (Powerlab, ADInstruments, <http://adstruments.com/>) using Labchart 8 Pro software. Sampling rate was 1000 Hz and a hardware bandpass filter between 0.3 and 1000 Hz was applied. Cardiac responses were estimated as changes in inter-beat-intervals (IBI) following the presentation of each stimulus. The R-peaks of the ECG's QRS complex were automatically detected using Labchart's HRV function. Visual inspection to detect artifacts and misidentified R-peaks was performed and manual correction applied where necessary. For

each stimulus, average IBIs in the initial 3 seconds and within 3-7 seconds after photo onset were subtracted from baseline (i.e. average IBI in the two seconds preceding stimulus onset) to estimate the initial heart deceleration and subsequent heart acceleration, respectively (Bradley et al, 2001). Higher IBI values in the initial 3 seconds reflect enhanced heart deceleration and lower IBI values in the final 3 seconds reflect increased heart acceleration.

Authenticity Judgments see Study 1

Political Orientation see Study 1

Toronto-Alexithymia Scale (TAS-20) see Study 1

Statistical Analysis We were interested in exploring if and how physiological responses, i.e. changes in IBI and GSR, to the images, predict later judgments of an images' realness. As in Study 1, data was analysed with mixed-model regressions using the lme4 v1.1 -17 package available for R software (R Core Team, 2013). We adopted a maximal linear mixed model approach with a random slopes and intercept effects structure for item and subject (Barr et al 2013). In a first step we fitted a linear mixed effects model with *Probability of Realness* as the outcome variable, *Final Heart acceleration* as fixed effect with a random slope for *Final Heart acceleration* by *Picture* and a random slope for *Final Heart acceleration* by *Participant* as well as random intercepts for *Picture* and *Participant*. In a second step, we included as fixed effects to the model our covariates of interest, *Age*, *Political orientation*, *TAS* and *Gender* as fixed effects, and added to the random effects structure *Age* as a random slope to *Picture*.

All covariates were mean centred and scaled. p-values for fixed-effect parameters were calculated with the lmerTest package in R, using Satterthwaite estimation of the degrees of freedom.

Study 3

Participants. Twenty participants completed the experiment. All participants gave informed consent and were paid for their participation. The procedures were approved by the local ethics committee.

Stimuli. Same as in Study 1

Measures

EEG-Recording Data was recorded using a BrainVision 64-electrode system placed according to the International 10–20 system with external EOG channels. Two auxiliary electrodes were placed ~1cm below the left and right collarbones to record ECG activity. Signals were recorded using a 1024 Hz sampling rate with default online filters (0.016-1000 Hz).

HEP measurement and analysis. Preprocessing was done using EEGLAB toolbox ³³ in Matlab (The Mathworks, Inc., MA). Data was down-sampled to 250 Hz and filtered (bandpass of 0.1 - 30 Hz) with a Hamming windowed-sinc finite impulse response zero-phase filter. Noisy channels which exceeded 5 SD threshold were removed and data was re-referenced to the average of the scalp electrodes. We ran independent component analyses (ICA) using runica algorithm. The removed channels were interpolated. ICA components corresponding to eye blinks, eye movements and cardiac artifacts were removed after visual inspection. Heartbeats were detected from the ECG channel using the FMRIB plug-in for EEGLAB ³⁴ and triggers were added at the onset of the QRS wave. Events of interest were redefined as heartbeats within 6 seconds of the onset of stimulus presentation and data was divided into epochs from -200 ms to 800 ms, with baseline correction from -200 to 0 ms (where 0 corresponds to the onset of the QRS wave). Artifact rejection was performed on the epoched data using moving window peak-to-peak method which results in removing trials with a peak-to-peak amplitude higher than 50 μ V threshold. Events of interest (i.e. heartbeats during image presentation) were classified as belonging to *Real* or *Fake* condition based on participants' responses. Then for each event, a "probability" of responding Real/Fake was estimated as 50 + confidence rating for images judged as real and 50 – confidence for images judged as fake. Median split was used to characterize events as having low or high probability of being judged as Real/Fake resulting in two conditions: *High Prob* and *Low Prob*. Following previous research, we analysed HEPs at the time interval from 485 ms to 625 after the onset of the QRS wave, which correspond to 455 ms to 595 ms after the R peak, as it has been shown that the impact of the electrocardiac field artifact in this time window is minimal ^{35,36} and this time-period was previously associated to interoception-related processes ^{37–41}. Monte Carlo cluster based permutations comparing *High Prob* and *Low Prob* conditions were run in FieldTrip ⁴². We tested electrodes from two ROI's: frontal (FP1, FPz, Fp2, AF7, AF3, AFZ, AF4, AF8, F7, F5, F3, F1, Fz, F2, F4, F6, F8) and central (FC5, FC3, FC1, FCz, FC2, FC4, FC6, C5, C3, C1, Cz, C2, C4, C6, CP5, CP3, CP1, CPz, CP2, CP4, CP6).

Study 4

Participants Data was collected from 69 participants (35 females; mean age = 38.347; SD = 10.916).

Experimental procedure. The experiment was divided in three parts with 42 trials each (stimuli n=40; attention checks n=2). Participants were unaware that there would be 2 other parts until completion of the previous one.

As in Study 1, participants were asked to attend to photojournalistic images ($n=40$) and to rate after each presentation, how much they felt aroused when looking at the image. Pictures were displayed for 3 seconds and answers were given on a slider, ranging from not at all to very much aroused (1-100). Stimuli were presented in a randomised order.

In the second part, participants were told that the images just displayed had been fact-checked by independent media agencies and that the images had been either rated as being possibly *fake* or verified as being *real* (see Study 1 for definition of categories *real* and *fake*). Participants were then exposed to the same set of images, associated with either the label *Real* or *Fake* and asked to provide judgement on their amount of felt surprise when seeing the given label together with the image. Labels were randomly assigned to the images (see *Stimuli*). Pictures were displayed for 3 seconds and answers were given on a slider, ranging from not at all to very much surprised (1-100). Stimuli were presented in a randomised order.

Lastly, participants were again exposed to the image set- that time without a label- and asked to recall whether the image had been rated as *real* or *fake* by the agencies in the previous block. After presentation of the image (3sec), participants were asked to decide whether the image had been rated as *real* or *fake* and then, to provide answer on their level of confidence regarding their recall, on a slider ranging from 1-50, from not at all to very confident.

After completion of the tasks, participants were requested to respond to the *Toronto Alexithymia Scale*, to demographical questions *Age*, *Gender* (*male*=0; *female*=1), *Country of residence* and to report on their *Political Orientation*.

Stimuli were all real images and the same as in Study 1. We created four sets with 40 stimuli each and 2 attention checks. First, we divided randomly the stimuli ($n=80$; see Study 1) in two sets of 40 stimuli. Then, we duplicated the two sets ($n=4$) that each image would be associated once with a *real* and once with a *fake* label (see *Experimental procedure* and *Surprise Ratings*). Labels were balanced per condition ($n_{real}=20$; $n_{fake}=20$) and transposed in the duplicated set, e.g. an image previously associated with the label *real* would be associated with a *fake* label in the duplicated set. For the four sets, we recruited participants in 4 different samples (see *Participants*), that they had neither prior information on the study nor seen the same image twice but with another label. After finishing, participants were debriefed on the purpose of the study and informed that the ratings of fact-checking agencies were made up, and the images displayed all photojournalistic images, driven from real-time events, to the best of our knowledge.

Measures

Arousal Ratings of the intensity of felt arousal when looking at the image (stimuli n=80, attention checks n=2). Asked after the display of the stimuli and assessed on a scale ranging from 1-100. The variable was mean centred and scaled for the purpose of further modelling.

Surprise Rating Fact-checked labels (*real/fake*) were placed above the image (stimuli n=80, attention checks n=2), centred and written in capital letters (*REAL/FAKE*). Three seconds after display of the stimuli, the amount of surprise regarding the label associated to the image was assessed on a scale ranging from 1-100.

Political orientation as in the previous studies.

Toronto Alexithymia Scale as in the previous studies.

Statistical Analysis We were interested if and how *Arousal ratings* and their interaction with the associated label *real/fake* may predict the amount of *Surprise* when exposed to an information rating the image's realness. As in Study 1 and 2, data was analysed with mixed-model regressions using the lme4 v1.1 -17 package available for R software (R Core Team, 2013). We adopted a parsimonious linear mixed model approach with a random slope and intercept effects structure for item and subject (Barr et al 2013, BATES XXX, Kliegl). In a first step we fitted a linear mixed effects model with *Surprise Ratings* as the outcome variable, *Arousal ratings* and *Label (real/fake)* as fixed effects with a random slope for *Arousal ratings* by *Picture* and a random slope for *Arousal ratings* by *Participant* as well as random intercepts for *Picture* and *Participant*. In a second step, we included as fixed effects to the model our covariates of interest, *Age*, *Political orientation*, *TAS* and *Gender* as fixed effects, together with their interaction with *Arousal* and *Label*. We added *TAS* as a random slope to *Picture*, as well as *Age* and *Political Orientation*.

All covariates were mean centred and scaled. p-values for fixed-effect parameters were calculated with the lmerTest package in R, using Satterthwaite estimation of the degrees of freedom.

Study 5

Participants

The experiment was designed and hosted in Qualtrics (www.qualtrics.com). Participants were recruited via Amazon's Mechanical Turk (MTurk) in May 2018. The allowed locations were Australia, New Zealand, United States, and United Kingdom. Eighty-four workers (i.e. participants) that responded to the experiment's ad completed the study. Five of these participants did not pass the attentional checks (see procedure) and were not reimbursed nor included in the analysis. Participants were informed about the procedure and gave their consent

to participate before starting the experiment. Therefore, N=79 participants (55 females; Age: Mean=42.04, SD=11.04, range=[24 69]) were included in the main analysis. For further demographics details, please refer to the supplemental materials.

Procedure: Participants that responded to the ad presented in MTurk were redirected to the Qualtrics page where the experiment was hosted. In the initial page, they received information about the procedure and had the opportunity to give their consent to participate. They were informed that some of the images depicted explicit violence and that could have strong emotional content. They were also informed that attention checks were included in the experiment to ensure participants pay attention to the task and that failing of reporting these checks would have losing the possibility of being paid. The experiment was divided into two parts, but participants were not aware of the second part for experimental reasons. In the first part, participants saw images (N=80) depicting various types of real events (see supplemental materials). Each image was presented once at a time at each trial and stayed on the screen for 3 seconds only. Then, a new page appeared with a list of emotions (Anger/Rage, Compassion, Disgust, Excitement, Fear, Guilt, Hope, Joy, Pain, Pleasure, Remorse, Sadness, Shame, Tenderness, or Nothing). The order of the emotions was randomly changed by Qualtrics at each trial. Participants were required to select up to two emotions that they felt the most while seeing the previous image. After selecting the emotions with the mouse, a new button appeared at the bottom of the screen to continue to the next page. Here, participants were presented with either one or two slider bars (depending whether they had selected one or two emotions in the previous page) and had to use the slider to estimate the intensity of the selected emotion(s). The question above the slider(s) asked “How intense were the emotions elicited by the photo?” and two labels marked the left (*Not intense at all*) and right (*Extremely intense*) sides of the slider(s). Each slider was also associated to the label of the chosen emotion(s). The slider had an interval scale ranging from 1 to 10, decimals were not used. Participants could not see the associated numbers when moving the slider.

After confirming the intensity rate using the button at the bottom of the page, a new trial started and the procedure repeated. The sequence of the images was randomly defined for each participant by Qualtrics. Participants saw two practice trials before the beginning of the experiment.

After completing this part of the experiment, a new set of instructions announced the second part of the experiment. Here, participants were presented again with the same 80 images seen in the first part, but were now required to judge whether each picture was real or fake. The instructions also defined what we meant with *real* (i.e., images that “were taken during a real

life event, in other words they capture an event as it happened when it happened. It was not staged in any way and the emotions and actions shown are genuine.”) and *fake* (i.e., images “showing an event that was staged or pictures that may have been manipulated in a way that alters the nature and/or content of the event. For example, they might have been taken from a movie, created in a studio, created digitally, or the actors staged the scene depicted.”). We also stressed the fact that photo editing (e.g., colour, luminosity, or composition adjustment) is common in photojournalism and they should not have used this type of information for the judgment. After the instructions, the experiment started. Each image was presented for 3 seconds and then a new page appeared asking the participants to select either the *Real* or *Fake* option. Below these two labels, a slider bar was also presented and participants had to use it to estimate the confidence level they experienced in giving the judgment. The slider had two labels on the left (*Low confidence/guess*) and right (*High confidence/certain*) sides of the bar. The slider had an interval scale ranging from zero to 50, decimals were not used. Participants could not see the associated numbers when moving the slider. Before starting the second part, participants did three practise trials. The entire session lasted approximately 40-50 minutes and participants received a reward of \$4.60.

Measures

Picture probability score: For each participant, we defined the *probability score* associated to each image as a combination of the Real judgment (Real/False) and the confidence level given. More specifically, the following formula was used:

$$Probability\ score = \begin{cases} \text{if response was real} \rightarrow 50 + Confidence \\ \text{if response was false} \rightarrow 50 - Confidence \end{cases}$$

As confidence ranged from 0 to 50, the probability score ranged between 0 and 100. Therefore, a value of zero would indicate that the participant provided said that the image was false and that she was certain about it (because she provided a confidence of 50 for a false response), a value of 100 would indicate that the participant said that the image was real and that she was certain about it (because she provided a confidence of 50 for a real response), and a value of 50 would indicate that the participant responded randomly to that image. All possible intermediate integer values were possible. The probability scores of each image were averaged across all participants in order to obtain a single descriptive value to each image. As expected, the majority of values were above 50 ($M=67.97$, $SD=11.67$), as most of the images were judged as real, but we observed some variability ($Range=[23.02 - 86.29]$). One of the main question

of this study was to build a model that accounted for the variability observed for the picture probability scores.

Picture Emotional states. We were interested in determining the type of emotional states that each image induced on average to the participants and investigate whether emotional states could predict the realness of an image. For this reason, we computed “patterns” of emotions associated to each image as the sum of the rating that each participant gave to the image divided by the maximum value of rating (i.e., $10 \times 79 \text{ participants} = 790$). Therefore, each image was associated with an array of 14 numbers (one for each image) ranging from zero to one. A value of zero would indicate that the related emotion had never been selected and rated for that image; a value of one would indicate that all participants selected and gave a rating of 10 to the image. As we expected some of these emotional states to be quite similar between images, we ran a principal component analysis to reduce the number of dimensions. These resulting dimensions were then used as explanatory variables in a multiple regression analysis to explain the probability score associated to each image.

All analyses were conducted in R (version 4.0.0; <https://www.R-project.org/>) and Matlab (R2017a; Natick, Massachusetts: The MathWorks Inc.). Refer to the supplementary materials for the used R packages.

Study 6

Data was collected from 80 participants (46 females; mean age = 32.2; SD = 10.813). No participant was excluded from further analysis.

Experimental procedure. The experiment was divided in two parts with 82 trials (stimuli $n=80$; *Real images* $n=40$, *Drill images* $n=40$; Attention checks $n=2$); participants were unaware that there would be a second part until completion of the first.

In the first part, participants were asked to attend to photojournalistic images and to rate after each presentation, how much they felt aroused when looking at the image. Pictures were displayed for 3 seconds and answers were given on a slider, ranging from not at all to very much aroused (1-100). Stimuli were presented in a randomised order.

In the second part, participants were asked to decide, whether they believed the previously displayed images had been fake images or not. Participants were instructed, that their judgment should be based on their felt authenticity of the moment depicted in the image (for more information regarding the definition of the categories see [Study 1](#)).

After becoming familiar with the task in 2 practise trials, participants were exposed again to the images (stimuli n=80; attention checks n=2) and asked to decide, after each presentation (3 seconds), whether they believed the image was real or fake. Stimuli were presented in a randomised order. They were also asked to report how confident they were regarding their evaluation, on a slider ranging from 1-50, not at all to very confident.

After completion, participants were requested to respond to the *Toronto Alexithymia Scale*, to demographical questions *Age*, *Gender* (*male=0; female=1*), *Country of residence* and to report on their *Political Orientation*.

Stimuli (Drill and Real images) We selected 80 images depicting either mocked (n=40) or real-time (n=40) emergency situations. The selected images were visuo-semantically matched.

Measures

Arousal Ratings see [Study 1](#)

Authenticity Judgments see [Study 1](#)

Political Orientation see [Study 1](#)

Toronto-Alexithymia Scale (TAS-20) see [Study 1](#)

Statistical Analysis

We were interested if and how arousal may predict a later judgment of an images' realness. Given the repeated-measures nature of the design, data was analysed with mixed-model regressions using the lme4 v1.1 -17 package available for R software (R Core Team, 2013). Due to confirmatory hypothesis testing, we adopted a maximal linear mixed model approach with a random slopes and intercept effects structure for item and subject (Barr et al 2013). In a first step we fitted a linear mixed effects model with *Probability of Realness* as the outcome variable, *Arousal*, and *Picture Condition (Real/Drill)* as fixed effects with a random slope for *Arousal* by *Picture* and a random slope for *Arousal* and *Picture Condition* by *Participant* as well as random intercepts for *Picture* and *Participant*. In a second step, we included as fixed effects to the model our covariates of interest, *Age*, *Political orientation*, *TAS* and *Gender* as fixed effects, and added to the random effects structure *TAS* as a random slope to *Picture*. All covariates were mean centred and scaled. p-values for fixed-effect parameters were calculated with the lmerTest package in R, using Satterthwaite estimation of the degrees of freedom.

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