How occupational status influences the processing of faces: An EEG study

Audrey Breton, Romain Ligneul, Karim Jerbi, Nathalie George, Jean-Yves Baudouin, Jean-Baptiste van Der Henst

Neuropsychologia 122 (2019) 125-135

https://doi.org/10.1016/j.neuropsychologia.2018.09.010

How occupational status influences the processing of faces: An EEG study

Audrey Breton[a,*], Romain Ligneul[b,c,**], Karim Jerbi[d,e], Nathalie George[f], Jean-Yves Baudouin[g], Jean-Baptiste Van der Henst[a]

[a] Institut des Sciences Cognitives Marc Jeannerod (UMR 5304), CNRS-Université Lyon 1, France
[b] Champalimaud Neuroscience Program, Champalimaud Center for the Unknown, Lisbon, Portugal
[c] Institut des Sciences Cognitives Marc Jeannerod (UMR 5229), CNRS-Université Lyon 1, France
[d] CoCo Lab, Psychology Department, University of Montreal, Montreal, QC, Canada
[e] MEG Unit, University of Montreal, Montreal, QC, Canada
[f] Inserm U 1127, CNRS UMR 7225, Sorbonne Universités, UPMC Univ Paris 06 UMR S 1127, Institut du Cerveau et de la Moelle épinière (ICM), Social and Affective Neuroscience (SAN) Laboratory and Centre MEG-EEG, Paris, France
[g] Laboratoire Développement, Individu, Processus, Handicap, Éducation (DIPHE), Département Psychologie du Développement, de l'Éducation et des Vulnérabilités (PsyDÉV), Institut de psychologie, Université Lumière Lyon 2, Bron, France

* Corresponding author at: Institut des Sciences Cognitives Marc Jeannerod (UMR 5229), CNRS-Université Lyon 1, France.
** Corresponding author at: Champalimaud Neuroscience Program, Champalimaud Center for the Unknown, Lisbon, Portugal.
E-mail addresses: audrey.breton8@gmail.com (A. Breton), romain.ligneul@gmail.com (R. Ligneul).

Please cite this article as: Breton, A., Neuropsychologia, https://doi.org/10.1016/j.neuropsychologia.2018.09.010

A R T I C L E I N F O

Keywords:
Social status
Gender
N170
Late positive potential (LPP)
ERPs
Face processing

A B S T R A C T

This study examines the influence of social hierarchy on the neural electrophysiological responses to faces. In contrast with earlier EEG studies that typically manipulate social rank through competitive situations, we implemented hierarchy through occupational status and thus contrasted faces associated with high- vs. low-status (e.g. lawyer vs. waiter). Since social hierarchies are largely intertwined with gender, both female and male faces were used as stimuli, and both female and male participants were tested. The procedure consisted in presenting a status label before the face it was associated with. The analyses focused mainly on two components that have been shown to be modulated by competitive hierarchies and other social contexts, namely the N170 and the Late Positive Potential (LPP). The results indicated that gender, but not status, modulated the N170 amplitude. Moreover, high-status faces elicited larger LPP amplitude than low-status faces but this difference was driven by female participants. This gender effect is discussed in line with research showing that women and men are sensitive to different kinds of hierarchy. Methodological differences are considered to account for the discrepancy between studies that find an effect of hierarchy on the N170 and those that do not.

1. Introduction

“My word, sir, I have never seen anything like it. [...] there was such power and majesty in his look that if he had bade me lie down that he might walk over me I would have done it at once, English middy though I was. The look on Napoleon's face was the revelation of the man and the explanation of his power. He was born to command (Admiral Eden in 1887, reported by John Rooker, 1901)[1]”. Presumably, the stunning experience of Admiral Eden would have been radically dif- ferent had he thought the face of the former Emperor of the French was that of a secondary junior officer. Our perception of other people deeply relies upon the social context in which they are embedded, and be- lieving a face is that of an emperor or believing it is that of a sub- ordinate individual makes a critical difference. In the current study, we investigate how knowledge about hierarchical status influences the neural processing of male and female faces by male and female participants.

Hierarchies constitute a critical factor that structures our social environment. They arise in all social mammals, and among humans they are observed even in the most egalitarian hunter-gatherer societies (Boehm, 1999), as well as in groups of two-year old children (Boyce, 2004; Strayer and Strayer, 1976). According to evolutionary accounts, the influence of social rank on reproductive success and quality of life has exerted selective pressure on many motivational and cognitive processes (Cummins, 2005; Dunbar and Shultz, 2007; Ellis, 1995). Ex- perimental works indicate that the desire for status, which is often considered as a fundamental human motive (Barkow et al., 1975; Maslow, 1943) emerges at preschool years and guides a number of behaviors among men and women from different cultures (Anderson et al., 2015). At the cognitive level, a wide range of results shows that adults and children display subtle abilities in detecting status (Charafeddine et al., 2015; Gülgöz and Gelman, 2017; Mascaro and Csibra, 2012; Schmid Mast et al., 2009), memorizing hierarchies (Zitek and Tiedens, 2012) and making transitive inferences from dominance relationships (Gazes et al., 2017).

Insofar as high-ranking individuals represent a higher risk of threat in conflicting interactions or, alternatively, a greater source of social support, it can be expected that those individuals will be monitored more by other group members. Consistent with this view, recent results obtained in the field of face processing indicate that the investment of cognitive resources is asymmetrical and more directed towards the top of the hierarchy. Eye-tracking studies show that faces of individuals who are dressed in high-status attire (Maner et al., 2008), who are ranked better in competitive situations (Breton et al., 2018), or who influence more interactive group decision making (Foulsham et al., 2010) receive more visual attention. Moreover, participants look more into the direction gazed by male faces associated with a high-status CV than into the direction gazed male faces associated a low-status CV (Dalmaso et al., 2012, 2014). A memory bias is also observed: faces associated with high occupational status are better remembered and their location in space is better memorized (Ratcliff et al., 2011). Fi- nally, functional magnetic resonance imaging (fMRI) data reveals that the processing of high status faces elicits stronger activation in areas associated with vision, attention, emotion, and mentalizing, as com- pared to low status faces (Farrow et al., 2011; Ligneul et al., 2017; Qu et al., 2017; Sanderson et al., 2005; Zink et al., 2008, see also Koski et al., 2015 for a review).

1.1. The influence of social rank on face processing: EEG evidence

Recently, a handful of studies attempted to examine the temporal dynamics of brain activities while participants observed high- and low-ranking faces, with the aim of identifying the ERP components modu- lated by social rank (Breton et al., 2014; Feng et al., 2015; Hu et al., 2014; Santamaria-Garcia et al., 2015). A key issue emerging from this literature is whether hierarchy affects the early stage of face processing, as indexed by the N170 component, or only influences ERP components reflecting higher level cortical processes such as the Late Positive Po- tentials (LPP).

The N170 is the most frequently investigated face-sensitive com- ponent. Its amplitude is maximal at occipitotemporal sites and between 140 and 200 ms after the presentation of the face (Eimer, 2011). It is usually considered to reflect the structural encoding of faces (Bentin et al., 1996; see Eimer, 2011 for a review), that is the configural pro- cessing of facial features (the eye, the nose, the mouth) enabling the recognition of a visual stimulus as a face (Rossion, 2014). A large body of studies has investigated whether social categories such as race, gender, and familiarity, modulate the N170 but results turned out to be inconsistent. While some studies found no influence of social informa- tion on this component (*familiarity*: Bentin and Deouell, 2000; Eimer, 2000; Henson et al., 2003; Jemel et al., 2003; Rossion et al., 1999; Schweinberger et al., 2002a, 2002b; *race*: Caldara et al., 2003, 2004; Ito et al., 2004; *gender*: Mouchetant-Rostaing et al., 2000; Mouchetant- Rostaing and Giard, 2003), others reported that the N170 was sensitive to social cues and lead researchers to argue that social information is integrated from the initial stage of face structural encoding (*familiarity*: Caharel et al., 2002, 2005, 2006; Kloth et al., 2006; Harris and Aguirre, 2008a, 2008b; *race*: Ito and Urland, 2005; Senholzi and Ito, 2012; Walker et al., 2008; *gender*: Freeman et al., 2010). One difficulty of investigating the influence of social categories on the N170 is that they can be associated with low-level perceptual cues (such as distinct skin colors for race, or distinct facial traits for gender) or with different level of experience (for familiarity). To overcome this difficulty, some studies contrasted the level of typicality within a social category (e.g. sex-ty- pical vs. sex-atypical faces; Freeman et al., 2010) rather than contrasting sub-categories (e.g. females vs. males) and others manipulated social information by neutralizing low-level perceptual influences. For instance, using a minimal group paradigm, Ratner and Amodio (2013) manipulated group membership and found a larger N170 amplitude for ingroup than for outgroup faces. Moreover, Bublatzky et al. (2014) manipulated the social relevance of faces (relevant faces being in- troduced as those of potential interaction partners) but found no modulation of this factor on the N170.

Hierarchy constitutes another key dimension for which low-level perceptual traits can be neutralized, unless, of course, it is manipulated through dominance and subordination traits (Chiao et al., 2008). In studies examining the N170 component, hierarchy is typically induced through competitive games that engaged perceptual and cognitive skills. Breton et al. (2014) found no modulation of the N170 amplitude but reported a larger LPP component at parietal sites and a greater reduction of alpha power for high-ranking faces. Two studies (Feng et al., 2015; Santamaria-Garcia et al., 2015), inspired by a methodology introduced by Zink et al. (2008), used a “star-system” to convey explicit hierarchical cues: high-ranking faces were presented together with three stars underneath while the low-ranking faces were presented with only one star. While the parietal LPP effect was replicated when tested (Feng et al., 2015), both studies also found a larger N170 amplitude for high-ranking (three-stars) than for low-ranking (one-star) faces (Feng et al., 2015; Santamaria-Garcia et al., 2015). Moreover, two other re- cent studies that did not examine the N170 component did however find a modulation of the LPP amplitude in other types of hierarchy (Furley et al., 2017; Gyurovski et al., 2018). In particular, pictures of leading athletes and faces associated with a high financial status eli- cited a late positivity of greater amplitude, as compared to trailing athletes and faces of low financial status (Furley et al., 2017; Gyurovski et al., 2018). Modulations of LPP are commonly observed in the context of other social categories (familiarity, race, and gender). The LPP evoked by familiar faces has been considered to reflect semantic and personal identity representations (Eimer, 2000; Paller et al., 2000; Schweinberger et al., 2002a), and for race, gender and hierarchy, LPP are viewed as reflecting the cognitive assessment of face and category- related information (Ito and Urland, 2003; Walker et al., 2008) or as the manifestation of motivated attention and social evaluations (Furley et al., 2017; Gyurovski et al., 2018; Ito et al., 2004).

To sum up, four studies did find the same modulation of hierarchy on LPP over parietal sites and in similar time-windows (Breton et al., 2014: 400–700 ms; Feng et al., 2015: 400–550 ms; Furley et al., 2017: 400–1000 ms; Gyurovski et al., 2018: 350–650 ms). However, for the N170 component, results were inconsistent as two studies did report a modulation of hierarchy (Feng et al., 2015; Santamaria-Garcia et al., 2015) and another did not (Breton et al., 2014).

The discrepancy in the N170 results could actually stem from methodological differences between studies. In Breton et al.'s work, participants had to remember the hierarchy presented to them during the learning phase. This might have reduced the saliency of the hierarchical information and might have delayed the identification of the face status. This evidently contrasts with the star-system methodology in which the hierarchical cues were always available (Feng et al., 2015; Santamaria-Garcia et al., 2015). However, a potential drawback of this latter approach is that high-ranking faces were presented with more complex and attention-capturing visual stimuli than low-ranking faces, namely three stars vs. one star (we will return to this issue in the Dis- cussion section). In the current study, we attempt to take advantage of both approaches while avoiding their limitations. On the one hand, each face was displayed just after presenting high- or low-status labels, so that status-face associations did not tax memory resources. On the other hand, each face was presented on its own, so as to prevent the status label to visually interfere with the processing of the face.

The current experiment focuses on the two components that have been previously investigated in the context of hierarchy, namely the N170 and the LPP. According to the view that hierarchy can modulate the early step of face processing and that high-status individuals are more likely to capture rapid attention (Feng et al., 2015; Santamaria et al., 2015), it could be expected that high occupational status faces elicit an N170 of greater amplitude than lower status faces. However, if the N170 modulation resulted from perceptual factors unrelated to hierarchy, this modulation might not be observed in the current study. In addition, given that four studies have consistently reported a modulation of LPP in the 400–1000 ms time-window, a similar effect could be replicated.

1.2. Gender and the perception of social rank

Another key issue we address in the current study is how the per- ception of social rank interacts with the face gender and the partici- pant's gender. Gender was largely overlooked in earlier EEG studies dedicated to the influence of hierarchy. Some studies included only male participants (Breton et al., 2014), others used only male stimuli (Breton et al., 2014; Gyurovski et al., 2018) and others included both male and female participants but did not analyze a potential effect of the participants' gender (Feng et al., 2015; Furley et al., 2017; Gyurovski et al., 2018; Hu et al., 2014). Moreover, although Santamaria-Garcia et al. (2015) examined gender and found that the modulation of status on the N170 amplitude was greater for male than for female participants, it is unclear whether this difference was an effect of the participants themselves or an effect of the stimuli, as male participants were presented only with male faces and female partici- pants only with female faces.

Gender is largely intertwined with hierarchy. From hunter-gatherer to modern industrial societies, women occupy less power positions, control less resources and are assigned to less prestigious activities than men (Eagly et al., 1992; Eagly and Wood, 1999; Sanderson et al., 2005; Whyte, 1978). From a psychological perspective it appears that domi- nant behaviors are more likely to be associated with men than women and also more likely to be tolerated among men than women (Copeland et al., 1995; Eagly et al., 1992; Johnson et al., 2008; but see Elsesser and Lever, 2011). Likewise, research on the representation of gender and hierarchy also indicates that people implicitly expect men to be more hierarchical and women to be more egalitarian (Schmid Mast, 2004); consequently, male hierarchies are learned more quickly than female ones (Zitek and Tiedens, 2012).

An important issue regarding the relationship between hierarchy and gender concerns the type of hierarchy males and females are sen- sitive to. For instance, significant gender differences have been reported regarding the attitude towards hierarchies that rely on competition. Women typically describe themselves as less competitive than men do and they are also less likely to enter competitive tournaments than men (Niederle and Vesterlund, 2007). Moreover, competitive environments differentially affect men and women's performance: Gneezy et al. (2003) found that competition significantly increases performance in cognitive tasks among men, but not among women. In the EEG research described above, the hierarchy always relied on a competitive context, which was therefore probably more relevant to male than to female participants. This could explain the gender difference showing a greater modulation of status on the N170 for males than for females (Santamaria-Garcia et al., 2015).

In an attempt to provide a social context that was highly relevant to male and female participants, the current study established a hierarchy that was based not on competitive games but on occupational status. In modern industrialized societies, being endowed with a high occupa- tional status is not only an indicator of high income, it is also a sign of elevated educational level and intellectual achievement. People have no difficulty in ranking job occupations from a high to low social rank (Treiman, 1977) and research conducted in western countries indicates that among teenagers and young adults, females aspire to high occu- pational status to the same extent than do males, though this was not the case in the past (Mello, 2008; Schoon, 2006; Schoon et al., 2007). Moreover, while in the early 1990s, participants valued less the same occupation when it was carried out by a woman than by a man, this seems to be no longer the case in the 2010s (Crawley, 2014). While most neuroscientific studies investigated social hierarchy in competi- tive or dominance contexts, a recent fMRI study, by Koski, Collins and Olson (2017) has manipulated the social status associated with faces through occupation. The authors found a sensitivity to the difference between high vs. low occupational status' faces in the left orbitofrontal cortex, a region which may play a role in social evaluation and social reward (Koski et al., 2017). However, the authors themselves ac- knowledge that the gender issue was a limitation of their study. Only male faces were used as stimuli and analyses comparing male and fe- male participants were not reported.

To summarize, the present study investigates the influence of hier- archy on the processing of faces and differs in three main respects from earlier work. First, while the association between the face and the status label was made readily accessible so as to minimize memory load, the two stimuli were not presented together. Second, the influence of gender was investigated at the level of the stimuli and at the level of the participants. Third, hierarchy was operationalized through occupa- tional status rather than through competitive games.

2. Methods

2.1. Participants

Forty-four healthy right-handed volunteers (twenty-two women) aged between 19 and 26 years (men: mean = 22.92 years ± 1.89 SD, median = 22.81 years, women: mean = 22.99 years ± 1.75 SD, median = 22.92 years) gave their informed written consent to parti- cipate in this study and were compensated for their participation. All participants were French, had comparable educational backgrounds, comparable educational qualification level (between Bachelor's and Master's degree), and had normal or corrected-to-normal vision. The protocol of this study was approved by the local ethics committee (Comité de Protection des Personnes, Gerling agency - File no: 0100630314037)

2.2. Stimuli

The stimulus set consisted of 120 high-resolution photographs of Caucasian neutral faces (60 female and 60 male faces) picked from the NimStim Set of Facial Expressions standardized database (Tottenham et al., 2009) and from the stimuli set used by Baudouin and Gallay (2006). We transformed them into grayscale images and normalized them in size, luminance and contrast. Faces were displayed on a screen with a light gray background and subtended horizontal and vertical visual angles of 10.1 × 10.1° at a viewing distance of 80 cm (400 × 400 pixels). One hundred twenty supplementary new faces (60 female faces) were created following the same procedure to serve as fillers in the last phase of the experiment.

To convey a high or low occupational status, one out of six pro- fessional titles was presented in French before each face. These nouns were selected on the basis of a pretest online study in which 292 French-speaking participants (146 women - men: mean age = 26.89 years ± 2,76 SD, median = 26,6 years, women: mean age = 27,19 years ± 2.57 SD, median = 27 years) comparable in educational background with the participants included in this EEG study, had to evaluate a set of eighteen profession titles according to two criteria. First, they were requested to estimate whether they thought there were more women or men for each occupational title using the following 5- point scale: (1) “many more women”, (2) “a little more women”, (3) “as many women as men”, (4) “a little more men”, (5) “many more men”. Second, they then had to assign each occupational title to the high or low-status category. This survey was conducted to ascertain status perception of job titles and to control the distribution of gender be- tween the two status groups. We thus selected three high-status occupational terms, in French: “pharmacien - pharmacienne” (phar- macist), “ingénieur - ingénieure” (engineer), “avocat - avocate” (lawyer); and three low-status occupational terms: “ouvrier - ouvrière” (worker[2]), “coiffeur - coiffeuse” (hairdresser), “serveur - serveuse” (waiter). Regarding the first question, the three high-status titles (“lawyer”, “engineer” and “pharmacist”) and the three low-status titles (“worker”, “hairdresser” and “waiter”) were judged to be occupied as much by women as by men by 42,1% and 31.3% of all the respondents respectively. Moreover, participants associated the three high-status occupational titles with masculinity (“many more men”) in similar proportion (17%) as they did for the three low-status occupational titles (22,6%). Responses percentages to each scale category are reported in Table 1 (below) according to respondent gender and for both high- and low-status occupational titles. Regarding the second question, 100% of the participants assigned the “lawyer”, “engineer” and “pharmacist” titles to the high-status category and the quasi-totality of participants assigned the “waiter” (98.3– 97,3% of the male respondents and 99% of the female respondents), the “hairdresser” (95.7–95,9% of the male respondents and 99,5% of the female respondents) and “worker” (97.7– 97,6% of the male respondents and 97,5% of the female respondents) to the low-status category. Importantly, these nouns displayed a different spelling in the masculine and feminine forms. As a consequence, when processing each profession noun, the participant knew whether the upcoming face would be a female or a male face.

2.3. Design and procedure

Upon her/his arrival to the lab, the participant was explicitly told that s/he was participating in a scientific project on the perception of social status from occupational titles. To make sure participants would clearly understand the notion of status investigated in this study, they were told that certain professions, which usually confer a high status in the society, require a high educational background, entail a high level of responsibility, and are associated with a high salary and a lot of prestige. On the opposite, they were told that professions, which confer lower social status in the society, do not require long years of study, imply little responsibility, with lower pay and lower prestige. As a cover story, participants were told that a large sample of individuals holding different occupations were photographed by other researchers from the lab, and that they will be presented with their faces preceded by the name of their professions. Participants were asked to pay attention to faces in the context of the associated occupations. They were then ex- plained the EEG recording technique and principles before being comfortably seated in front of a computer screen, in a dimly lit room. The EEG cap was then installed and prepared for recording. The ex- periment was designed using Presentation®14.3 (Neurobehavioral System, http://www.neurobs.com/) and was divided into two different phases: the *priming phase* and the *status-face association phase*.

2.3.1. The priming phase

During this phase, each participant had to categorize 30 professions (the 6 “target” professions and 24 “filler” professions) as being of high or low social status. Participants were presented with a profession noun on the top of the computer screen and had to categorize it by selecting the “HIGH” or “LOW” response (Fig. 1A) with two buttons on the keyboard. The presentation order of the 30 professions was randomly set for each participant. After completing this task, the participant was presented with the full set of her/his categorizations (Fig. 1B). We re- viewed with him/her all his/her choices and s/he was then told that 3 high-status and 3 low-status titles (as classified by her-/him-self) would be selected from the list. As a matter of fact, for all participants, the 6

titles described in the stimulus section were the ones selected for the next status-face association phase. In line with the pretest study, all participants included in the EEG study categorized pharmacist, en- gineer and lawyer as high-status titles, and worker, hairdresser and waiter as low-status titles. This phase not only primed the association of occupational titles with either a high or a low status, it also reinforced the participant's commitment by taking into account her/his own ca- tegorizations. The participant was then informed that s/he would be presented with photographs of men and women occupying the 6 se- lected titles. This phase lasted approximately 8 min

[2] In French, the tittle "worker" (*ouvrier*) depicts a specific profession, not just a general qualifier for people who “work” in various areas. This title is associated with a low social status.

Table 1
Mean responses percentages to each category of the scale used in the pre-test survey (first question), for both high- and low-status occupational titles and according to participants gender.

		Many more women	A little more women	As many women as men	A little more men	Many more men
High-status titles	Men	0,46%	5,25%	41,32%	38,13%	14,84%
	Women	0,23%	3,20%	42,92%	34,47%	19,18%
Low-status titles	Men	18,49%	19,63%	29%	8,22%	24,66%
	Women	19,18%	17,81%	33,56%	8,90%	20,55%

2.3.2. The status-face association phase

EEG recordings started during this second phase. Participants were presented with three blocks of 360 trials according to a 2 (gender of the face) by 2 (status) design resulting in four conditions (90 trials per condition). The set of stimuli was administered in three blocks (120 trials per block) each separated by a short break. Each trial adhered to the following sequence: i) a fixation circle presented for a random in- terval of 1000–1400 ms, ii) the gendered noun (feminine or masculine) of a profession appeared in the center of the screen during 1000 ms, followed by iii) a fixation cross for a random time interval of 1000–1400 ms, and iv) a female or male face, matching the gendered spelling of the occupation title for 600 ms. A black screen was presented in the inter-trial interval. This inter-trial interval was randomized be- tween 1600 and 2000 ms (Fig. 1C). To maintain participant's attention, ten percent of the trials (i.e. 36 randomly chosen among 360, 12 per block) were followed by a question about the status associated with the preceding face. The participant had to determine as fast as possible if the face s/he just saw was of high- or of low-status by pressing the instructed buttons (Fig. 1C). Participants were explicitly asked to focus on the status-face association they were presented with. Before starting the experiment, participants were requested to limit head movements, facial muscles contractions and they were invited to avoid blinking during the title and face presentation to reduce signal artifacts. The 120 face pictures were presented 3 times each and were displayed in a pseudo-randomized order, with no face appearing in two consecutives trials. For a given participant, each of the 6 occupations was associated with 10 different female faces and 10 different male faces; these asso- ciations remained unchanged over the course of the experiment and were counterbalanced across participants. Thus, there were 30 trials for each gendered occupation, resulting in a total of 90 trials by status (high-/low-status occupations) for each face gender (men, women). This phase lasted a total of approximately 25 min.

2.4. EEG recording

EEG recording was performed from 64 active electrodes connected to an *Acticap* (International 10–20 System, American Encephalographic Society, 1994) amplified by a BrainAmp amplifier (Brain Products, Gilching, Germany). The sampling rate was of 1024 Hz and an online 0.01–100 Hz bandpass filter was applied during recording. The ground electrode was placed on the forehead. The reference electrode was placed on the tip of the nose; this reference was kept for off-line analysis. Two supplementary external electrodes were placed on each ear lobe, and vertical and horizontal eye movements (EOG) were monitored on-line using two bipolar montages. All the electrodes had their impedance below 5 kΩ before starting the recording.

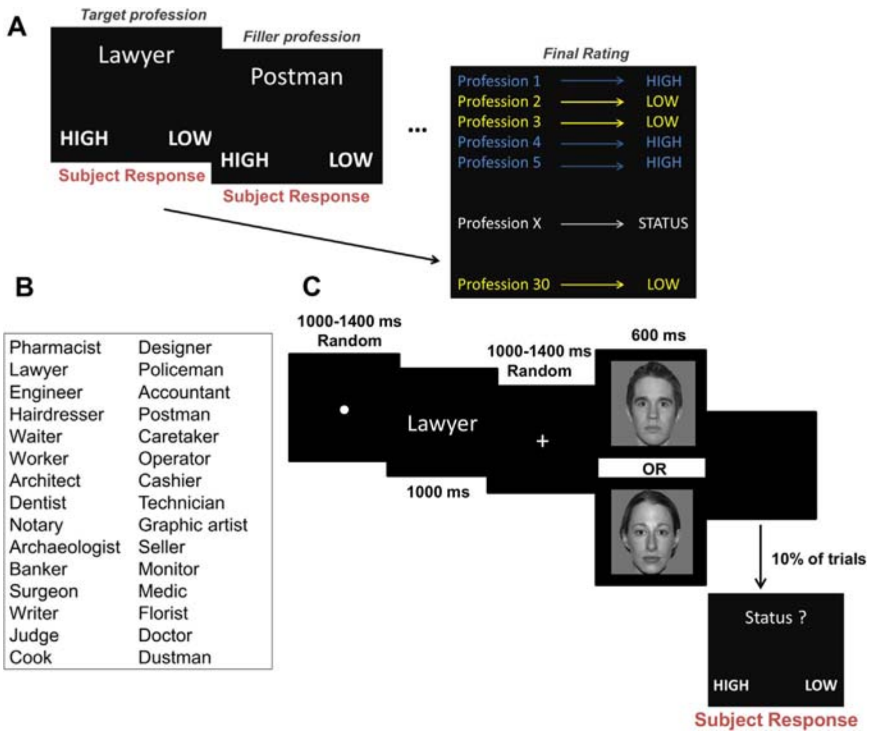

Fig. 1. Representation of the different experimental phases. A) Example of occupational title classification according to a high or low status performed by the participant during phase 1. B) List of the 30 occupational titles used in phase 1. C) Representation of the trials displayed during the status-face association phase (2) with examples of male and female faces stimuli. EEG recordings of interest were performed during face presentation.

2.5. ERP analysis

All EEG preprocessing and processing steps were performed using ELAN software developed by the INSERM U1028 at the Lyon Neuroscience Research Center (CRNL), Lyon, FRANCE (Aguera et al., 2011; http://elan.lyon.inserm.fr). The signal was re-referenced offline according to the averaged left and right earlobes electrodes. The dif- ferent preprocessing and processing steps were conducted in parallel both on signal referenced to the nose and on signal referenced to the average earlobes, in order to adapt accordingly to the various in- vestigated ERP components. We applied off-line two 3rd order infinite impulse response (IIR) Butterworth filters on continuous (non-seg- mented) EEG data: a band-stop (notch) filter to attenuate AC line noise (50 Hz in France; low cut-off frequency at 51 Hz, high cut-off frequency at 49 Hz) and a band-pass filter (low cut-off frequency at 0.05 Hz, high cut-off frequency at 35 Hz). We then performed two artefacts rejection steps using the same criteria for all participants. First, trials con- taminated by ocular movements or blinks were rejected using an au- tomatic detection procedure (voltage changes in any of the two ocular bipolar montages electrodes lower than 1 µV or greater than 80 µv, for any time-window of 80 ms). This automated procedure was completed by a visual inspection of the signal. Second, we rejected trials con- taminated by electrical drifts (maximal or minimal voltage value on any scalp electrode respectively greater or lower than ± 150 µv). For each procedure, we kept the same voltage threshold and/or latency criteria for all the participants. EEG signal was then segmented into epochs of 1600 ms, starting 600 ms prior to the face onset and ending 1000 ms post-stimulus. For computing the ERPs, epochs were averaged for each subject according to the four status x gender conditions. Following the artifact rejection described above, a minimum of 15 epochs for each subject was averaged for each occupational title (6)-by-face gender (2) sub-condition, resulting in a total of at least 45 trials for each status (2) by face gender (3) condition. Participants who did not reach this criterion were excluded from the analysis (4 men and 4 women). Thus, the ERP analysis was conducted on 18 men and 18 women (Men: mean = 23.06 years ± 2.02 SD, median = 22.82 years; Women: mean = 22.95 years ± 1.89 SD, median = 22.92 years; Student *t*-test $t(35) = -0.19$; $p = .85$). After rejection procedure, the analysis included in average 80,3% of the trials for men (289,3 over 360; high-status male faces: 80,6%; low-status male faces: 78,1%; high-status female faces: 80,8%; low-status female faces: 82%) and 82,7% for women (297,9 over 360 in total; high-status male faces: 83%; low-status male faces: 81%; high-status female faces: 83,4%; low-status female face: 83,5%). The averaged activity from −300 to 0 ms pre-stimulus was subtracted to each epoch as the baseline correction.

ERP components of interest were measured as the mean signal amplitude in a given time window. Concerning the early neuronal re- sponse, we focused on the N170 ERP component considering the signal referenced according to the nose electrode as a standard (Eimer, 2000). We determined the N170 peak latency (i.e. latency of the maximal amplitude) on the temporo-parietal sites P7 and P8 where this ERP was maximal in the grand average over all the participants. The N170 mean amplitude was then measured on four electrodes P7, P8, PO7 and PO8 (Bentin et Deouell, 2000; Walker et al., 2008) (Fig. 2A), as the mean signal value over a ± 20 ms-window around the grand average peak latency (160 ms), i.e. [140–180 ms] as in Mouchetang-Rostaing et al. (2000), Eimer (2000), and Breton et al. (2014). Using a ROI approach, the N170 amplitude was analyzed in two parieto-occipital clusters considering the mean amplitude in P7/PO7 and in P8/PO8.

Concerning the late neuronal response, we focused on the LPP considering the signal referenced according to the averaged earlobes as a standard (Schupp et al., 2004). The LPP mean amplitude was mea- sured on a cluster of 10 electrodes located in the posterior medial region (PM: CP1, CPz, CP2, P1, Pz, P2, POz, O1, Oz, O2, see Fig. 3A) as defined in Furley et al. (2017). The time-window selected for measuring the LPP amplitude was based on the four studies that previously ex- plored this component in a hierarchy context. Averaging across the four time-windows used in those studies (Breton et al., 2014: 400–700 ms; Feng et al., 2015: 400–550 ms; Furley et al., 2017: 400–1000 ms; Gyurovski et al., 2018: 350–650 ms) resulted in the 390–650 ms time- window. The mean LPP amplitude was thus computed in each electrode for each sub-condition and each participant in the [390–650 ms] in- terval and then averaged across cluster's electrodes.

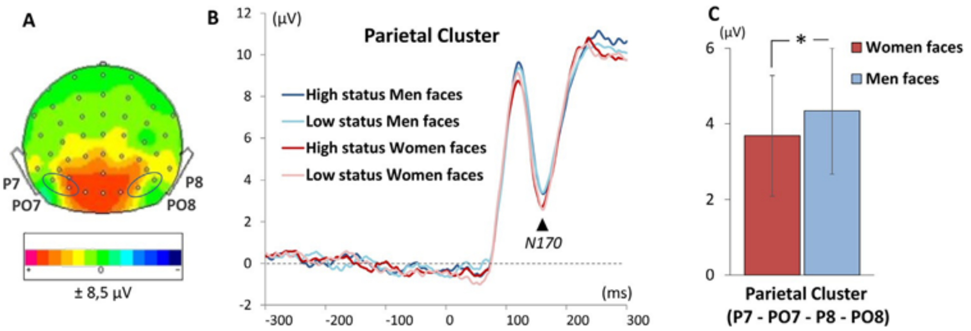

Fig. 2. A) Scalp topographic map of the mean potential value averaged across all the parti- cipants and all the conditions in the 140–180 ms time window. The two clusters of electrodes included in the analyses are sur- rounded by a gray circle (left: PO7, P7; right: PO8, P8). B) Mean ERP waveforms of the N170 component averaged on the two clusters of electrodes P7/PO7 and P8/PO8 in response to the four face gender by face status conditions (dark-blue: high status men faces, light blue: low-status men faces, dark red: high-status women faces, light red: low-status women faces). The time course of the ERP was aver- aged across the 36 participants. C) Bar plot of the mean N170 amplitude in the 140–180 ms time window averaged on the two clusters of electrodes P7/PO7 and P8/PO8. The vertical lines in the plot represent the confidence interval at 95% and * indicates significant differences. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Additionally, the visual inspection of the ERP waveforms revealed two others very early components evoked in the occipital sites, one negative deflection peaking at ~70 ms and associated to a N70 and a second, positive, deflection peaking at ~100 ms after the stimulus onset and associated to a P100. Although these two components were not our main focus in the current study, we chose to report their analyses (Section 3.3.). The N70 and the P100 were examined on the signal re- referenced according to the averaged earlobes electrodes as the stan- dard reference for these two potentials (Eimer and Forster, 2003; Zani and Proverbio, 2012). We applied the same procedure as for the N170: the latency peak of each components was determined on the electrodes where they were the most prominent in the grand average, i.e. Oz for the N70 and O1/O2 for the P100. The amplitude peak was 71 ms for the N70 and 117 ms for the P100. For each of these components, the mean potential value was computed within time-windows centered on the peak latency, in agreement with past studies. For the N70, a 20 ms time- window was used (i.e. 61–

81 ms) as in Eimer and Forster (2003) and for the P100, a 40 ms time-window was used (i.e. 97–137 ms) as in Walker et al. (2008). As visual stimuli were displayed at the center of the screen, no lateralization effect was expected on the P100. Statistical analysis was thus conducted on the P100 mean amplitude averaged over the two O1/O2 electrodes.

To investigate the time course of the neural processing of social status conveyed by faces of distinct gender, the mean amplitudes of N170 and the LPPs were submitted to distinct repeated measure ANOVAs. For the N170, the ANOVA included social status (2 levels), face gender (2) and laterality (2 levels) as within-subject factors, and participant's gender (2 levels) as between-subject factor. For the LPP, the ANOVA included social status (2 levels), face gender (2 levels) as within-subject factors and participant's gender as between-subject factor.

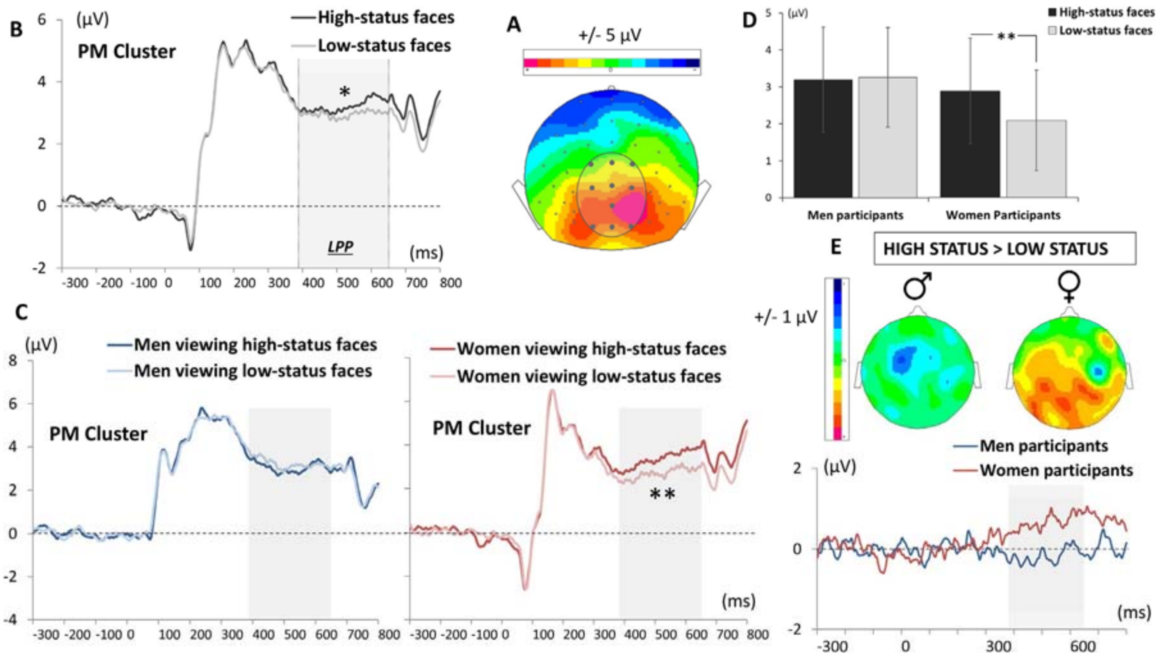

Fig. 3. A) Scalp topographic map of the mean signal in the 390–650 ms time window over all the participants and in all the conditions. Electrodes included in the parietal medial (PM) cluster (CP1, CPz, CP2, P1, Pz, P2, POz, O1, Oz, O2) used to measure the LPP are marked in black. ERP waveforms of the LPP mean amplitude computed on the PM cluster and evoked by B) high- and low- status faces, C) the four participants' gender by face status conditions. The time courses of the ERP averaged across the 36 participants is represented D) Averaged LPP amplitude computed in the 390–650 ms time window over the PM cluster recording sites. The vertical lines in the plots represent the confidence interval at 95%. E) Representation of the differential activity between high-status faces and low-status faces conditions for men and women participants. (from top to bottom) Scalp topography representing the difference in men (left head) and in women (right head). Differential ERP waveforms computed over the PM cluster for men (in blue) and women (in red).. The gray area on the graphs corresponds to the 390–650 ms interval over which the mean amplitude of the LPP was measured. * indicated significant difference (* at $p < .05$ and ** at $p < .001$) between conditions. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Least significant difference (LSD) Fisher's tests were used for post-hoc comparisons. In addition, to evaluate whether our data sup- ported the null hypothesis regarding the sensitivity of the N170 to status, we first subtracted the ERP elicited by high status faces (both male and female) from the ERP elicited by low-status faces (both male and female), averaged over P7 and P8 electrodes. We then performed a Bayesian One-Sample *t*-test using the statistical software JASP (.8.0.1, https://jasp-stats.org/) and evaluated the Bayes factor for the null (typically, BF01 > 3 is considered as substantial evidence for the null). Finally, supplementary ANOVAs were performed on the averaged amplitude of two additional early components, the N70 and the P100, including social status (2 levels), face gender (2) and as within-subject factors, and participant's gender (2 levels) as between-subject factor.

3. Results

During the status - face association phase, participants were very accurate in categorizing the face status of the 10% target faces (male participants: 94,14 ± 10,1% of hits and female participants: 95,52 ± 7,9% of hits among 36 trials).

3.1. N170

The N170 peaked at 160 ms across participants (Fig. 2B). The ANOVA on the N170 mean amplitude showed no main effect of face status ($F(1,34) = 0.02$; $p = .89$; partial $\eta^2 < 0.001$, Fig. 3B), partici- pant's gender ($F(1,34) = 2{,}66$; $p = .11$; partial $\eta^2 = 0.07$) or laterality ($F(1,34) = 2{,}43$; $p = .12$; partial $\eta^2 = 0.07$). However, it revealed a main effect of face gender ($F(1,34) = 6{,}52$; $p = .02$; partial $\eta^2 = 0.16$; Fig. 2B). Female faces elicited a larger N170 (3,68 µV ± *0,81 SE*) than male faces did (4,34 µV ± *0,85 SE*) (Fig. 2C). There was neither any significant interaction between face status and gender ($F(1,34) = 0.004$; $p = .96$; partial $\eta^2 < 0.0017$) nor between face status and participant's gender ($F(1,34) = 0.12$; $p = .73$; partial $\eta^2 < 0.004$). Importantly, the Bayesian *t*-test on the N170 amplitude difference be- tween high and low status faces showed substantial evidence for the null hypothesis that status has no influence on the N170 amplitude (mean difference: 0,003 µV ± *1,18* SE; BF_{01} =5.58).

3.2. *LPP*

Visual inspection of the signal revealed a sustained late positivity corresponding to the expected LPP, starting around 400 ms after the face onset, distributed across the scalp according to a anterior < central < posterior gradient and maximal over parietal sites (see Fig. 3A); in accordance with what has been observed in the literature (Breton et al., 2014; Pastor et al., 2008; Schupp et al., 2000). The ANOVA conducted on the mean LPP amplitude in the posterior medial cluster yielded a main effect of face's status ($F(1,34) = 4{,}18$; $p = .04$, partial $\eta^2 = 0.11$, see Fig. 3B) revealing that high-status faces elicited larger LPP (3,03 μV ± *0,*52 *SE*) than low-status faces (2,67 μV ± *0,51 SE*). This effect was also qualified by a significant interaction between face's status and participant's gender ($F(1,34) = 5{,}90$; $p = .02$, partial $\eta^2 = 0.15$; see Fig. 3C and E). No significant difference in LPP ampli- tude was observed in men between high-status faces (3,19 μV ± *0,73 SE*) and low-status faces (3,26 μV ± *0,69 SE*, $p = .79$), while high- status faces (2,87 μV ± *0,76 SE*) evoked larger LPPs than low-status faces in women (2,08 μV ± *0,74 SE*) ($p = .003$) (Fig. 3D).

3.3. *Supplementary results*

3.3.1. *N70*

The N70 component was examined on Oz and reached his maximum amplitude at 71 ms. We observed only a main effect of participant's gender on the N70 amplitude ($F(1,34) = 13{,}60$; $p < .001$, partial $\eta^2 = 0.29$); revealing that female participants presented a larger N70 (-3,32 μv ± *0,77 SE*) than male participants (-0,017 μv ± *0,54 SE*). Precisely, most of the women (14 over 18; 89%) presented this poten- tial, while it was only present in 44% of the men (8 over 18). No other main effect was observed on the N70 amplitude (face's gender: $F(1,34) = 0{,}22$; $p < .64$, partial $\eta^2 = 0.006$; face's status: $F(1,34) = 0{,}005$; $p < .95$, partial $\eta^2 < 0.001$) as well as no interaction between face's status and gender ($F(1,34) = 0{,}18$; $p < .67$, partial $\eta^2 < 0.005$) and between face's status and participant's gender ($F(1,34) = 0{,}003$; $p < .96$, partial $\eta^2 < 0.001$).

3.3.2. *P100*

The repeated-measures ANOVA conducted on the mean P100 am- plitude over O1/O2 revealed no main effect of face's gender ($F(1,34) = 0{,}40$; $p = .53$, partial $\eta^2 = 0.01$), of face's status ($F(1,34) = 0{,}002$; $p = .97$, partial $\eta^2 < 0.001$), and of participant's gender ($F(1,34) = 0{,}18$; $p = .71$, partial $\eta^2 = 0.005$), but a significant interaction be- tween participant's and face's gender ($F(1,34) = 4{,}75$; $p = .04$, partial $\eta^2 = 0.12$). Male faces elicited larger P100 (7,30 μv ± *1,45 SE*) than female faces (6,85 μv ± *1,51 SE*) only for women participants ($p = .05$), not for men participants (male faces: 7,72 μv ± *0,99 SE*; female faces: 7,97 μv ± *1,00 SE*; $p = .28$). No other significant inter- action was observed.

4. Discussion

The goal of the current study was to examine the influence of social hierarchy on the brain electrophysiological responses associated with the processing of faces. In contrast with earlier EEG studies, wherein social ranks arose from competitive situations, we relied on occupa- tional status to induce social hierarchy representations. Moreover, given that the attitude towards hierarchy can be influenced by gender, we systematically manipulated the gender of the stimuli and also took into account the gender of the participants in our analyses. We speci- fically focused on the N170 and LPP components, which were pre- viously found to be modulated by social rank in competitive contexts (Breton et al., 2014; Chiao et al., 2008; Feng et al., 2015; Furley et al., 2017; Gyurovski et al., 2018; Hu et al., 2014; Santamaria-Garcia et al., 2015). We did not find any effect of occupational status on the N170 and a Bayesian analysis indicated substantial evidence for the null hypothesis in our dataset. Moreover, our data demonstrated that oc- cupational status modulated the LPP. Faces associated with high oc- cupational status elicited greater LPP amplitude than faces associated with low occupational status. However, this effect was observed only in female participants, suggesting an increased neural sensitivity to oc- cupational statuses among women as compared to men. In the fol- lowing, we discuss these two main findings in greater detail. In addi- tion, we also examined two supplementary components, the N70 and the P100, associated with very early stages of visual processing. Given that these analyses were exploratory and that no effect of status has been reported on these two potentials, we discuss them very briefly.

4.1. *N170 modulation: gender but not status*

The absence of status modulation on the N170, which was also re- ported by Breton et al. (2014), is in contrast with the two recent EEG studies that used a star-system to convey social rank (Feng et al., 2015; Santamaria-Garcia et al., 2015). Methodological considerations are usually proposed to account for these differences and a concern for methodology actually guided our experimental approach. With respect to earlier research on hierarchy, we estimated that presenting high- status faces together with more complex stimuli than low-status faces (that is, with three stars vs. one star) would be detrimental to the in- terpretability of the results. Indeed, as indicated above, Feng et al. (2015) and Santamaria-Garcia et al. (2015) used a star-system that introduced a confound between hierarchical status and stimulus com- plexity: *three* stars below the face indicated high status, and *a single* star indicated low status. In both studies, the authors themselves acknowl- edged this confound and conducted an additional control experiment, with no hierarchy manipulation, in which the stars under the faces did not mean anything for the faces. They observed no difference between three- and one-star faces on the N170 amplitude, which seemed to in- dicate that the initial N170 modulation resulted from hierarchy and not from the difference in the number of stars. However, precisely because the stars did not mean anything for the faces, the two kinds of stimuli (stars and faces) were unrelated and the stars were thus more likely to be ignored by the participants. It follows that the greater complexity introduced by the three stars in the control experiment was less likely to affect the processing of faces, and that the confound remains partially. In Feng et al. (2015) study, the procedure in the control experiment even reinforces the disconnection between the two kinds of stimuli: participants were either asked to evaluate the number of stars regard- less of the face or to identify the gender of the face regardless of the number of stars while in the hierarchy experiment the star and the face stimuli had to be processed in interaction. Another problem concerns the gender discrepancy between the hierarchy and control experiments in Santamaria-Garcia et al.’s (2015) study. The hierarchy experiment, which manipulated the number of stars associated with status, included 22 participants with as many female as male participants (gender-ratio: 1:1). Interestingly, the authors reported a significant interaction be- tween gender and hierarchy indicating that the effect of stars on the N170 amplitude was greater for male than for female participants. However, the control experiment, included 4 times more female than male participants (16 vs. 4), a rate that significantly differed from the hierarchy experiment (16/20 vs. 11/22; $\chi^2(1) = 4.107$, $p = .043$). On the basis of the effect obtained in the hierarchy experiment, the gender ratio in the control experiment was more likely to produce a null result than the sex ratio of the hierarchy experiment; and thus was not an appropriate control. We therefore conclude that N170 effects found in the Santamaria et al.'s and Feng et al.'s experiments are not convincing enough to firmly establish an influence of hierarchy on this face-specific component. That said, we do not deny that hierarchy could potentially influence the N170 amplitude, and we do not deny that the effect found by Feng et al. (2015) and Santamaria-Garcia et al. (2015) might actu- ally be a consequence of their manipulation of hierarchical status. We simply claim that the paradigms and control conditions used in those studies make this conclusion uncertain, and we believe that more convincing evidence of such modulation might arise in the field.

We will now discuss some methodological aspects of the current experiment that might have hindered a modulation of the N170 by occupational status. First, although the present study involves a type of hierarchy that is highly relevant to our everyday social environment, it is important to note that the participants' own status was not really at stake. Participants were all undergraduate students with an undefined occupational title. They were therefore dealing with an allocentric hierarchy, one that concerns external agents, rather than a self-refer- ential hierarchy, which involves the participant's position within the hierarchy (Farrow et al., 2011). It thus cannot be ruled out that hier- archy could modulate the N170 component when participants can di- rectly compare their own status to that of individuals they are facing. In the area of familiarity, faces of personal importance for participants (e.g. their own face or their mother's face) elicit a larger N170 ampli- tude than faces of people whose familiarity is based on fame (Caharel et al., 2002, 2005, 2006; Harris and Aguirre, 2008a, 2008b; Kloth et al., 2006). It would therefore be worth investigating in the future whether the self-referential hierarchies involving occupational titles are more likely to elicit a N170 modulation.

Second, even if occupational status is more rooted in everyday life than the fictitious status that results from competitive games, asso- ciating it with a face might be more difficult than it is for other social categories such as race, familiarity or gender, as these categories can be directly perceived from physical characteristics of the face. The face of an individual does not immediately tell the truth about her or his social status. Appreciating that a specific face is that of a high status in- dividual might therefore require a certain level of experience with that individual to elicit a robust face-status association (but see Bjornsdottir and Rule, 2017). To overcome these difficulties, hierarchies that are daily experienced, such as those encountered in the work-place, might be used as a source of stimuli (e.g. Chiao et al., 2004; Schmid Mast et al., 2009).

Additionally, the absence of difference in the N170 component can also be connected with the results of a recent fMRI study by Koski et al. (2017) who also manipulated face's status through job occupation. Interestingly, while they found a sensitivity to status' differences in the left orbitofrontal context, they found no difference in the occipital face area nor the fusiform face area, which are considered as potential generators of the N170. While no effect of occupational status on the N170 amplitude was found, we did observe a larger N170 amplitude for female than male faces. This suggests that the absence of a significant difference between high- and low- status did not result from a lack of sensitivity to N170 modulations. Although an effect of gender face may actually reflect low-level processing differences, rather than an influence of the gender social category per se (Freeman et al., 2010), it should be noted that such effect is usually not observed (Ito and Urland, 2005; Mouchetant- Rostaing et al., 2000; Mouchetant-Rostaing and Giard, 2003). There- fore, another explanation that goes beyond the influence of low-level physical traits is worth considering. For example, since male and female faces were not systematically evaluated and matched for higher-level facial attributes, we cannot exclude that the N170 effect derives from systematic differences in attractiveness, trustworthiness or dominance. Yet, a critical difference between the current experiment and the studies that did not find any gender modulation of the N170 is the social context in which the task was embedded. In those studies, par- ticipants had to distinguish male from female faces with no specific context emphasizing the social difference between men and women. In contrast, in the current experiment, faces were presented in a socially marked context, which was highly relevant to gender since men and women often differ in terms of occupational status and income. In ad- dition, before each face, the participant saw a gendered social cue, which by referring to status and occupation, was likely to activate gender-related information and stereotypes. Such procedure may have therefore fostered the social distinction between men and women. In other words, in previous studies the male vs. female opposition might have been more likely to be viewed as a *sex* distinction, based on bio- logical and physical differences, while in our study, it was more likely to be viewed as a *gender* distinction based on different social constructs (De Beauvoir, 1949). Interestingly, the emergence of N170 effects through the activation of social information and social stereotypes has been previously observed in the case of race by Ito and Urland (2005, Experiment 1). While they did not find any race effect on the N170 in a non-social categorization task, they did find such an effect when the task had a social categorization goal.

4.2. LPP modulation: participant's gender affects the perception of status

An important result of the current study is the effect of occupational status on the parietal LPP in the 390–650 ms time interval. High-oc- cupational status faces elicited larger LPP amplitudes than low-occu- pational status faces. Similar LPP modulations in the same sites and in the same time window were also recently reported in the contexts of competition-based (Feng et al., 2015; Breton et al., 2014; Furley et al., 2017) and wealth-based hierarchies (Gyurovski et al., 2018). Hence, the larger LPP elicited by individuals occupying a higher position in a hierarchy appears to be a robust phenomenon. Occupational status of individuals is an important cue to determine their influence on the social environment because it provides information on their talents and on the advantages they benefit from. Since interacting with high-status individuals can result in higher positive or negative effects than with other individuals, they represent motivationally relevant stimuli. For instance, Deaner et al. (2005) found that monkeys can sacrifice juice in order to see faces of high-status individuals and Koski et al. (2017) interpret the lateral orbitofrontal cortex sensitivity to the occupational status as a response to rewarding stimuli. Motivationally relevant sti- muli are known to elicit larger LPP such as sexual stimuli, money, ap- petitive stimuli (Briggs and Martin, 2009; Gable and Harmon-Jones, 2010; Keil et al., 2001).

Moreover, because the higher relevance of stimuli representing high-status individuals rests on the consideration of potential interac- tions with those individuals, their processing is likely to involve an evaluative step. Past research has shown that negative and positive stimuli evoke larger LPP than neutral ones and that negative stimuli evoke larger LPP than positive ones (Cacioppo et al., 1996). Viewing facial negative expressions, such as threat, fear and sadness elicit larger LPP than positive ones. In the hierarchy context, Gyurovski et al. (2018) have interpreted the greater parietal positivity elicited by high financial status faces as a sign of negative evaluation and also found a similar positivity for faces associated with low moral status individuals. The negative evaluation of higher ranking individuals has also been shown in an fMRI study by Feng et al. (2016) in the context of a competitive hierarchy based on perceptual skills. The authors reported that the empathic neuronal response was reduced when pain was inflicted on individuals who were ranked higher than the participant, than when it was inflicted on lower ranked individuals. However, not all forms of hierarchy elicit the same evaluative answer. While a dominant in- dividual who exerts power and coercion on others is likely to be judged negatively due to her/his antisocial behavior, a prestigious individual is more likely to elicit respect and admiration because of the valued skills she/he displays (Cheng et al., 2013). Similarly, when participants are involved in competitive and/or social comparisons situations they may experience feelings such as envy and schadenfreude towards in- dividuals who are ranked as superior (Smith et al., 1996; Takahashi et al., 2009). However, since in the current experiment the participants' status was not at stake, they were less likely to engage in social com- parison process and to view high-status faces negatively.

However, the striking point in the results is that only female par- ticipants did show LPP modulation. This contrasts with Breton et al.'s (2014) work in which the LPP difference between high- and low-rank faces was obtained with male participants. No conclusion could be drawn regarding females in this earlier experiment as it included only males, but the difference between both studies suggests that the sen- sitivity to hierarchy might depend upon participants' gender and the type of hierarchy. This possibility is actually in keeping with results showing gender differences on the attitude towards different manifes- tations of hierarchies. Compared to women, men preferred competitive over non-competitive contexts in problem-solving tasks (Niederle and Vesterlund, 2007). Moreover, men and women not only differ with respect to competition; they also differ in their attitude towards *power* and *status* (Hays, 2013; Offermann and Schrier, 1985), which are two distinct hierarchical constructs. Power depends upon the amount of resource an individual controls in a group, and may involve dominance and coercion towards other members. In contrast, status relies on dis- tinctive abilities that are socially valued by others and can therefore lead to respect and admiration (Cheng et al., 2013; Henrich and Gil- White, 2001; Magee and Galinsky, 2008). Hays (2013) found that in an imaginary work context, men valued more power than did women (see also Offermann and Schrier, 1985), while women valued more status than did men. The women's preference for status information over other hierarchical indicators (such as power and competition), could thus lead them to attend, more than men, to status differences. It could also lead them to attend more to the social and affective nature of the paradigm while male participants might have focused more on the mere categorization aspect of the task (i.e. discriminating correctly the face status). Given that the current ERP study was the first one to thoroughly investigate gender, the difference between male and female participants was not previously observed and it would still need to be replicated to ascertain its robustness. Future work should also investigate in a more systematic way the extent to which men and women differ in their processing of various types of hierarchy, since in the current study the LPP amplitude did not differ according to occupational status among male participants while it did for competition-based hierarchies in earlier work (Breton et al., 2014).

4.3. Additional N70 and P100: no modulation of status in the early visual processing

Two others components were examined in this study: the N70 and the P100. No effect of status were observed on these component, but 1) a larger N70 amplitude for women compared to men participants and 2) a larger P100 in response to male faces compared to female faces, only in women participants.

Regarding the N70, this potential reflects the very first step of human visual processing in the primary cortex V1 (Saint-Amour et al., 2005) and is influenced by attentional allocation (Eimer and Forster, 2003; Mouchetant-Rostaing and Giard, 2003; Santos et al., 2008; Zani and Proverbio, 2012). When participants sustain their attention to a particular stimulus or attend to a specific location in the visual field, the N70 amplitude increases (Eimer and Forster, 2003). Similarly, when participants are engaged in an active categorization task, the N70 po- tential is larger than when they are passively presented with faces (Mouchetant-Rostaing and Giard, 2003). This larger N70 for female participants could suggest that they allocated more attention to the task requirements than male participants.

Regarding the P100, this component has been shown to be modu- lated by attention orientation mechanisms. In particular, visual stimuli evoke larger P100 when they are associated with a high attentional focus. This could be either due to their intrinsic relevance, as it is the case for emotional fearful or angry faces (Batty and Taylor, 2003; Chiao et al., 2008) and for particular facial features (such as the eye region, Doi et al., 2007; Kloth et al., 2013), or to constraints related to the task itself (Hillyard and Anllo-Vento, 1998; Rossion et al., 1999; Rutman et al., 2009; Taylor, 2002). One could have expected that labels fore- warning high-status faces would translate into a more positive P100 due to the strong relationship between social hierarchy and attentional allocation. However, status had no effect on the P100 amplitude in our study. The interaction between stimulus gender and participant gender would suggest that women allocated more attentional resources to male than female faces.

5. Conclusion

In conclusion, the current study brought new insights regarding the neural processing of hierarchy conveyed by occupational status. First, the status of a face did not penetrate the structural encoding of the face reflected by the N170, but appeared to be encoded later, about 400 ms after the presentation of the faces, in the time range of the LPP. Interestingly, this influence of status on late potentials elicited by faces was only observed in women participants, not in men. We propose that this modulation of the LPP amplitude according to face status found for women might reflect a differential gender-based engagement in the task (i.e. focus in the status-face association they were presented with). Further work is obviously needed to fully disentangle this issue. Our research raised also new questions concerning the localization of the neural networks involved in the processing of hierarchical context re- lated to faces and more specifically, of social status information. Future investigations using high spatial resolution neuroimaging techniques and including gender as a critical variable will help to determine if social status processing recruits similar or distinct neural networks in men and women.

Acknowledgements

We would like to thank Antoine Berrot for his precious help in the EEG acquisition. This study was supported by the CNRS, a DGA (Direction Generale de l'Armement) grant awarded to AB. The present research was also supported by the CNRS (" Defi GENRE " program attributed to JBVDH). NG was partly funded by the French Program "Investissement d'Avenir" under Grant no. ANR-10-IAIHU-06 and ANR- 11-INBS-0006. KJ was supported by funding from the Canada Research Chairs Program and a Discovery Grant (RGPIN-2015-04854) from the Natural Sciences and Engineering Research Council of Canada, a New Investigators Award from the Fonds de Recherche du Québec - Nature et Technologies (2018-NC-206005) and an IVADO-Apogée Fundamental Research Project grant.

References

Aguera, P.E., Jerbi, K., Caclin, A., Bertrand, O., 2011. ELAN: a software package for analysis and visualization of MEG, EEG, and LFP signals. Comput. Intell. Neurosci. 2011, 5.

Anderson, C., Hildreth, J.A.D., Howland, L., 2015. Is the desire for status a fundamental human motive? A review of the empirical literature. Psychol. Bull. 141, 574–601. https://doi.org/10.1037/a0038781.

Barkow, J.H., Akiwowo, A.A., Barua, T.K., Chance, M.R.A., Chapple, E.D., Chattopadhyay, G.P., Freedman, D.G., Geddes, W.R., Goswami, B.B., Isichei, P.A.C., Knudson, M.S., Manson, S.M., Parker, C.E., Price, J.A., Sarles, H.B., 1975. Prestige and culture: a biosocial interpretation. Curr. Anthropol. 16, 553–572.

Batty, M., Taylor, M.J., 2003. Early processing of the six basic facial emotional expres- sions. Cogn. Brain Res. 17, 613–620.

Baudouin, J.Y., Gallay, M., 2006. Is face distinctiveness gender based? J. Exp. Psychol. Hum. Percept. Perform. 32, 789.

Bentin, S., Allison, T., Puce, A., Perez, E., McCarthy, G., 1996. Electrophysiological stu- dies of face perception in humans. J. Cogn. Neurosci. 8, 551–565.

Bentin, S., Deouell, L.Y., 2000. Structural encoding and identification in face processing: erp evidence for separate mechanisms. Cogn. Neuropsychol. 17, 35–55.

Bjornsdottir, R.T., Rule, N.O., 2017. The Visibility of Social Class From Facial Cues. Boehm, C., 1999. Hierarchy in the Forest: Egalitarianism and the Evolution of Human Altruism. Harvard University Press, Cambridge, MA.

Boyce, W.T., 2004. Social stratification, health, and violence in the very young. Ann. N.Y. Acad. Sci. 1036, 47–68. https://doi.org/10.1196/annals.1330.003.

Breton, A., Cheylus, A., Baudouin, J.-Y., Van der Henst, J.-B., 2018. Status lies in the eye of the beholder: evidence from eye-tracking data. PsyArXiv. https://doi.org/10.17605/OSF.IO/R4Q3C.

Breton, A., Jerbi, K., Henaff, M.-A., Cheylus, A., Baudouin, J.-Y., Schmitz, C., Krolak- Salmon, P., Van der Henst, J.-B., 2014. Face the hierarchy: ERP and oscillatory brain responses in social rank processing. PLoS One 9, e91451. https://doi.org/10.1371/ journal.pone.0091451.

Briggs, K.E., Martin, F.H., 2009. Affective picture processing and motivational relevance: arousal and valence effects on ERPs in an oddball task. Int. J. Psychophysiol. 72, 299–306.

Bublatzky, F., Gerdes, A., White, A.J., Riemer, M., Alpers, G.W., 2014. Social and emo- tional relevance in face processing: happy faces of future interaction partners en- hance the late positive potential. Front. Hum. Neurosci. 8, 493.

Cacioppo, J.T., Crites, S.L., Gardner, W.L., 1996. Attitudes to the right: evaluative pro- cessing is associated with lateralized late positive event-related brain potentials. Personal. Soc. Psychol. Bull. 22, 1205–1219.

Caharel, S., Courtay, N., Bernard, C., Lalonde, R., Rebaï, M., 2005. Familiarity and emotional expression influence an early stage of face processing: an electro- physiological study. Brain Cogn. 59, 96–100. https://doi.org/10.1016/j.bandc.2005. 05.005.

Caharel, S., Fiori, N., Bernard, C., Lalonde, R., Rebaī, M., 2006. The effects of inversion and eye displacements of familiar and unknown faces on early and late-stage ERPs. Int. J. Psychophysiol. 62, 141–151.

Caharel, S., Poiroux, S., Bernard, C., Thibaut, F., Lalonde, R., Rebai, M., 2002. ERPs as- sociated with familiarity and degree of familiarity during face recognition. Int. J. Neurosci. 112, 1499–1512.

Caldara, R., Rossion, B., Bovet, P., Hauert, C.A., et al., 2004. Event-related potentials and time course of the" other-race" face classification advantage. Neuroreport 15, 905.

Caldara, R., Thut, G., Servoir, P., Michel, C.M., Bovet, P., Renault, B., 2003. Face versus non-face object perception and the other-race'effect: a spatio-temporal event-related potential study. Clin. Neurophysiol. 114, 515–528.

Charafeddine, R., Mercier, H., Clément, F., Kaufmann, L., Berchtold, A., Reboul, A., Van der Henst, J.-B., 2015. How preschoolers use cues of dominance to make sense of their social environment. J. Cogn. Dev. 16, 587–607.

Cheng, J.T., Tracy, J.L., Foulsham, T., Kingstone, A., Henrich, J., 2013. Two ways to the top: evidence that dominance and prestige are distinct yet viable avenues to social rank and influence. J. Personal. Soc. Psychol. 104, 103–125. https://doi.org/10.1037/a0030398.

Chiao, J.Y., Adams, R.B., Tse, P.U., Lowenthal, W.T., Richeson, J.A., Ambady, N., 2008. Knowing who's boss: fMRI and ERP investigations of social dominance perception. Group Process Intergroup. Relat. 11, 201–214.

Chiao, J.Y., Bordeaux, A.R., Ambady, N., 2004. Mental representations of social status. Cognition 93, B49–B57. https://doi.org/10.1016/j.cognition.2003.07.008.

Copeland, C.L., Driskell, J.E., Salas, E., 1995. Gender and reactions to dominance. J. Soc. Behav. Personal. 10, 53–68.

Crawley, D., 2014. Gender and perceptions of occupational prestige: changes over 20 years. Sage Open 4 (2158244013518923).

Cummins, D., 2005. Dominance, status, and social hierarchies. Handb. Evol. Psychol. 676–697.

Dalmaso, M., Galfano, G., Coricelli, C., Castelli, L., 2014. Temporal dynamics underlying the modulation of social status on social attention. PLoS One 9, e93139. https://doi. org/10.1371/journal.pone.0093139.

Dalmaso, M., Pavan, G., Castelli, L., Galfano, G., 2012. Social status gates social attention in humans. Biol. Lett. 8, 450–452. https://doi.org/10.1098/rsbl.2011.0881.

De Beauvoir, S., 1949. Le deuxième sexe. Paris Gall. 1, 949.

Deaner, R.O., Khera, A.V., Platt, M.L., 2005. Monkeys pay per view: adaptive valuation of social images by Rhesus Macaques. Curr. Biol. 15, 543–548. https://doi.org/10.1016/j.cub.2005.01.044.

Doi, H., Sawada, R., Masataka, N., 2007. The effects of eye and face inversion on the early stages of gaze direction perception: an ERP study. Brain Res. 1183, 83–90. https:// doi.org/10.1016/j.brainres.2007.08.073.

Dunbar, R.I., Shultz, S., 2007. Evolution in the social brain. Science 317, 1344–1347.

Eagly, A.H., Makhijani, M.G., Klonsky, B.G., 1992. Gender and the evaluation of leaders: a meta-analysis. Psychol. Bull. 111, 3.

Eagly, A.H., Wood, W., 1999. The origins of sex differences in human behavior: evolved dispositions versus social roles. Am. Psychol. 54, 408.

Eimer, M., 2011. The face-sensitive N170 component of the event-related brain potential. Oxf. Handb. Face Percept. 329.

Eimer, M., 2000. Attentional modulations of event-related brain potentials sensitive to faces. Cogn. Neuropsychol. 17, 103–116.

Eimer, M., Forster, B., 2003. Modulations of early somatosensory ERP components by transient and sustained spatial attention. Exp. Brain Res. 151, 24–31.

Ellis, L., 1995. Dominance and reproductive success among nonhuman animals: a cross- species comparison. Ethol. Sociobiol. 16, 257–333.

Elsesser, K.M., Lever, J., 2011. Does gender bias against female leaders persist? Quantitative and qualitative data from a large-scale survey. Hum. Relat. 64, 1555–1578.

Farrow, T.F.D., Jones, S.C., Kaylor-Hughes, C.J., Wilkinson, I.D., Woodruff, P.W.R., Hunter, M.D., Spence, S.A., 2011. Higher or lower? The functional anatomy of per- ceived allocentric social hierarchies. NeuroImage 57, 1552–1560. https://doi.org/10. 1016/j.neuroimage.2011.05.069.

Feng, C., Li, Z., Feng, X., Wang, L., Tian, T., Luo, Y.-J., 2016. Social hierarchy modulates neural responses of empathy for pain. Soc. Cogn. Affect. Neurosci. 11, 485–495. https://doi.org/10.1093/scan/nsv135.

Feng, C., Tian, T., Feng, X., Luo, Y.-J., 2015. Attention modulations on the perception of social hierarchy at distinct temporal stages: an electrophysiological investigation. Neuropsychologia 70, 21–29.

Foulsham, T., Cheng, J.T., Tracy, J.L., Henrich, J., Kingstone, A., 2010. Gaze allocation in a dynamic situation: effects of social status and speaking. Cognition 117, 319–331.

Freeman, J.B., Ambady, N., Holcomb, P.J., 2010. The face-sensitive N170 encodes social category information. Neuroreport 21, 24–28. https://doi.org/10.1097/WNR.0b013e3283320d54.

Furley, P., Schnuerch, R., Gibbons, H., 2017. The winner takes it all: event-related brain potentials reveal enhanced motivated attention toward athletes' nonverbal signals of leading. Soc. Neurosci. 12, 448–457. https://doi.org/10.1080/17470919.2016.1182586.

Gable, P.A., Harmon-Jones, E., 2010. Late positive potential to appetitive stimuli and local attentional bias. Emotion 10, 441.
Gazes, R.P., Hampton, R.R., Lourenco, S.F., 2017. Transitive inference of social dom- inance by human infants. Dev. Sci. 20.
Gneezy, U., Niederle, M., Rustichini, A., 2003. Performance in competitive environments: gender differences. Q. J. Econ. 118, 1049–1074.
Gülgöz, S., Gelman, S.A., 2017. Who's the boss? Concepts of social power across devel- opment. Child Dev. 88, 946–963.
Gyurovski, I., Kubota, J., Cardenas-Iniguez, C., Cloutier, J., 2018. Social status level and dimension interactively influence person evaluations indexed by P300s. Soc. Neurosci. 13, 333–345. https://doi.org/10.1080/17470919.2017.1326400.
Harris, Alison M., Aguirre, G.K., 2008. The effects of parts, wholes, and familiarity on face-selective responses in MEG. J. Vis. 8. https://doi.org/10.1167/8.10.4.
Harris, A.M., Aguirre, G.K., 2008. The effects of parts, wholes, and familiarity on face- selective responses in MEG. J. Vis. 8https://doi.org/10.1167/8.10.4. (4–4).
Hays, N.A., 2013. Fear and loving in social hierarchy: sex differences in preferences for power versus status. J. Exp. Soc. Psychol. 49, 1130–1136. https://doi.org/10.1016/j. jesp.2013.08.007.
Henrich, J., Gil-White, F.J., 2001. The evolution of prestige: freely conferred deference as a mechanism for enhancing the benefits of cultural transmission. Evol. Hum. Behav. 22, 165–196.
Henson, R.N., Goshen-Gottstein, Y., Ganel, T., Otten, L.J., Quayle, A., Rugg, M.D., 2003. Electrophysiological and haemodynamic correlates of face perception, recognition and priming. Cereb. Cortex 13, 793–805.
Hillyard, S.A., Anllo-Vento, L., 1998. Event-related brain potentials in the study of visual selective attention. Proc. Natl. Acad. Sci. USA 95, 781–787.
Hu, J., Cao, Y., Blue, P.R., Zhou, X., 2014. Low social status decreases the neural salience of unfairness. Front. Behav. Neurosci. 8. https://doi.org/10.3389/fnbeh.2014.00402.
Ito, T.A., Thompson, E., Cacioppo, J.T., 2004. Tracking the timecourse of social percep- tion: the effects of racial cues on event-related brain potentials. Personal. Soc. Psychol. Bull. 30, 1267–1280.
Ito, T.A., Urland, G.R., 2005. The influence of processing objectives on the perception of faces: an ERP study of race and gender perception. Cogn. Affect. Behav. Neurosci. 5, 21–36.
Ito, T.A., Urland, G.R., 2003. Race and gender on the brain: electrocortical measures of attention to the race and gender of multiply categorizable individuals. J. Personal. Soc. Psychol. 85, 616–626. https://doi.org/10.1037/0022-3514.85.4.616.
Jemel, B., Calabria, M., Delvenne, J.-F., Crommelinck, M., Bruyer, R., 2003. Differential involvement of episodic and face representations in ERP repetition effects. Neuroreport 14, 525–530.
Johnson, S.K., Murphy, S.E., Zewdie, S., Reichard, R.J., 2008. The strong, sensitive type: effects of gender stereotypes and leadership prototypes on the evaluation of male and female leaders. Organ. Behav. Hum. Decis. Process. 106, 39–60.
Keil, A., Müller, M.M., Gruber, T., Wienbruch, C., Stolarova, M., Elbert, T., 2001. Effects of emotional arousal in the cerebral hemispheres: a study of oscillatory brain activity and event-related potentials. Clin. Neurophysiol. 112, 2057–2068.
Kloth, N., Dobel, C., Schweinberger, S.R., Zwitserlood, P., Bölte, J., Junghöfer, M., 2006. Effects of personal familiarity on early neuromagnetic correlates of face perception. Eur. J. Neurosci. 24, 3317–3321. https://doi.org/10.1111/j.1460-9568.2006.05211.x.
Kloth, N., Itier, R.J., Schweinberger, S.R., 2013. Combined effects of inversion and feature removal on N170 responses elicited by faces and car fronts. Brain Cogn. 81, 321–328. https://doi.org/10.1016/j.bandc.2013.01.002.
Koski, J.E., Collins, J.A., Olson, I.R., 2017. The neural representation of social status in the extended face-processing network. Eur. J. Neurosci.
Koski, J.E., Xie, H., Olson, I.R., 2015. Understanding social hierarchies: the neural and psychological foundations of status perception. Soc. Neurosci. 1–24. https://doi.org/ 10.1080/17470919.2015.1013223.
Ligneul, R., Girard, R., Dreher, J.-C., 2017. Social brains and divides: the interplay be- tween social dominance orientation and the neural sensitivity to hierarchical ranks. Sci. Rep. 7, 45920. https://doi.org/10.1038/srep45920.
Magee, J.C., Galinsky, A.D., 2008. 8 Social hierarchy: the self-reinforcing nature of power and status. Acad. Manag. Ann. 2, 351–398.
Maner, J.K., DeWall, C.N., Gailliot, M.T., 2008. Selective attention to signs of success: social dominance and early stage interpersonal perception. Personal. Soc. Psychol. Bull. 34, 488–501.
Mascaro, O., Csibra, G., 2012. Representation of stable social dominance relations by human infants. Proc. Natl. Acad. Sci. USA 109, 6862–6867. https://doi.org/10.1073/ pnas.1113194109.
Maslow, A.H., 1943. A theory of human motivation. Psychol. Rev. 50, 370.
Mello, Z.R., 2008. Gender variation in developmental trajectories of educational and occupational expectations and attainment from adolescence to adulthood. Dev. Psychol. 44, 1069.
Mouchetant-Rostaing, Y., Giard, M.H., 2003. Electrophysiological correlates of age and gender perception on human faces. J. Cogn. Neurosci. 15, 900–910.
Mouchetant-Rostaing, Y., Giard, M.H., Bentin, S., Aguera, P.E., Pernier, J., 2000. Neurophysiological correlates of face gender processing in humans. Eur. J. Neurosci. 12, 303–310.
Niederle, M., Vesterlund, L., 2007. Do women shy away from competition? Do men compete too much? Q. J. Econ. 122, 1067–1101. https://doi.org/10.1162/qjec.122. 3.1067.
Offermann, L.R., Schrier, P.E., 1985. Social influence strategies: the impact of sex, role and attitudes toward power. Personal. Soc. Psychol. Bull. 11, 286–300.
Paller, K.A., Gonsalves, B., Grabowecky, M., Bozic, V.S., Yamada, S., 2000. Electrophysiological correlates of recollecting faces of known and unknown individuals. Neuroimage 11, 98–110.
Pastor, M.C., Bradley, M.M., Löw, A., Versace, F., Moltó, J., Lang, P.J., 2008. Affective picture perception: emotion, context, and the late positive potential. Brain Res. 1189, 145–151.
Qu, C., Ligneul, R., Van der Henst, J.-B., Dreher, J.-C., 2017. An integrative inter- disciplinary perspective on social dominance hierarchies. Trends Cogn. Sci. 21, 893–908. https://doi.org/10.1016/j.tics.2017.08.004.
Ratcliff, N.J., Hugenberg, K., Shriver, E.R., Bernstein, M.J., 2011. The allure of status: high-status targets are privileged in face processing and memory. Personal. Soc. Psychol. Bull. 37, 1003–1015.
Ratner, K.G., Amodio, D.M., 2013. Seeing “us vs. them”: minimal group effects on the neural encoding of faces. J. Exp. Soc. Psychol. 49, 298–301.
Rossion, B., 2014. Understanding face perception by means of human electrophysiology. Trends Cogn. Sci. 18, 310–318. https://doi.org/10.1016/j.tics.2014.02.013.
Rossion, B., Campanella, S., Gomez, C.M., Delinte, A., Debatisse, D., Liard, L., Dubois, S., Bruyer, R., Crommelinck, M., Guerit, J.M., 1999. Task modulation of brain activity related to familiar and unfamiliar face processing: an ERP study. Clin. Neurophysiol. 110, 449–462.
Rutman, A.M., Clapp, W.C., Chadick, J.Z., Gazzaley, A., 2009. Early top–down control of visual processing predicts working memory performance. J. Cogn. Neurosci. 22, 1224–1234. https://doi.org/10.1162/jocn.2009.21257.
Saint-Amour, D., Saron, C.D., Schroeder, C.E., Foxe, J.J., 2005. Can whole brain nerve conduction velocity be derived from surface-recorded visual evoked potentials? Neuropsychologia 43, 1838–1844. https://doi.org/10.1016/j.neuropsychologia.2005.02.010.
Sanderson, S.K., Heckert, D.A., Dubrow, J.K., 2005. Militarist, marxian, and non-marxian materialist theories of gender inequality: a cross-cultural test. Soc. Forces 83, 1425–1441. https://doi.org/10.1353/sof.2005.0080.
Santamaria-Garcia, H., Burgaleta, M., Sebastian-Galles, N., 2015. Neuroanatomical mar- kers of social hierarchy recognition in humans: a combined ERP/MRI study. J. Neurosci. 35, 10843–10850. https://doi.org/10.1523/JNEUROSCI.1457-14.2015.
Santos, I.M., Iglesias, J., Olivares, E.I., Young, A.W., 2008. Differential effects of object- based attention on evoked potentials to fearful and disgusted faces. Neuropsychologia 46, 1468–1479. https://doi.org/10.1016/j.neuropsychologia.2007.12.024.

Schmid Mast, M., 2004. Men are hierarchical, women are egalitarian: an implicit gender stereotype. Swiss J. Psychol. 63, 107–111.
Schmid Mast, M., Jonas, K., Hall, J.A., 2009. Give a person power and he or she will show interpersonal sensitivity: the phenomenon and its why and when. J. Personal. Soc. Psychol. 97, 835–850. https://doi.org/10.1037/a0016234.
Schoon, I., 2006. Risk and Resilience: Adaptations in Changing Times. Cambridge University Press, Cambridge, UK; New York.
Schoon, I., Martin, P., Ross, A., 2007. Career transitions in times of social change. His and her story. J. Vocat. Behav. 70, 78–96. https://doi.org/10.1016/j.jvb.2006.04.009.
Schupp, H., Cuthbert, B., Bradley, M., Hillman, C., Hamm, A., Lang, P., 2004. Brain processes in emotional perception: motivated attention. Cogn. Emot. 18, 593–611. https://doi.org/10.1080/02699930341000239.
Schupp, H.T., Cuthbert, B.N., Bradley, M.M., Cacioppo, J.T., Ito, T., Lang, P.J., 2000. Affective picture processing: the late positive potential is modulated by motivational relevance. Psychophysiology 37, 257–261.
Schweinberger, S.R., Pickering, E.C., Burton, A.M., Kaufmann, J.M., 2002a. Human brain potential correlates of repetition priming in face and name recognition. Neuropsychologia 40, 2057–2073.
Schweinberger, S.R., Pickering, E.C., Jentzsch, I., Burton, A.M., Kaufmann, J.M., 2002b. Event-related brain potential evidence for a response of inferior temporal cortex to familiar face repetitions. Cogn. Brain Res. 14, 398–409.
Senholzi, K.B., Ito, T.A., 2012. Structural face encoding: how task affects the N170's sensitivity to race. Soc. Cogn. Affect. Neurosci. https://doi.org/10.1093/scan/ nss091.
Smith, R.H., Turner, T.J., Garonzik, R., Leach, C.W., Urch-Druskat, V., Weston, C.M., 1996. Envy and schadenfreude. Personal. Soc. Psychol. Bull. 22, 158–168.
Strayer, F.F., Strayer, J., 1976. An ethological analysis of social agonism and dominance relations among preschool children. Child Dev. 47, 980–989. https://doi.org/10.2307/1128434.
Takahashi, H., Kato, M., Matsuura, M., Mobbs, D., Suhara, T., Okubo, Y., 2009. When your gain is my pain and your pain is my gain: neural correlates of envy and scha- denfreude. Science 323, 937–939.
Taylor, M.J., 2002. Non-spatial attentional effects on P1. Clin. Neurophysiol. 113, 1903–1908.
Tottenham, N., Tanaka, J.W., Leon, A.C., McCarry, T., Nurse, M., Hare, T.A., Marcus, D.J., Westerlund, A., Casey, B.J., Nelson, C., 2009. The NimStim set of facial expressions: judgments from untrained research participants. Psychiatry Res. 168, 242–249.
Treiman, D.J., 1977. Occupational Prestige in Comparative Perspective. Academic Press, New York.
Walker, P.M., Silvert, L., Hewstone, M., Nobre, A.C., 2008. Social contact and other-race face processing in the human brain. Soc. Cogn. Affect. Neurosci. 3, 16–25.
Whyte, M.K., 1978. Cross-cultural codes dealing with the relative status of women. Ethnology 211–237.
Zani, A., Proverbio, A.M., 2012. Is that a belt or a snake? Object attentional selection affects the early stages of visual sensory processing. Behav. Brain Funct. 8.
Zink, C.F., Tong, Y., Chen, Q., Bassett, D.S., Stein, J.L., Meyer-Lindenberg, A., 2008. Know your place: neural processing of social hierarchy in humans. Neuron 58, 273–283.
Zitek, E.M., Tiedens, L.Z., 2012. The fluency of social hierarchy: the ease with which hierarchical relationships are seen, remembered, learned, and liked. J. Personal. Soc. Psychol. J. Personal. Soc. Psychol. 102, 98.