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Opening the Pandora box: Neural processing of self-relevant negative social information

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ABSTRACT

Curiosity is a powerful motivator of information-seeking behavior. People seek not only positive, but also aversive social information about others. However, whether people also seek unfavorable social information about themselves, as well as the neural mechanisms that may drive such seemingly counterintuitive behavior remain unclear. To address this gap, we developed a novel electroencephalography-compatible Social Incentive Delay (SID) task, which was implemented in 30 healthy young adults as they responded as fast as possible to a target to receive positive or avoid negative comments about their own or about others' Instagram photos. Reaction times were slower for negative vs positive comments' conditions, but only for participants' own photos, revealing less motivation to avoid negative rather than seek positive self-relevant social feedback. Coherently, receiving negative feedback, as opposed to avoiding it, evoked larger amplitudes in the Reward Positivity (RewP) and FB-P3 time-range, especially for participants' own photos, indicating that receiving a negative comment was more rewarding and more salient than not receiving any comment at all. Our findings challenge prior evidence suggesting that humans instinctively avoid aversive stimuli, and they shed light on the neurophysiological mechanisms that may underlie this counterintuitive behavior.

Humans are curious beings that engage in persistent informationseeking to close an information gap or resolve uncertainty (Baumeister, 2010). Information-seeking helps humans make informed decisions and navigate the physical and social world more effectively (Kidd & Hayden, 2015). While it may seem reasonable for people to seek out positive or useful information, it is more difficult to understand why people are attracted to useless or negative information. In line with the incentive salience hypothesis (FitzGibbon et al., 2020), people are willing to incur monetary costs (Eliaz & Schotter, 2010; FitzGibbon et al., 2021) or receive physical pain to obtain information that is not even instrumental or useful (Hsee & Ruan, 2016; Lau et al., 2020; Bode et al., 2023). In addition, people consistently seek out and report interest for information that is experienced as unpleasant (Niehoff & Oosterwijk, 2020), suggesting that in certain contexts, negative information can be engaging.

For example, people deliberately choose to access intensely negative

social stimuli such as images of dead bodies (Oosterwijk, 2017) and violent social conflicts (Oosterwijk et al., 2020), and they also choose to uncover a screened image containing sensitive or distressing social content (Bridgland et al., 2023). People also engage more with negative rather than positive news, such that negative words in online news headlines increase consumption rates (Robertson et al., 2023). These findings suggest that curiosity is not repressed in front of potentially aversive stimuli (FitzGibbon et al., 2020; Niehoff & Oosterwijk, 2020). On the contrary, people are more likely to engage with a stimulus if the consequences of such engagement are uncertain and negative in nature in the so-called "Pandora Effect" (Hsee & Ruan, 2016). This tendency may be because negative information is more salient, novel, and more deviant from the norm than positive information (Silvia & Kashdan, 2009; Alves et al., 2017; Niehoff & Oosterwijk, 2020).

Interestingly, evidence suggests that choosing to engage with negative social stimuli activates the reward circuitry (e.g., Nucleus

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accumbens and caudate) more strongly than choosing to engage with positive social stimuli (Oosterwijk et al., 2020). Similarly, negative gossip about celebrities evokes stronger activity in the striatum (Peng et al., 2015), captures people's attention more easily, and affects conscious visual experience more than positive gossip (Anderson et al., 2011). This negativity bias is also reflected on social media platforms, where negative comments on brand posts can attract new customers (Labrecque et al., 2022) and where users are more likely to share negative rather than positive content (Brady et al., 2017; Rathje et al., 2021; Schöne et al., 2021), especially when it comes from public figures (Schöne et al., 2023). In addition, negative emotional comments on social media draw more attention than positive comments (Kohout et al., 2023), and negative tweets draw more gaze dwell time and are recognized better than positive tweets (Kätsyri et al., 2016). While this bias towards negative information about others (e.g., celebrities, public figures, etc.) can be partly attributed to the fact that this information is often more novel, deviant from the norm, and therefore more salient (i. e., Niehoff & Oosterwijk, 2020), it can also be attributed to the fact that negative information about others serves a purpose: it facilitates vicarious learning and allows individuals to learn from others' misfortunes (i. e., Jolly & Chang, 2021), offering high adaptive value for low emotional costs.

While these previous studies have shown that people tend to engage in negative social information about others (e.g., other-relevant information regarding celebrities, public figures, news), there has been a notable scarcity of research exploring whether people also engage in negative social information about themselves (e.g., self-relevant information). This research question is especially intriguing, because, while positive social information about oneself typically boosts self-esteem and well-being, negative social information can damage self-esteem and emotional well-being and can have high emotional costs (Leary & Baumeister, 2000; Crocker & Canevello, 2008). Since it is generally agreed that people have strong motivations to maintain favorable concepts of themselves and would therefore try to avoid a bad opinion about themselves as a form of self-protection (Banaji & Prentice, 1994; Baumeister et al., 2001; Alicke & Sedikides, 2009), seeking negative information about oneself in this context could be considered counterintuitive.

However, it could also be argued that people might be more drawn to self-relevant negative information because it might protect them from future negative outcomes. For example, prior research suggests that negative information is usually more threatening than positive information is beneficial, and requires an enhanced and more rapid processing compared to positive information (Baumeister et al., 2001; Rozin & Royzman, 2001). Therefore, a negative bias towards negative information about oneself in this context could be considered adaptive.

The goal of the present study was to explore whether people seek out not only positive, but also negative information about themselves and whether the neural processing of that information differs from the processing of negative information about others. Given the welldocumented attention-grabbing power of negative content, especially in social contexts, as well as the adaptive advantage that this negativity bias may confer, we hypothesized that individuals may also seek out negative social information about themselves. Coherently, we hypothesized that the receipt, compared to the avoidance of self-relevant negative feedback will be more salient and will be perceived as a more positive outcome, and this will be reflected in larger ERP amplitudes in the time-range of Reward Positivity (RewP) and Feedback- P3 (FB-P3), two ERP components that have been associated with the processing of positive (Proudfit, 2015) and salient (San Martín, 2012; Novak & Foti, 2015) feedback, respectively. To reach our goal and test these hypotheses, we developed a novel paradigm, adapted from the Social Incentive Delay task (SID), which was originally designed to measure brain activity related to positive and negative social feedback, and has been shown to reliably elicit ERPs locked to the receipt and avoidance of positive and negative social feedback (Ait Oumeziane

et al., 2017, 2019; Flores et al., 2015; Greimel et al., 2018).

Similar to the original SID task, participants in our novel paradigm had to respond as fast as possible to a target to receive positive or avoid negative comments about their own or about others' Instagram photos. On a behavioral level, we predicted that participants would not want to avoid the negative comments as much as they would want to receive the positive comments and would therefore have slower reaction times in the negative relative to the positive comments' conditions, especially for their own photos. On a neural level, we predicted that the receipt vs the avoidance of social feedback would elicit larger amplitudes in the time range of RewP and FB-P3, not only for the positive, but also for the negative feedback, and this effect would be especially pronounced for participants' own photos. In addition, consistent with prior literature suggesting that the RewP and the FB-P3 reflect activity in frontocentral and centroparietal areas, respectively (e.g, Glazer et al., 2018), we predicted that differences in the RewP would be maximal at frontocentral sites and differences in the FB-P3 would be maximal at centroparietal sites.

1. Method

1.1. Participants

We recruited thirty volunteers (M_{age} = 23.03, SD = 3.03, 70 % females) from the University of Barcelona (Spain), who reported having no diagnosis of a psychiatric or neurological disorder. Considering that prior ERP studies using social reward tasks such as the SID found consistently large effects of feedback on both the RewP and the FB-P3 (e. g., $\eta_p^2 = .20 - .79$; Ait Oumeziane et al., 2017, 2019; Distefano et al., 2018; Funkhouser et al., 2020; Nelson & Jarcho, 2021), we performed an a priori power analysis using MorePower 6.0 (Campbell & Thompson, 2012) to identify the minimum sample size required to detect such large effects in our study. Using a 2 \times 2 \times 2 within-subjects design, with η_p^2 = .3, Cohen's f = .66, power= 0.80, and alpha= 0.05, this analysis indicated that a minimum of 22 participants would be required to detect such large effects. However, in case we had to remove some participants due to excessive artifacts in the EEG data, we collected data from 30 participants, which gives 80 % power for any effect with $\eta_p^2 \ge .23$ or larger.

As the task contained written stimuli (the comments), only native Spanish speakers were included in the study. All procedures were approved by the Bioethics committee of the University of Barcelona (IRB00003099) and all participants signed an informed consent form before starting the experiment.

1.2. Materials and procedure

At the time of recruitment, participants were led to believe that they were participating in an electroencephalography (EEG) study on reward on social media, and they were asked to authorize the researchers to check their Instagram profile (by allowing the principal researcher to follow them on Instagram from an account created only for the purpose of the study), use their photos in the experiment, and have those photos viewed and evaluated by a group of young volunteers external to the experiment. They were told that if these external volunteers liked the photo, they wrote a positive comment about it just like they would if they saw this photo on Instagram, and if they didn't like it, they wrote a negative comment about the photo. They were also told that, given the subjective nature of liking a photo on Instagram, each photo would receive comments from four different individuals to provide a broader range of opinions, and during the task, participants would have the opportunity to view all four comments associated with each photo (each photo was presented 2 times per information cue). In addition, they were told that during the task, they would see the photos selected from their own Instagram account as well as the photos selected from other participants' Instagram account, and based on their performance on

each trial, they could see the positive comments and avoid seeing the negative comments that the volunteers wrote about their own photos and about the photos of other participants.

It is noteworthy that the comments were not really written by external volunteers but were created by the researchers and were mostly generic (e.g., 'Love this photo'or 'Nothing special') and could include 'emojis' to make them feel more genuine. They were written in Spanish before data collection and rated by an independent group of participants (N = 57) on a Likert scale from 1 (very negative) to 5 (very positive) in a survey on Qualtrics. This step served to validate the comments and to ensure that the positive comments were indeed perceived as 'positive', and the negative ones were indeed perceived as 'negative'. A midpoint split was performed on the ratings, such that comments with a rating above 3 were used as 'positive' feedback (M = 4.41; SD = .21) in the positive information conditions, and comments with a rating below 3 were used as 'negative' feedback (M = 1.89; SD = .32) in the negative information conditions. Any comments rated as 'neutral' were excluded and were not incorporated in the experiment. A final list of 186 generic comments was generated, 113 of which were classified as 'positive' and 73 of which were classified as 'negative'. In addition to the generic comments, for each participant we created 12 comments that were specific to the content of 12 of his/her own photos (e.g., ";This sunset is beautiful!" or "Nothing new, everyone posts sunsets") and 12 comments that were specific to the content of 12 of other participants' photos, so that participants would really believe that the photos had been genuinely evaluated by outsiders. The photos of "other participants" were in fact photos taken by the first author, and they were the same for all participants. The specific comments for other participants' photos were also the same for all participants.

Once participants provided authorization, their Instagram profile was checked to ensure they had at least 40 photos that did not include selfies, photos of other people or pets (inclusion criteria). If inclusion criteria were met, the participant was given a scheduled time for the experiment approximately 1–2 weeks later to ensure enough time for participants to really believe that other people evaluated their photos. Meanwhile, the selected 40 photos were screenshotted from each participants' account and resized to 1080×1080 pixels.

1.2.1. Experimental task

The experimental task was a modified version of the Social Incentive delay task (Spreckelmeyer et al., 2009; Kohls et al., 2013; Flores et al., 2015; Ait Oumeziane et al., 2017; Nawijn et al., 2017; Wei et al., 2020; Martins et al., 2021; Xu et al., 2022). The task consisted of 320 trials (approximate duration: 1 hour and 15 minutes). These 320 trials were

divided into 5 blocks of 64 trials each (duration of each block: around 15 minutes). The experiment was programmed using PsychoPy 3 version 2021.2.3 (Peirce et al., 2019). As shown in Fig. 1, each trial started with the presentation of a photo of the participant's own Instagram account or a photo of other participants' Instagram account for 2000 ms. Then, a visual cue appeared for 400 ms, indicating the contingency for that trial. Specifically, if the cue was a circle (positive information cue), the participant had the potential to receive a 'Like' and to see a positive comment written about the photo he saw at the beginning of the trial (possibility to obtain positive information). However, if the cue was a square (negative information cue), the participant had the potential to avoid receiving a 'Dislike' and seeing a negative comment (avoid negative information) about the photo he saw at the beginning of the trial. There were 40 photos of each type (own vs others'), and each one of them was presented twice with each information cue throughout the task, leading to 80 trials with positive information cues and 80 trials with negative information cues for participants' own photos (N = 160), and 80 trials with positive information cues and 80 trials with negative information cues for other participants' photos (N = 160). These trials were presented in a random order throughout the task.

After the information cue, a variable time interval between 600 and 1600 ms was introduced, and then, a white square appeared on the screen and participants were instructed to respond to it by pressing the SPACE key as quickly as possible. The target remained on the screen until participants made a response. Two seconds after the response, the feedback was presented. The first feedback (Feedback Phase 1) informed the participant whether they hit or missed, and, at the same time, served as an anticipatory cue for a potential posterior comment. Hits were defined as reaction times below a threshold (i.e., fast enough responses), while misses were defined as reaction times above a threshold (i.e., too slow responses). In the positive information condition, hits earned the feedback of a Like with a 1, indicating that the response was fast enough and that the participant would be rewarded with the receipt of a positive comment (receipt of positive information). Misses earned the feedback of a Like with a 0, indicating that the response was too slow and that the participant would be punished by missing out on a positive comment (omission of positive information). Conversely, in the negative information condition, hits earned the feedback of a thumbs down with a 0, indicating that the response was fast enough and that the participant would be rewarded with the avoidance of a negative comment (omission of negative information). However, misses earned the feedback of a thumbs down with a 1, indicating that the response was too slow and that the participant would be punished with the receipt of a negative comment (receipt of negative information). Prior to the task,



Fig. 1. Schematic illustration of the SID task, depicting all the different combinations of information cue and feedback that can arise in each trial. For positive information cues, a hit (i.e., fast enough response) earned a Like with 1 and the receipt of a positive comment as feedback, and a miss (i.e., too slow response) earned a Like with 0 and the omission of a positive comment. However, for negative information cues, a hit earned a Dislike with 0 and the omission of a negative comment as feedback, and a miss earned a Dislike with 1 and the receipt of a negative comment.

participants were explicitly informed about the relationship between the response time and the type of feedback that would appear. That is, they were explicitly told that if they responded fast enough, they would see a positive comment in the positive information condition and avoid a negative comment in the negative information condition, and that if they did not respond fast enough, they would see an empty comment in the positive information condition and a negative comment in the negative information condition. The task was designed for participants to attain a 65-70 % hit rate, dynamically adjusting the minimum reaction time for a hit based on each participant's performance on previous trials. Specifically, we used an adaptive algorithm, such that the minimum reaction time for a hit on a given trial was the seventh fastest reaction time of the last ten trials. One second after the first feedback, participants saw a speech bubble (Feedback Phase 2) with a positive comment if they were fast enough in the positive information condition, or a negative comment if they were not fast enough in the negative information condition. Otherwise, they saw an empty speech bubble.

Finally, to ensure that participants were attentive to the cues, 16 catch trials were introduced semi-randomly (approximately every 15–20 trials) throughout the experiment, where instead of the target, both the negative information and positive information cues appeared on the screen and the participant had to select the cue he/she had seen at the beginning of the trial. To ensure participants did not associate a specific side with a specific cue, on half of the catch trials the negative and positive information cues appeared on the left and right side of the screen, respectively, whereas the sides were reversed in the other half of the catch trials. Then, participants were fully debriefed, thanked for their participation, and received monetary compensation of 30 euros. During debriefing, participants were also asked to verify whether they believed they were receiving real feedback or whether they suspected that they had been deceived. All the participants reported that they believed the cover story.

1.3. Electroencephalographical recording and data analysis

EEG was continuously recorded using the Brain Vision Recorder (Brain Products Company, Munich, Germany) with 32 electrodes following the standard 10/20 system. The reference electrode was placed at Cz during online recordings. A vertical electrooculogram (EOG) was recorded with an electrode placed approximately 2 cm below the right eye and centered under the pupil. The continuous EEG signal was amplified and digitized at a sampling rate of 500 Hz in DC acquisition mode. Electrode impedances were kept below 10 k Ω . Data were re-referenced to the mastoid average and low-passed filtered offline at 45 Hz. Data processing was performed with the EEGLAB toolbox (Delorme & Makeig, 2004), implemented in Matlab.

The signals were epoched from -2000-2000 ms relative to the feedback 1 onset, and the activity from -200-0 served as the baseline. We only analyzed Feedback Phase 1 (i.e., delivery of Likes and Dislikes), because the comments delivered in Feedback Phase 2 differed in several ways including length, use of emojis, and use of capital and lower-case letters.

320 trials were analyzed, leading to 80 trials for each type of cue (own-positive information, own-negative information, others-positive information, others-negative information). Out of these 320 trials, those containing movement-related artifacts were eliminated manually. Then, Infomax-based independent component analysis (Bell & Sejnowski, 1995) was performed to correct for ocular artifacts. Both vertical (e. g., eye blinks) and horizontal eye movement related components were removed by human inspection (e.g., components with an EOG electrode contribution and a scalp distribution in the frontal region). Event-Related-Potentials (ERPs) were extracted from -200 ms (baseline) to 1000 ms post feedback 1 onset for each artifact-free epoch, and epochs in the same condition were then averaged and corrected relative to their respective baseline windows to generate the grand-average ERP waveforms corresponding to the feedback 1 delivery.

ERPs were analyzed using time-window averages, which were determined by exploring the grand-average waveforms across all conditions and by reviewing prior studies using the SID task (e.g., Ait Oumeziane et al., 2017). As shown in the grand-average waveforms for all conditions in Fig. 3, our RewP peaks ~300 ms and the FB-P3 ~400 ms post-feedback onset, which is consistent with a prior study using the SID task that also found the RewP to peak approximately at 298 ms (SD = 41.47) and the FB-P3 at 395 ms (SD = 39.51) post-feedback onset (Ait Oumeziane et al., 2017). Therefore, we measured the RewP as the mean amplitude from 260 to 340 ms post feedback 1 onset (i.e., 300 ± 40 ms), and given that the P3 is considered the largest positive peak of the ERP waveform within the time window of 300-500 ms (Li et al., 2015; Polich, 2007), we measured the FB-P3 as the mean amplitude from 340 to 500 ms post-feedback onset to ensure that we include the peak and to avoid overlap with the previous component. Mean ERP amplitudes averaged for each participant across the corresponding time-window at the frontal, central, and parietal midline electrodes (Fz, Cz, Pz) were then subjected to repeated measures ANOVA (rm-ANOVA) for statistical analysis. Since we were mainly interested in event-related potentials such as the FB-P3 and the RewP, which are maximal at midline parietal and frontocentral electrodes, respectively, and are thought to reflect activation at more central sites (Holroyd et al., 2008; Holroyd et al., 2011; Glazer et al., 2018), we only focused on these three midline electrodes for the statistical analyses. Importantly, these three midline electrodes have also been previously reported to display the largest feedback-related responses (Miltner et al., 1997; Hajcak et al., 2005). In addition, to ensure that our novel task elicits reliable ERPs, we assessed the internal consistency of the ERPs by quantifying the Cronbach's alpha. Following recommendations by Thigpen et al. (2017), we used the condition-averaged ERPs as "items" and the 30 participants as observations for the Cronbach's Alpha. We calculated the alpha separately for each of the three electrodes (Fz, Cz, and Pz). Excellent internal consistency was defined as alpha > .9., and acceptable internal consistency was defined as alpha > .70 (Cronbach, 1951).

For the behavioral data, we employed 2×2 repeated-measures ANOVAs (rm-ANOVA) with mean reaction times and hit rates as dependent variables, and Information Cue (Positive vs Negative Information) and Photo Type (Own vs Others) as within-subjects factors. For each participant's reaction time data, we removed any trials with exceedingly short or long reaction times (\pm 3 SD from the individual mean RT), consistent with prior studies using the SID task (Xu et al., 2022). For the RewP and FB-P3 ERPs, we employed two separate repeated-measures ANOVAs with the mean amplitudes as dependent variables, and Information Cue (Positive vs Negative), Photo Type (Own vs Others), Electrode (Fz, Cz, Pz), and Feedback (Hit vs Miss) as within-subjects factors. Further simple effect analyses were conducted if ANOVAs displayed a significant interaction. We applied the Greenhouse-Geisser correction to all rm-ANOVAs involving factors with more than two levels (Luck, 2014).

2. Results

2.1. Behavioral

2.1.1. Reaction times

The Rm-ANOVA revealed a significant Information-Cue x Photo-Type interaction, F(1, 29) = 6.00, p = .02, $\eta_p^2 = .171$. As shown in Fig. 2A, simple effect tests showed that participants were significantly faster on positive information trials they saw their own (M = 0.32, SD =0.08) relative to other participants' photos (M = 0.36, SD = 0.10), F(1,29) = 20.90, p < .001, $\eta_p^2 = .419$, but were equally slow on negative information trials, regardless of whether they saw their own (M = 0.38, SD = 0.17) or other participants' photos (M = 0.39, SD = 0.14), F(1, 29)= .74, p = .40, $\eta_p^2 = .025$. Alternatively, simple effect tests also showed that participants were significantly slower towards negative information (M = 0.38, SD = 0.17) relative to positive information cues (M = 0.32,



Fig. 2. A) Reaction times and B) hit rates as a function of Information Cue and Photo Type. Error bars represent standard errors of the mean. *Note.* $p \le .05 *$, p < .001 ***.

SD = 0.08) on trials they saw their own photos, F(1, 29) = 5.07, p = .03, $\eta_p^2 = .148$, while there was no significant difference in reaction times as a function of information cue (Negative information: M = 0.39, SD = 0.14; Positive information: M = 0.36, SD = 0.10) on trials they saw other participants' photos, F(1, 29) = 3.16, p = .09, $\eta_p^2 = .098$. In addition, the Rm-ANOVA revealed a main effect of photo-type, F(1, 29) = 9.65, p = .004, $\eta_p^2 = .249$, such that participants had significantly faster reaction times on trials they saw their own photos (M = 0.35, SD = 0.11) than on trials they saw other participants' photos, F(1, 29) = .132, such that participants overall had slower reaction times in negative information (M = 0.39, SD = 0.15) relative to positive information trials (M = 0.34, SD = 0.09).

2.1.2. Hit rates

According to the Rm-ANOVA, the Information-Cue x Photo-Type interaction did not significantly predict hit rates, F(1, 29) = 1.83, p = .19, $\eta_p^2 = .059$. However, as shown in Fig. 2B, the main effect of photo-type was significant, F(1, 29) = 32.38, p < .001, $\eta_p^2 = .527$, such that participants had a significantly lower hit rate in conditions where they saw other participants' photos (M = 0.62, SD = 0.10) relative to conditions where they saw their own photos (M = 0.71, SD = 0.09). The main effect of information cue was also significant, F(1, 29) = 4.10, p = .05, $\eta_p^2 = .123$, such that participants had a marginally lower hit rate in negative information conditions (M = 0.64, SD = 0.15), relative to positive information conditions (M = 0.69, SD = 0.07).

2.1.3. Catch trials

To ensure that participants paid proper attention to the cues, we analyzed their accuracy in correctly identifying the cues on catch trials. Participants displayed high accuracy overall (M = 0.95, SD = 0.07), suggesting that they genuinely paid attention to the cues. In addition, all participants correctly identified the cue on at least 13 out of the 16 catch trials, hence none of the participants were excluded from the analyses based on this criterion. We also examined differences in accuracy across conditions, and a rm-ANOVA showed that there was no main effect of information cue on accuracy on catch trials, F(1, 29) = 3.14, p = .09, η_p^2 = .101, nor was there a main effect of photo-type, F(1, 29) = .69, $p = .41, \eta_p^2 = .024$. However, there was a marginally significant Photo-Type x Information-Cue interaction, F(1, 29) = 4.19, p = .05, η_p^2 = .130, where participants identified more accurately the negative information cues (M = 0.98, SD = 0.06) than the positive information (M= 0.90, SD = 0.17) cues on others' photos, t(29) = 2.59, p = .02, but were equally accurate in identifying both information cues on their own

photos (Negative information cues: M = 0.96, SD = 0.12; Positive information cues: M = 0.96, SD = 0.10), t(29) = -.01, p = .99. These results suggest that slower reaction times in the negative information condition are not because participants paid less attention in this condition.

2.2. ERP components

2.2.1. Reward positivity

Fig. 3 illustrates the grand average ERP waveforms elicited during the initial feedback evaluation stage (Feedback Phase 1), as well as scalp voltage maps for the RewP and the FB-P3. The ERPs in the RewP timerange were measured as the mean amplitude from 260 to 340ms post feedback onset. The Rm-ANOVA on the amplitude in the RewP timerange showed that there was no significant 4-way interaction between Photo-Type, Information Cue, Feedback, and Electrode, F(1.40, 40.70)= 0.39, p = .61, $\eta_p^2 = .013$, nor were there any significant 3-way interactions [Information Cue x Feedback x Electrode, F(1.29, 37.31)= 2.05, p = .16, $\eta_p^2 = .066$, Photo-Type x Feedback x Electrode, F(1.52, 43.98) = .08, p = .88, $\eta_p^2 = .003$, Photo-Type x Information Cue x Electrode, F(1.52, 44.06) = 2.03, p = .15, $\eta_p^2 = .065$, or Photo-Type x Information Cue x Feedback, F(1, 29) = .16, p = .70, $\eta_p^2 = .005$].

However, there was a significant 2-way interaction between Information Cue and Feedback, F(1, 29) = 12.58, p = .001, $\eta_p^2 = .302$, and between Feedback and Electrode, $F(1.20, 34.92) = 4.00, p = .04, \eta_p^2$ = .121. As shown in Fig. 3, simple effect tests showed that for the negative information condition, participants had significantly more positive RewP amplitudes when they received feedback for misses (i.e., Dislike with 1 and receipt of negative comment; M = 3.03, SD = 4.26) compared to feedback for hits (i.e., Dislike with 0 and omission of negative comment; M = 1.65, SD = 3.60), F(1, 29) = 21.70, p < .001, η_p^2 = .428, whereas for the positive information condition, the RewP amplitudes did not significantly differ as a function of the Feedback [Hits: M = 2.79, SD = 4.05; Misses: M = 2.50, SD = 4.03], F(1, 29) = .84, p = .37, $\eta_p^2 = .028$. As evidenced by the significant Feedback by Electrode interaction and as shown in the topographic maps in Fig. 3, the difference in amplitudes between feedback for hits and misses in the RewP time-range was significant in frontocentral areas, specifically Fz, F $(1, 29) = 8.95, p = .006, \eta_p^2 = .236, \text{ and } Cz, F(1, 29) = 8.20, p = .008, \eta_p^2$ = .220, but not Pz, F(1, 29) = 1.22, p = .28, $\eta_p^2 = .040$. Aside from these interactions, no other 2-way interactions significantly predicted the amplitude in the RewP time-range [Photo-Type x Information Cue, F(1,29) = 1. 61, p = .21, $\eta_p^2 = .053$, Photo Type x Feedback, F(1, 29) = .02, $p = .89, \eta_p^2 = .001$, Information Cue x Electrode, F(1.23, 35.63) = .85,



Fig. 3. Feedback-locked ERPs and bar plots showing the mean amplitudes in the RewP and FB-P3 time-range for each condition at each level of Information Cue at Fz and Pz. ERPs were low pass filtered at 20 Hz for visualization purposes. The dark and light gray areas represent the time-windows used to quantify the RewP and the P3, respectively. Scalp voltage maps show the topographical distribution of the difference between feedback for hits and misses at each level of information cue across the RewP (260–340ms) and P3 (340–500ms) time-window. Notice that in the negative information condition, feedback for hits (i.e., Dislike with 0 and omission of negative comment) yielded smaller amplitudes in the RewP and FB-P3 time-range than feedback for misses (i.e., Dislike with 1 and receipt of negative comment).

Note. $p \leq .05$ * , p < .001 ***.

 $p = .39, \eta_p^2 = .029$].

Finally, the Rm-ANOVA also revealed a main effect of photo-type, F $(1, 29) = 16.70, p < .001, \eta_p^2 = .365$, such that participants had significantly more positive amplitudes on trials they received feedback on their own photos (M = 3.02, SD = 3.92) compared to trials they received feedback on others' photos (M = 1.96, SD = 3.95). There was no significant main effect of information cue, F(1, 29) = 2.65, p = .11, η_p^2 = .084, such that the RewP amplitudes did not differ for negative (M =2.34, SD = 3.86) and positive information cues (M = 2.64, SD = 3.95). However, the main effect of feedback was significant, F(1, 29) = 7.90, $p = .009, \eta_p^2 = .214$, such that the RewP amplitudes were significantly larger for misses (M = 2.76, SD = 4.04) than for hits (M = 2.22, SD =3.77). The main effect of electrode was also significant, F(1.58, 45.88)= 56.99, p < .001, $\eta_p^2 = .663$, such that regardless of the feedback, the largest amplitudes in the RewP time-range were found at Pz (M = 4.72, *SD* = 3.78), followed by Cz (*M* = 2.36, *SD* = 4.68) and Fz (*M* = .39, *SD* = 3.70).

Finally, the RewP component showed excellent internal consistency, yielding Cronbach's alphas of .97, .98, and .97, for the electrodes Fz, Cz, and Pz, respectively.

2.2.2. Feedback-P3 (FB-P3)

The ERPs in the FB-P3 time-range were measured as the mean amplitude from 340 to 500ms post feedback 1 onset. The Rm-ANOVA on the FB-P3 amplitude showed that there was no significant 4-way interaction between Photo Type, Information Cue, Feedback, and Electrode, *F*(1.35, 39.28) = 1.82, *p* = .18, η_p^2 = .059, nor were there any significant 3-way interactions [Information Cue x Feedback x Electrode, *F*(1.41, 41.02) = 1.06, *p* = .33, η_p^2 = .035, Photo-Type x Feedback x Electrode, *F*(1.50, 43.49) = .98, *p* = .36, η_p^2 = .033, Photo-Type x Information Cue x Electrode, *F*(1.41, 40.86) = 1.07, *p* = .33, η_p^2 = .036, or Photo-Type x Information Cue x Feedback, *F*(1, 29) = 1.76, *p* = .20, η_p^2 = .057].

However, there was a significant 2-way Information-Cue x Feedback interaction, F(1, 29) = 6.84, p = .01, $\eta_p^2 = .191$. Specifically, as shown in Fig. 3, simple effect tests showed that for the negative information condition, feedback for misses (i.e., Dislike with 1 and receipt of negative comment; M = 7.30, SD = 4.36) evoked significantly larger FB-P3 amplitudes than feedback for hits (i.e., Dislike with 0 and omission of negative comment; M = 5.56, SD = 3.90), F(1, 29) = 10.9, p.003, η_p^2 = .272, whereas for positive information, there was no significant difference in the FB-P3 amplitudes as a function of the feedback received [Hits: M = 5.55, SD = 3.61; Misses: M = 5.26, SD = 4.44], F(1, 29)= .33, p = 0.57, $\eta_p^2 = .011$. As expected, the differences between feedback for hits and misses in FB-P3 amplitudes were maximal in centroparietal areas, as shown in the topographic maps in Fig. 3. No other 2way interactions significantly predicted the amplitude in the FB-P3 time-range [i.e., Photo-Type x Information-Cue, F(1, 29) = 1. 29, $p = .27, \ \eta_p^2 = .043, \ \text{Photo-Type x Feedback}, \ F(1, \ 29) = 1.38, \ p = .25,$ η_p^2 = .046, Information-Cue x Electrode, *F*(1.47, 42.65) = .27, *p* = .70,

 η_p^2 = .009, Feedback x Electrode, *F*(1.38, 39.95) = 1.86, *p* = .18, η_p^2 = .060].

Additionally, the Rm-ANOVA also revealed a main effect of phototype, F(1, 29) = 50.99, p < .001, $\eta_p^2 = .637$, such that participants had significantly larger FB-P3 amplitudes on trials they received feedback on their own photos (M = 7.29, SD = 4.42) compared to trials they received feedback on others' photos (M = 4.54, SD = 3.33). Results also revealed a significant main effect of information cue, F(1, 29) = 14.21, p < .001, $\eta_p^2 = .329$, such that the FB-P3 amplitudes were significantly larger for negative (M = 6.43, SD = 3.87) relative to positive information cues (M= 5.40, SD = 3.82), irrespective of the feedback type. The main effect of feedback was also significant, F(1, 29) = 4.80, p = .04, $\eta_p^2 = .142$, such that the FB-P3 amplitudes were significantly larger for feedback on misses (M = 6.28, SD = 4.16) rather than feedback on hits (M = 5.55, SD= 3.58). In addition, the main effect of electrode was also significant, F $(1.68, 48.82) = 125.89, p < .001, \eta_p^2 = .813$, such that the largest FB-P3 amplitudes were found at Pz (M = 8.80, SD = 3.95), followed by Cz (M =5.84. SD = 4.37) and Fz (M = 3.12, SD = 3.43).

Finally, the FB-P3 component showed excellent internal consistency, yielding Cronbach's alphas of .93, .96, and .96, for the electrodes Fz, Cz, and Pz, respectively.

To ensure the differences we observed are due to the feedback per se and not due to differences in the baseline, we re-analyzed the ERP data without removing the baseline. As shown in Figure S1 (see supplementary material), the Information Cue x Feedback interaction we observed for the amplitudes in the RewP and the FB-P3 time-range at the feedback phase remained significant even in the un-baselined data.

3. Discussion

In the current study, we aimed to investigate whether people seek out negative social information about themselves, as well as the neurophysiological mechanisms that may underlie this counterintuitive behavior. As predicted, participants exhibited significantly slower reaction times in the negative information relative to the positive information conditions specifically for their own photos, showing less motivation to avoid negative rather than seek positive information about oneself. Coherently, receiving (vs. avoiding) negative information evoked larger amplitudes in the RewP and FB-P3 time-range, especially for participants' own photos, indicating that receiving negative information was more rewarding and more salient than not receiving any information. These results add to the growing literature on the attentiongrabbing nature of negative information on social media (Winter et al., 2015; Kätsyri et al., 2016; Boot et al., 2021; Kohout et al., 2023), and for the first time, they also reveal the neurophysiological mechanisms that may underlie this effect.

Importantly, present study helps clarify in which contexts the selfrelevance of negative content may inhibit or facilitate information seeking. Current findings contradict prior work showing that people choose to ignore negative outcomes in a personal lottery task (Charpentier et al., 2018) and reject medical screenings to avoid potentially negative outcomes (Golman & Loewenstein, 2012; Niehoff & Oosterwijk, 2020; but see the work of Lieberman et al., 1997 for opposing results). While in financial and health domains people seem to value ignorance more than knowledge, our findings unveil the possibility of self-relevant negative feedback acting as reinforcement in certain social domains. In contrast with financial domains where negative feedback is always interpreted as a loss and positive feedback as a gain, feedback in the social domain is not necessarily interpreted as such. Depending on social framing, social feedback can have different meanings, for example, positive feedback could mean a friendly apology (Weiß et al., 2020), and negative feedback could mean an opportunity to induce a positive change in behavior. In addition, negative social feedback, especially in the absence of positive feedback (i.e., in the negative information conditions where there is no possibility for a positive comment), may be preferred to indifference (Gallimore et al., 1969).

Our ERP results shed light into the underlying neurophysiological mechanisms that may drive self-relevant negative information seeking. Given that the FB-P3 is thought to reflect motivational salience and is generally larger for feedback stimuli with high salience and emotional value (San Martín, 2012; Novak & Foti, 2015; Glazer et al., 2018), a larger FB-P3 for negative feedback in the negative information condition (especially for participants' own photos) suggests that the prospect of accessing negative information was processed as the most salient feedback. In addition, given that the RewP is thought to reflect mesocorticolimbic reward circuit activation (e.g., ventral striatum and vmPFC) (Carlson et al., 2011; Proudfit, 2015) and is generally larger for wins vs losses in both monetary (Marco-Pallares et al., 2008; Nelson et al., 2016; Burkhouse et al., 2017) and social reward tasks (Ethridge et al., 2017; Distefano et al., 2018), a larger amplitude in the RewP time-range for negative feedback in the negative information condition (especially for participants' own photos) suggests that the prospect of receiving a negative comment was processed as rewarding feedback. Therefore, the increased salience and reward processing for negative feedback in the negative information condition as indexed by the P3 and RewP ERPs, respectively, may explain the engaging nature of self-relevant negative social information. The heightened salience of negative comments in our study may also be because social media users predominantly receive positive feedback on their posts (Valkenburg et al., 2006), with negative comments being rare, which may therefore make them more salient or more intriguing. This could also explain the non-significant difference in RewP and FB-P3 amplitudes between positive and negative feedback in the positive information condition.

However, given that the RewP was initially conceptualized as a loss signal known as the feedback-related negativity (FRN) and was thought to reflect negativity that is increased to loss rather than reward-related positivity (Gehring & Willoughby, 2002; Glazer et al., 2018), the larger RewP we found for the negative feedback could also be interpreted as a smaller FRN. A smaller FRN would suggest that receiving vs avoiding the negative feedback is processed as a less negative rather than a more positive outcome. Further, given that some researchers argued that the RewP reflects salience rather than reward prediction errors (Talmi et al., 2013), a larger RewP for negative feedback in our data may indicate that negative information is more salient, not necessarily more rewarding. However, while these alternative explanations are plausible, growing evidence suggests that the RewP reflects reward-specific activation (Carlson et al., 2011; Glazer et al., 2018; Holroyd et al., 2008, 2011; Carlson et al., 2015; Foti et al., 2011).

One of the strengths of our current study is our unique experimental approach. The modifications we made to the original SID task were instrumental in addressing our research question. Using participants' own Instagram photos as stimuli and introducing personalized and informative social feedback via comments were crucial modifications. While earlier versions of the SID used social incentives such as smiling faces and body gestures (Kohls et al., 2013), these may not have been genuinely social since they lacked direct human interaction. Even in more recent studies where participants believed the feedback came from the experimenter (Ait Oumeziane et al., 2017; Wei et al., 2020), simple gestures like thumbs up and down may have been perceived as automatic or mindless (Carr et al., 2016; Zell & Moeller, 2018), or too impersonal to convince participants of genuine social evaluation. Additionally, even when these gestures were more ecological since they were adapted from popular social medial platforms, they were not associated with participants' own photos or posts as would normally occur in the social media environment, which may have dampened their motivational salience and personal relevance in the task. In our study, using participants' own Instagram photos made the feedback more self-relevant and more motivationally salient, and the use of comments made the feedback feel more genuine, because comments are more concrete (Winter et al., 2015; Boot et al., 2021), more informative, and more effortful than Likes (Zell & Moeller, 2018). In addition, by being more informative and more specific to the content of the photos, comments were more curiosity-evoking and more likely to incentivize participants to seek negative feedback.

While our experimental approach is promising, our study is not without limitations. First, while our sample size is similar to that of prior EEG studies that found large effects using the SID (e.g., Ait Oumeziane et al., 2017) and other tasks assessing the neural correlates of social acceptance and social rejection (Zhang et al., 2022), larger samples are needed to detect smaller effects, especially for interactions. Second, although we included comments as a step forward from previous versions of the SID, we did not analyze the ERPs time-locked to the comments' delivery (Feedback Phase 2). Therefore, one might argue that the feedback phase that we analyzed does not represent the actual rewards or punishments. However, seeing the comments was associated with first seeing the Likes/Dislikes, which likely increased the rewarding value of the Likes/Dislikes. In addition, while the use of participants' own photos as stimuli increased the ecological validity of the task, some photos may have been more important to participants than others, which may have further influenced the results. Further, while the dislike symbol used to signal negative feedback in the negative information condition is known from Facebook and X (formerly known as Twitter), it is not generally known to be embedded in a pink speech bubble. The reason we employed it this way was to make it perceptually similar to the Like symbol adapted from Instagram. Although participants received explicit instructions and underwent sufficient practice trials to familiarize themselves to the stimuli, we cannot eliminate the possibility that reduced prior familiarity with the dislike stimulus may have influenced results. In addition, while slower reaction times in the negative information vs positive information condition may reflect participants' motivation to avoid the negative comments, they may also reflect participants' difficulty in keeping track of when they needed to be slower vs. faster to achieve their goals, or they may suggest that participants were conflicted about whether they wanted to see the negative comments. Given that reaction times may be confounded by other factors and do not represent an explicit or a direct measure of participants' preference to seek rather than avoid self-relevant negative information, our behavioral data must be interpreted with caution. In this regard, future studies might use a more straightforward decision-making task directly asking whether participants want to see the negative comments on a given photo or not. This approach may help clarify participants' intentions and might provide more compelling evidence for participants' tendency to seek vs avoid negative information. Finally, since prior studies suggest that negativity biases are more common in younger people (Reed et al., 2014), future research should replicate this study in older populations to explore whether the negativity bias we found still holds for older adults.

4. Conclusion

Findings show that people engage in self-relevant negative social information and unveil the potential neurophysiological mechanisms that may underlie this counterintuitive behavior.

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CRediT authorship contribution statement

Daniel Vega Moreno: Writing - review & editing, Supervision,

Software, Resources, Methodology, Funding acquisition, Conceptualization. **Stella Nicolaou:** Writing – original draft, Visualization, Methodology, Formal analysis, Conceptualization. **Josep Marco-Pallares:** Writing – review & editing, Supervision, Software, Resources, Methodology, Funding acquisition, Conceptualization.

Declaration of Generative AI and AI-assisted technologies in the writing process

The author(s) did not use generative AI technologies for preparation of this work.

Declaration of Competing Interest

All authors declare that they have no conflict of interest with respect to their authorship or the publication of this article.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.biopsycho.2024.108982.

Data availability

Data will be made available on request.

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