Face-n-Food: Gender Differences in Tuning to Faces

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Abstract

Faces represent valuable signals for social cognition and non-verbal communication. A wealth of research indicates that women tend to excel in recognition of facial expressions. However, it remains unclear whether females are better tuned to faces. We presented healthy adult females and males with a set of newly created food-plate images resembling faces (slightly bordering on the Giuseppe Arcimboldo style). In a spontaneous recognition task, participants were shown a set of images in a predetermined order from the least to most resembling a face. Females not only more readily recognized the images as a face (they reported resembling a face on images, on which males still did not), but gave on overall more face responses. The findings are discussed in the light of gender differences in deficient face perception. As most neuropsychiatric, neurodevelopmental and psychosomatic disorders characterized by social brain abnormalities are sex specific, the task may serve as a valuable tool for uncovering impairments in visual face processing.

Introduction

Faces represent valuable signals for social cognition and non-verbal communication. In accordance with widespread beliefs, a wealth of findings shows that females are more proficient in recognition of facial expressions [1–10]. This advantage is already noticeable early in perceptual development [2]. At identifying emotions in photographs (choosing a picture that corresponds to a described emotion) girls aged 3.5 years are as good as 5-year-old boys [11]. In females, activation in cortical and subcortical brain structures is more bilaterally distributed presumably enabling contribution of both hemispheres to facial affect recognition [12–15].

Yet accuracy in facial affect recognition most likely depends on the emotion type. Women are better in recognizing facial expressions of fear and sadness [16,17], whereas males have an edge in identifying anger [16,18,19]. Anger expressed by male actors is more accurately perceived than anger portrayed by female expressers [19,20]. Both behavioral and the amygdala responses to threat-related face expressions (fear and anger) in young men are correlated with testosterone level [21]. Females experience happy faces as more pleasant and sad faces as more...
unpleasant than do males [22]. Females tend to better recognize emotions from faces than from voices, whereas males exhibit the opposite tendency [23].

Gender differences have not always been observed in the explicit recognition of dynamic (more natural) face expressions [24–26]. In women, dynamic expressions have been associated with higher intensity ratings for anger and happiness whereas in men, influence of dynamics was limited to anger [27]. Furthermore, women exhibit higher sensitivity to facial emotional expressions in dynamic as compared with static displays (photographs) [27]. Autistic individuals are impaired on visual processing of dynamic faces [28], and have increased functional magnetic resonance imaging, fMRI, brain activation in the fusiform gyri in response to emotional faces [29]. Females with and without Asperger syndrome are better at recognizing emotions from dynamics faces than males [23]. This report is in accord with the data indicating that autistic traits are linked to reduced face identity and face recognition in men but not in women [30]. Overall, the findings suggest that facial affect recognition mechanisms and their impairments are gender specific.

It remains unclear whether females excel on non-affective face perception. Boys and girls perform equally well on face processing task—finding a line drawing of a target face among an array of distracters [31]. Yet females outperform on facial detection task (recognition of a face as a face) and facial identity discrimination [32,33]. By contrast, males excel both on the Mooney Face Test [34] and in detecting the Mooney faces, two-tone face depictions, among two similar distracters [35]. The Mooney faces, however, seem to be subject of rather unique perceptual and neural processing [34,36].

Actor gender-based effects may contribute to female superiority in non-affective face processing: Females are better in recognizing faces, especially their own—gender faces [37], and 9-year-old girls outperform boys in recognition of female but not male faces [38]. Yet males are reported to be wired for her face: males exhibit attentional bias toward female faces, and female faces elicit stronger brain response in the face selective part of the fusiform gyri [39]. Other findings indicate that both male and female observers are more efficient in recognition of female faces, and several brain areas, including the hippocampal region, exhibit greater fMRI response to female compared to male faces [40].

The present study is aimed at investigation of gender differences in tuning to faces. For this purpose, a new Face-n-Food task has been created. We presented healthy adult females and males with a set of food-plate images composed of food ingredients (fruits, vegetables, sausages, etc.) in a manner slightly bordering on the style of Giuseppe Arcimboldo (1526–1593), an Italian painter best known for creating fascinating imaginative portraits composed entirely of fruits, vegetables, plants and flowers (Fig 1). It appears that typically developing adults and children have an entire bias for seeing faces and their spontaneous and effortless recognition in the Arcimboldo-like images. In other words, healthy individuals are well tuned to faces in such images.

**Methods**

**Participants**

One hundred four young adults, students of the University of Tübingen, participated in the study. They were assigned to one of two groups: a pilot group and an experimental one. The pilot group consisted of 40 participants (age range 19–35 years, 20 females, 20 males). The experimental group included 64 participants (age range 18–36 years; 34 females aged 22±1.46 years (median± 95% confidence interval), and 30 males, aged 22±0.7 years; with no gender differences in age, Mann-Whitney test, $U = 460.5$, n.s.). Participants were run individually. For the absence of acute hunger (that could potentially intensify observers’ focus on food...
ingredients), they were tested right after having a snack. All participants had normal or corrected-to-normal vision. None had a history of neurological or psychiatric disorders including autistic spectrum disorders (ASD) or regular medication. None had previous experience with such tasks. The study was conducted in line with the Declaration of Helsinki and was approved by the local Ethics Committee at the University of Tübingen Medical School. Informed written consent was obtained from all participants. Participation was voluntary, and the data were processed anonymously.

**Task and procedure**

The Face-n-Food task was administered to participants. For this task, a set of ten food-plate images were created that were composed of food ingredients (fruits, vegetables, sausages, etc.) and resembled faces. The images slightly border on the Giuseppe Arcimboldo style. As a first step, the pilot group of participants had to arrange the set of ten images according to their recognizability as a face from the least (number 1) to most recognizable one (number 10; see Fig 2). Then the experimental group was presented with the set of these images in the predetermined order from the least to most resembling a face (images 1 to 10). On each trial, participants had to perform a spontaneous recognition task: they were asked to briefly describe what they saw. On each trial, no immediate feedback was provided. To avoid time pressure that could potentially cause stress and negative emotional and physiological reactions blocking cognitive processes, there was no time limit on the task. With each participant, the testing procedure lasted for about 15–20 min.

**Results**

Participants either described a food-plate image in terms of food composition (typical food responses: Wurst, Joghurt, Obst, eine merkwürdige Mischung—sousages, yoghurt, fruits, an odd
mixture; Jemand mag keine Wurst im Essen—Somebody does not like sausages on a plate; eine Kalorienbombe—a heart attack on a plate) or as a face (typical face responses: Picasso beim Kochen? Ein komisches Gesicht—Picasso by cooking? An odd face; ein erstauntes oder erschrockenes Gesicht—an astonished or scared face; eine dicke Oma—a thick grandma; ein Gesicht, schreit um Hilfe—a face, appeals for help; Slonge Bob; ein Gesicht, sieht böse aus wegen der Augenbrauen, weint gleich—a face, looks angry because of eyebrows, will cry soon; eine Diva, stark geschminkt—a diva, with strong make-up; das Gesicht von Miss Piggy—Miss Piggy’s face). Other than face or food responses (e.g., sieht wie ein Kleid aus—looks like a dress) were given extremely rarely with a rate of 0.016.

Fig 3 shows the average image number, on which resembling a face on the Face-n-Food task (face response) was initially reported, separately for female and male participants. As can be seen from this figure, females more readily recognized the images as a face than males: females reported seeing a face on average on 4.35±1.69 (mean±standard deviation, SD) image, whereas males gave the first face response on average only on 6.27±2.03 image. The gender difference is highly significant (t(62) = 3.83, \( p < 0.0002 \), two-tailed, with an effect size Cohen’s \( d = 1.025 \)). This gender difference cannot be explained by a stronger experimenter expectancy of females (when participants try to interpret the purpose of the experiment and to please the experimenter) or by entire bias towards seeing faces, because 14 out of 34 females gave at least one non-face response on subsequent images after their initial face response. By contrast, 27 out of 30 male participants reported seeing a face on all subsequent images. As not all participants reported seeing a face on all subsequent images, we performed an additional analysis on the total number of images recognized as a face by females and males. The outcome indicates that percentage correct is 60.09±14.85% (mean±standard deviation) for females and 46±20.94% for males. The gender difference in the percentage of face responses is significant (t(62) = 2.97, \( p < 0.002 \), two-tailed, with Cohen’s \( d = 0.82 \)). Although this analysis provides an additional support for female superiority on the Face-n-Food task, an initial face report appears to be a more proper measure of tuning to faces. Subsequent reports may be potentially affected by other factors such as low or high self-confidence or a kind of aha!-effect.

Fig 2. Examples of the Face-n-Food images. The least resembling face (left panel) and most resembling face (right panel) images from the Face-n-Food task.

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Fig 4 represents the proportion of face responses for each Face-n-Food image for females and males. As seen from this figure, females not only earlier report seeing a face, give more face responses, but also faster than males reach a ceiling level of performance giving the maximal number of face responses. This is confirmed by statistical analysis performed on individual participants.

Fig 3. Gender difference in tuning to faces. In the Face-n-Food task, females more readily recognize images as a face than males. Vertical bars represent SEM.

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Fig 4. Proportion of face responses to each image in the Face-n-Food task for female and male participants. The image number reflects its recognizability as a face (1—the least recognizable, 10—the most recognizable). Fitted trend curves represent moving average of face response proportion across the images. Females not only earlier report seeing a face and give on overall more face responses, but also faster reach a ceiling level of performance.

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frequencies of face responses as dependent measure and images used. The analysis reveals a highly significant effect of gender ($\chi^2 (1; 64) = 52.45, p < 0.0001$). The gender by image interaction ($\chi^2 (1; 64) = 14.01, p < 0.0002$) is also highly significant indicating that the slope of the fitted curves for females is much steeper than for males.

**Discussion**

Although mounting evidence points to females’ advantage in facial affect recognition, it is unclear whether females are also better tuned to faces. By using the newly created Face-n-Food task consisting of a set of food-plate images comprising food ingredients (fruits, vegetables, sausages, etc.) in a manner slightly bordering on the Giuseppe Arcimboldo style, we investigated gender differences in tuning to faces. The findings indicate females’ superiority in recognizing food-plate images as a face: they report resembling faces on images that are still described by males in terms of food ingredients only. Females not only earlier report seeing a face, but also give on overall more face responses and faster achieve the ceiling level of performance. The outcome reveals that females are likely to have an advantage not only in emotional face processing: they are also better tuned to faces, at least, on the Face-n-Food task.

The present data dovetail with reports on superior skills of females on some other essential components of visual social cognition such as body language reading (the ability for understanding emotions, intentions, drives, and dispositions of others through body motion). Females are faster in discrimination of emotional from neutral body motion [41]. Both facial affect processing and body language reading [42,43] appear to be profoundly modulated by the type of portrayed emotion. Brain fMRI activity elicited by threatening facial and bodily expressions is modulated by observer’s gender [25]. Females are also more accurate in recognition of point-light neutral body motion (such as walking or jumping on the spot) [41]. Neuroimaging reveals gender dependent modes in the brain response to neutral body motion even in the absence of behavioral gender differences. In females, early magnetoencephalographic, MEG, activation occurs over the right parietal, left temporal, and right temporal cortex, a core of the social brain, whereas in males, the boosts of later activation are greater over the right frontal and occipital cortices [44]. In females, increased fMRI activity is found during viewing of point-light body motion (waving, playing pat-a-cake and peek-a-boo) over the regions constituting the social brain (the temporal pole, medial temporal gyrus, cerebellum, and amygdala) [45]. Overall, observers demonstrate greater ease in judging the neutral actions compared to judging emotional body language. When healthy adults judge emotions represented by stick human body postures, patterns of fMRI activity are sex specific, in particular, over the left anterior insula, left dorsal premotor cortex and right superior parietal lobule [46]. Yet sex differences are not evident in the neural circuitry underpinning visual processing of social interaction in Heider-and-Simmel movies, but rather in the regions engaged in perceptual decision making: In males, the MEG oscillatory induced gamma response boosts later than in females over the left prefrontal cortex [47]. It appears that females anticipate social interaction predicting others’ actions ahead of their occurrence, whereas males require accumulation of more sensory evidence for reaching proper decisions. Future research should be directed at uncovering sex differences in the social brain. Among other issues to clarify is whether neural circuits underlying tuning to faces are sex specific.

The present findings on female superiority in tuning to faces are in agreement with previous reports: females outperform on facial detection task (recognition of a face as a face) and facial identity discrimination [32,33]. At first glance, our data contradict male benefit in visual processing of the Mooney faces [34,35]. These images, however, seem to be subject of rather unique perceptual and neural processing [34,36]. Moreover, to find any facial feature such as
an eye or nose, one must first holistically perceive the Mooney image as a face [48]. One can speculate that right-hemisphere dominant fusiform brain activation reported in men favors holistic face processing [49]. Yet identification of the precise nature of gender effects in tuning to faces is beyond the scope of this study. Methodological issues (such as the nature of stimuli: static or dynamic displays; real or artsy faces; different stages of face processing addressed; and various task demands that may be non-specific to face encoding itself) may be of potential importance for the outcome of studies aimed at uncovering gender effects in face processing.

Although the Face-n-Food images had been created without any purpose to appear gender specific, they could potentially produce a gender related impression. The cues that may affect encoding face gender-specificity (such as a longer nose and oval face shape in masculine face, thinner eyebrows, bigger eyes and lips in feminine faces; or presence of a smiling expression: across cultures, women smile more often [50]) are minimized or totally absent in the food-plate images. However, clarification of the issue of whether the Face-n-Food images elicit gender related impression requires experimental proof.

The present work may be considered as a first step towards putting the Face-n-Food task into clinical setting. Most neuropsychiatric, neurodevelopmental and psychosomatic disorders are characterized by impairments in visual social cognition, non-verbal communication, body language reading, social competence and social interaction with others [51]. Face perception and facial emotional assessment of a social counterpart is of particular importance for adaptive social behavior. Most diseases related to impairments in visual social cognition are gender-specific: females and males are differently affected in terms of clinical picture, prevalence, and severity. Females are more often affected by anxiety disorders with a ratio of 2:1 or even 3:1, and gender differences increase with age [52,53]. Depression is approximately twice as common in females as in males [54]. By contrast, males have a higher risk for developing autistic disorders, with a ratio of about 4:1 [55] or even higher. Neuroanatomy of autism is sex specific [56]. Schizophrenia occurs 1.4 times more frequently in males than females, and the onset of disease is earlier in men [57]. Males are at a 14–20% higher risk for premature birth and of its complications in the brain development and cognition [58]. Males are also more often affected by attention deficit hyperactivity disorders, ADHD [59].

Visual social cognition, body language reading and different aspects of face processing is altered in most of these disorders [30,60,61]. Face perception is reported to be impaired in individuals with autistic traits with different gender impact: face identity and face recognition are stronger impaired in autistic males [29,30]. In autistic girls, but not boys, atypical face-sensitive component of the event related potentials (ERP), N170, is associated with symptom severity [62]. Preterm born children are also reported to experience difficulties in face processing [63,64], but gender impact on different aspects of face perception and other components of visual social cognition is largely unknown. As indicated by fMRI, during facial emotional categorization young females with major depressive disorder, MDD, exhibit hyperactivation, whereas young males display hypoactivation in the precuneous brain area [65]. Several aspects of face processing are also deficient in social anxiety [66]. Women, but not men, with social anxiety are hypersensitive to threat (avoidance-related) and approval-related facial emotional expressions such as fear, sadness and happiness [67]. Face processing and other aspects of social cognition are compromised in ADHD [68]. Boys with ADHD show impairments in response inhibition toward facial expression of anger that is accompanied by reduced P300 amplitude of the ERP [69], and selective difficulties in matching facial expressions to situations [70]. Although facial affect recognition is poor in both schizophrenia and ADHD, brain imaging indicates reduced activity in the medial prefrontal and limbic (amygdala) brain regions in schizophrenia, but more localized loss of activity in these regions in ADHD [71].
Last but not least, there are pronounced gender differences in eating disorders with a higher risk for developing eating abnormalities in women. Lifetime prevalence is about 0.9% in females to 0.3% in males in anorexia nervosa, and 0.5% in females to 0.15% in males in bulimia nervosa [72]. Categorization of facial emotions, in particular, negative emotions (fear and anger), but also other facial expressions (happiness and surprise) are reported to be impaired in females both in anorexia nervosa and bulimia nervosa [73–78] with a tendency to mislabel anger for sadness [78]. In eating disorders, alterations in brain processing of emotional faces are also reported [76,77]. For example, in females with bulimia nervosa, face-specific N170 amplitude of the ERP is lower for angry faces [77]. Yet it is unclear whether individuals with eating disorders experience difficulties in tuning to faces, in facial affect recognition only, or in both aspects of face processing. As the Food-n-Face task can potentially differentiate observers’ focus either on faces or food, in future work, we intend to prove the viability of this task as a quick and reliable indicator of tendencies to exhibit eating abnormalities.

A tendency of seeing faces in ambiguous images such as clouds or ink blots that contain elements resembling those of a face, is sometimes called face pareidolia. The time-course of the brain MEG response in the right ventral face fusiform area (FFA) during processing of faces and face-like images is rather similar: the brain is likely to be hardwired to detect the presence of a face as quickly as possible, rather than to process face-like images later on under influence of top-down mechanisms [79]. Yet the right superior temporal sulcus differentiates between faces and face-like images. Functional MRI also indicates that the right FFA is active during perception of noise images containing components resembling a face: images even with the slightest face cues are interpreted as faces [80].

Further step in elaborating the Face-n-Food images in relation to sex differences in the social brain and cognition would be recording the brain activity, in particular, by means of fMRI, in different patient population groups. Specific topographic patterns of activity within the neural circuitry underpinning facial processing including the FFA, can add essential information about processing of these images in the typical and atypical social brain.

Conclusions

The outcome of the present work indicates that females are more sensitive to faces represented by a composition of food ingredients in a manner bordering on the Guiseppe Archimboldo style. Females more readily recognize the images as a face: they not only earlier report resembling a face on images that are still described in terms of food by males, but also give on overall more face responses, and faster reach the ceiling level of face recognition. As most neuropsychiatric, neurodevelopmental and psychosomatic disorders characterized by social brain abnormalities are gender specific, the task may serve as a valuable tool for uncovering impairments in visual face processing.

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Author Contributions
Conceived and designed the experiments: MAP. Performed the experiments: MAP. Analyzed the data: MAP ANS. Contributed reagents/materials/analysis tools: MAP KS ANS. Wrote the paper: MAP KS ANS. Supervised the whole project: MAP.

References
1. Hall JA (1978) Gender effects in decoding nonverbal cues. Psychol Bull 85: 45–857.
2. McClure EB (2000) A meta-analytic review of sex differences in facial expression processing and their development in infants, children, and adolescents. Psychol Bull 126: 424–453. PMID: 10825784
3. Thayer JF, Johnsen BH (2000) Sex differences in judgement of facial affect: A multivariate analysis of recognition errors. Scan J Psychol 41: 243–246.
4. Campbell R, Elgar K, Kuntsi J, Akers R, Tenstege J, Coleman M, et al. (2002) The classification of ‘fear’ from faces is associated with face recognition skill in women. Neuropsychologia 40: 575–584. PMID: 11792399
5. Hall JA, Matsumoto D (2004) Gender differences in judgments of multiple emotions from facial expressions. Emotion 4: 201–206. PMID: 15222856
6. Montagne B, Kessels RP, Frigerio E, de Haan EH, Perrett DI (2005) Sex differences in perception of affective facial expressions: do men really lack emotional sensitivity? Cogn Process 6: 424–453. doi:10.1007/s10339-005-0050-6 PMID: 18219511
7. Hampsen E, van Anders SM, Mullin LI (2006) A female advantage in the recognition of emotional facial expressions: Test of an evolutionary hypothesis. Evol Hum Behav 27: 401–416.
8. Hoffmann H, Kessler H, Eppel T, Rukavina S, Traue HC (2010) Expression intensity, gender and facial emotion recognition: Women recognize only subtle facial emotions better than men. Neuropsychologia 48: 220–225.
9. Proverbio AM, Riva F, Martin E, Zani A (2010) Face coding is bilateral in the female brain. PLoS One 5: e11242. doi:10.1371/journal.pone.0011242 PMID: 20574528
10. Lazar SM, Evans DW, Myers SM, Moreno-De Luca A, Moore GJ (2014) Social cognition and neural substrates of face perception: implications for neurodevelopmental and neuropsychiatric disorders. Behav Brain Res 263: 1–8. doi:10.1016/j.bbr.2014.01.010 PMID: 24462962
11. Nowicki S Jr, Hartigan M (1988) Accuracy of facial affect recognition as a function of locus of control orientation and anticipated interpersonal interaction. J Soc Psychol 128: 363–372. PMID: 3419145
12. Rotter NG, Rotter GS (1988) Sex differences in encoding and decoding of negative facial emotion. J Nonverb Behav 12: 139–148.
13. Wagner HL, MacDonald CJ, Manstead ASR (1986) Communication of individual emotions by spontaneous facial expressions. J Person Soc Psychol 50: 737–743.
14. Goos LM, Silverman I (2002) Sex related factors in the perception of threatening facial expressions. J Nonverb Behav 26: 27–41.
15. Demtl B, Windischberger C, Robinson S, Kryspin-Exner I, Gur RC, Moser E, et al. (2009) Amygdala activity to fear and anger in healthy young males is associated with testosterone. Psychoneuroendocrinology 34: 687–693. doi:10.1016/j.psyneuen.2008.11.007 PMID: 19138216
16. Wild B, Erb M, Bartels M (2001) Are emotions contagious? Evoked emotions while viewing emotionally expressive faces: quality, quantity, time course and gender differences. Psychiatry Res 10: 109–124.
23. Golan O, Baron-Cohen S, Hill J (2006) The Cambridge Mindreading (CAM) Face-Voice Battery: the complex emotion recognition in adults with and without Asperger syndrome. J Autism Dev Dis 36: 169–183. PMID: 16477515

24. Rahko J, Paakki JJ, Starck T, Nikkinen J, Remes J, Hurtig T, et al (2010) Functional mapping of dynamic happy and fearful facial expression processing in adolescents. Brain Imag Behav 4: 164–176.

25. Kret ME, Pichon S, Grèzes J, De Gelder B (2011) Men fear other men most: Gender specific brain activations in perceiving threat from dynamic faces and bodies—An fMRI study. Front Psychol 2: 3. doi: 10.3389/fpsyg.2011.00003 PMID: 21713131

26. Nelson NL, Russell JA (2011) Preschoolers’ use of dynamic facial, bodily, and vocal cues to emotion. J Exp Child Psychol 110: 52–61. doi: 10.1016/j.jexpchildpsychol.2011.03.014 PMID: 21524423

27. Biele C, Grabowska A (2006) Sex differences in perception of emotion intensity in dynamic and static facial expressions. Exp Brain Res 171: 1–6. PMID: 16628369

28. Han DH, Yoo HJ, Kim BN, McMahon W, Renshaw PF (2014). Brain activity of adolescents with high functioning autism in response to emotional words and facial emoticons. PLoS One. 9: e91214. doi:10.1371/journal.pone.0091214 PMID: 24621866

29. Halliday DW, MacDonald SW, Sherf SK, Tanaka JW (2014). A reciprocal model of face recognition and autistic traits: evidence from an individual differences perspective. PLoS One 9: e94013. doi:10.1371/journal.pone.0094013 PMID: 24853862

30. Rhodes G, Jeffery L, Taylor L, Grèzes J, De Gelder B (2011) Men fear other men most: Gender specific brain activations in perceiving threat from dynamic faces and bodies—An fMRI study. Front Psychol 2: 3. doi: 10.3389/fpsyg.2011.00003 PMID: 21713131

31. LoBue V (2009) More than just another face in the crowd: Superior detection of threatening facial expressions in children and adults. Dev Sci 12: 305–313. doi:10.1111/j.1467-7687.2008.00767.x PMID: 19143803

32. McBain R, Norton D, Chen Y (2009) Females excel at basic face perception. Acta Psycholog 130: 168–173. doi: 10.1016/j.actpsy.2008.12.005 PMID: 19159861

33. Lewin C, Herlitz A (2002) Sex differences in face recognition—Women’s faces make the difference. Brain Cogn 50: 121–128. PMID:12372357

34. Foreman N (1991) Correlates of performance on the Gollin and Mooney tests of visual closure. J Gen Psychol 118: 13–20. PMID:2037848

35. Verhallen RJ, Bosten JM, Goodbourn PT, Bargary G, Lawrance-Owen AJ, et al. (2014) An online version of the Mooney Face Test: phenotypic and genetic associations. Neuropsychologia 63:19–25. doi: 10.1016/j.neuropsychologia.2014.08.011 PMID: 25138019

36. Bruce V (1988). Recognising faces. New York. Erlbaum.

37. Rehnman J, Herlitz A (2007) Women remember more faces than men do. Acta Psycholog 124: 344–355. PMID: 16764811

38. Rehnman J, Herlitz A (2006) Higher face recognition ability in girls: Magnified by own-sex and own-ethnicity bias. Memory 14: 289–296. PMID: 16574585

39. Okazaki Y, Abrahamyan A, Stevens CJ, Ioannides AA (2010) Wired for her face? Male attentional bias for female faces. Brain Topogr 23: 14–26. doi: 10.1007/s10548-009-0112-7 PMID: 19809873

40. Ino T, Nakai R, Azuma T, Kimura T, Fukuyama H (2010) Gender differences in brain activation during encoding and recognition of male and female faces. Brain Imaging Behav 4: 55–67. doi: 10.1007/s11682-009-9085-0 PMID: 20503114

41. Alaerts K, Nackaerts E, Meyns P, Swinnen SP, Wenderoth N (2011) Action and emotion recognition from point light displays: an investigation of gender differences. PLoS ONE 6: e20989. doi: 10.1371/journal.pone.0020989 PMID: 21695266

42. Sokolov AA, Krüger S, Enck P, Krägeloh-Mann I, Pavlova MA (2011) Gender affects body language reading. Front Psychol 2: 16. doi: 10.3389/fpsyg.2011.00016 PMID: 21713180

43. Krüger S, Sokolov AN, Enck P, Krägeloh-Mann I, Pavlova MA (2013) Emotion through locomotion: gender impact. PLoS ONE 8: e81716. doi: 10.1371/journal.pone.0081716 PMID: 24278456

44. Anderson LC, Bolling DZ, Schelinski S, Coffman MC, Pelphrey KA, et al. (2013) Sex differences in the development of brain mechanisms for processing biological motion. NeuroImage 83: 751–760. doi: 10.1016/j.neuroimage.2013.07.040 PMID: 23876243

45. Pavlova MA, Sokolov AN, Bidet-Ildei C (2014) Sex differences in the cortical neuromagnetic response to biological motion. Cereb Cortex advanced online access doi: 10.1093/cercor/bhu175

46. Kana RK, Travers BG (2012) Neural substrates of interpreting actions and emotions from body postures. Soc Cogn Affect Neurosci 7: 446–456. doi: 10.1093/scan/nsr022 PMID: 21504992
47. Pavlova M, Guerreschi M, Lutzenberger W, Sokolov AN, Krägeloh-Mann I (2010) Cortical response to social interaction is affected by gender. NeuroImage 50: 1327–1332. doi: 10.1016/j.neuroimage.2009.12.096 PMID: 20056153

48. Farzin F, Rivera SM, Whitney D (2009) Holistic crowding of Mooney faces. J Vis 9(6):18.1–15.

49. Tiedt HO, Weber JE, Pauls A, Beier KM, Lueschow A (2013) Sex-differences of face coding: evidence from larger right hemispheric M170 in men and dipole source modelling. PLoS One 8(7): e69107. doi: 10.1371/journal.pone.0069107 PMID: 23874881

50. Buchala S, Davey N, Gale TM, Frank R (2005) Principal component analysis of gender, ethnicity, age, and identity of face images. Proc. IEEE ICMI, vol. 7.

51. Pavlova MA (2012) Biological motion processing as a hallmark of social cognition. Cereb Cortex 22: 981–995. doi: 10.1093/cercor/bhr156 PMID: 21775676

52. Craske MG (2003) Origins of phobias and anxiety disorders: Why more women than men? Amsterdam (Netherlands): Elsevier.

53. Beesdo-Baum K, Knappe S (2012) Developmental epidemiology of anxiety disorders. Child Adolesc Psychiatr Clin N Am 21: 437–478. doi: 10.1016/j.chc.2012.05.001 PMID: 22800989

54. Difforio A, Jones I (2010) Is sex important? Gender differences in bipolar disorder. Int Rev Psych 22: 437–452. doi: 10.3109/09540261.2010.514601 PMID: 21047158

55. Newschaffer CJ, Croen LA, Daniels J, Giarelli E, Grether JK, et al. (2007) The epidemiology of autism spectrum disorders. Ann Rev Publ Health 28: 235–258.

56. Lai MC, Lombardo MV, Suckling J, Ruigrok AN, Chakrabarti B, et al. (2013) Biological sex affects the neurobiology of autism. Brain 136: 2799–2815. doi: 10.1093/brain/awt16 PMID: 23935125

57. Picchioni MM, Murray RM (2007) Schizophrenia. BMJ. 335: 91–95. PMID: 1762963

58. Pavlova MA, Krägeloh-Mann I (2013) Limitations on the developing preterm brain: Impact of periventricular white matter lesions on brain connectivity and cognition. Brain 136: 998–1011. doi: 10.1093/brain/aws334 PMID: 23550112

59. Bloom B, Cohen RA, Freeman G. (2012). Summary health statistics for U.S. children: National Health Interview Survey, 2011. National Center for Health Statistics. Vital Health Stat. 10.

60. Feuerriegel D, Churches O, Hofmann J, Keage HA (2014) The N170 and face perception in psychiatric and neurological disorders: A systematic review. Clin Neuropsychol doi: 10.1016/j.clinph.2014.09.015

61. Weigelt S, Koldewyn K, Kanwisher N (2012) Face identity recognition in autism spectrum disorders: a review of behavioral studies. Neurosci Biobehav Rev 36: 1060–1084. doi: 10.1016/j.neubiorev.2011.12.008 PMID: 22212588

62. Coffman MC, Anderson LC, Naples AJ, McPartland JC (2015) Sex differences in social perception in children with ASD. J Autism Dev Disord 45: 589–599. doi: 10.1007/s10803-013-2006-5 PMID: 24293083

63. Rose SA, Feldman JF, Jankowski JJ (2002) Processing speed in the 1st year of life: a longitudinal study of preterm and full-term infants. Dev Psychol 38: 895–902. PMID: 12428702

64. Fazzi E, Bova S, Giovenzana A, Signorini S, Uggetti C, Bianchi P (2009) Cognitive visual dysfunctions in preterm children with periventricular leukomalacia. Dev Med Child Neurol 51: 974–981. doi: 10.1111/j.1469-8749.2009.03272.x PMID: 19416337

65. Briceño EM, Rapport LJ, Kassel MT, Bielaukas LA, Zubieta JK, Weisenbach SL, et al. (2014) Age and gender modulate the neural circuitry supporting facial emotion processing in adults with major depressive disorder. Am J Geriatr Psychiatry. doi: 10.1016/j.jagp.2014.05.007

66. Gilboa-Schechtman E, Shachar-Lavie I (2013) More than a face: a unified theoretical perspective on nonverbal social cue processing in social anxiety. Front Hum Neurosci 7: 904. doi: 10.3389/fnhum.2013.00904 PMID: 24427129

67. Arrais KC, Machado-de-Sousa JP, Trzesniak C, Santos Filho A, Ferrari MC, Osório FL, et al. (2010) Social anxiety disorder women easily recognize fearful, sad and happy faces: the influence of gender. J Psychiatr Res 44: 535–540. doi: 10.1016/j.jpsychires.2009.11.003 PMID: 19962717

68. Uekermann J1, Kraemer M, Abdel-Hamid M, Schimmelmann BG, Hebebrand J, Daum I, et al. (2010) Social cognition in attention-deficit hyperactivity disorder (ADHD). Neurosci Biobehav Rev 34: 734–743. doi: 10.1016/j.neubiorev.2009.10.009 PMID: 19857516

69. Köchel A1, Leutgeb V, Schienle A (2014) Disrupted response inhibition toward facial anger cues in children with attention-deficit hyperactivity disorder (ADHD): an event-related potential study. J Child Neurol 29: 459–468. doi: 10.1177/0883073813476139 PMID: 23449686

70. Yuill N, Lyon J (2007) Selective difficulty in recognising facial expressions of emotion in boys with ADHD. General performance impairments or specific problems in social cognition? Eur Child Adolesc Psychiatry 16: 398–404. PMID: 17401608
71. Marsh PJ, Williams LM (2006) ADHD and schizophrenia phenomenology: visual scanpaths to emo-
tional faces as a potential psychophysiological marker? Neurosci Biobehav Rev 30: 651–665. PMID: 16466794

72. Hudson JI, Hiripi E, Pope HG, Kessler RC (2007) The prevalence and correlates of eating disorders in
the National Comorbidity Survey Replication. Biol Psychiatry 61: 348–358. PMID: 16815322

73. Kucharska-Pietura K, Nikolaou V, Masiak M, Treasure J (2004) The recognition of emotion in the faces
and voice of anorexia nervosa. Intern J Eat Dis 35: 42–47.

74. Jones L, Harmer C, Cowen P, Cooper M (2008) Emotional face processing in women with high and low
levels of eating disorder related symptoms. Eat Behav 9: 389–397. doi: 10.1016/j.eatbeh.2008.03.001
PMID: 18928901

75. Legenbauer T, Vocks S, Rüddel H (2008) Emotion recognition, emotional awareness and cognitive
bias in individuals with bulimia nervosa. J Clin Psychol 64: 687–702. doi: 10.1002/jclp.20483 PMID:
18473338

76. Pollatos O, Herbert BM, Schandry R, Gramann K (2008). Impaired central processing of emotional
faces in anorexia nervosa. Psychosom Med 70: 701Y8. doi: 10.1097/PSY.0b013e31817e41e6 PMID:
18606730

77. Kühnpast N, Gramann K, Pollatos O (2012) Electrophysiologic evidence for multilevel deficits in emo-
tional face processing in patients with bulimia nervosa. Psychosom Med 74: 736–744. doi: 10.1097/
PSY.0b013e31825ca15a PMID: 22826291

78. Ridout N, Wallis DJ, Autwal Y, Sellis J (2012) The influence of emotional intensity on facial emotion rec-
ognition in disordered eating. Appetite 59: 181–186. doi: 10.1016/j.appet.2012.04.013 PMID:
22542716

79. Hadjikhani N1, Kveraga K, Naik P, Ahlfors SP (2009). Early (M170) activation of face-specific cortex by
face-like objects. Neuroreport 20: 403–407. doi: 10.1097/WNR.0b013e328325a8e1 PMID: 19218867

80. Liu J, Li J, Feng L, Li L, Tian J, Lee K (2014) Seeing Jesus in toast: neural and behavioral correlates of
face pareidolia. Cortex 53: 60–77. doi: 10.1016/j.cortex.2014.01.013 PMID: 24583223