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研究課題名（和文）Face and lips coloration as a fertility signal in women

研究課題名（英文）Face and lips coloration as a fertility signal in women

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研究成果の概要（和文）：唇と頬の色合いの差は、各女性の性周期による違いよりも女性間のバリエーションのほうが大きいということが分かった。しかし、その他の霊長類に見られるのと同様に、排卵前後では唇の輝度が低くなっていた。ただし、この効果は肉眼ではおそらく感知できないほどに非常に小さく。つまり、ヒトは女性の皮膚の赤さについての生物学的基盤とメカニズムを現生霊長類との共通祖先から受け継いでいると考えられる。性的コミュニケーションと配偶者選択における社会生態的制約についてなど、女性の皮膚の赤さのヒトと霊長類における多様性や機能の違いについての研究は、このようなシグナルの進化について理解するうえで重要である.

研究成果の学術的意義や社会的意義
Psychologists have long studied the "red effect": red color enhances a woman attractivity as it suggests fertility. Along with other studies, my results provide empirical support against this hypothesis: red color is unlikely to play a role into mate choice -at least in modern humans.

研究成果の概要（英文）：I found that there is more difference between than within women in cheek and lip coloration. However, lip luminance (how dark or light the skin appears), is a bit more susceptible to intra-cycle variation in the probability of ovulation: around ovulation lips became darker, as seen in other non-human primate species. But the effect is quite small and likely imperceptible -which is not surprising since we may have noticed that about our own species before. Thus, humans could have inherited the biological bases and mechanisms of expression for female red skin colour from a primate ancestor. This doesn’t necessarily imply that lip luminance plays or does not play an active role in concealing ovulation or in mate choice. Investigating the different forms and functions of female red skin colour in human and non-human primates is necessary to better understand their evolution, i.e., to unveil the different socio-ecological constraints on sexual communication and mate choice.

研究分野：psychology

キーワード：sexual communication　fertility　ovulation　skin coloration　lips　primates　humans

１．研究開始当初の背景

Do females display visual information about their reproductive status that can modulate mate attraction and mating strategies? This question is central to sexual selection theory. The number of offspring a female can have is constrained by physiological factors such as menstrual cyclicity, gestation and post-partum amenorrhea, as well as reproductive senescence. Reproduction is usually more costly for females due to the production of larger gametes, extended maternal care, and male monopolization [1,2]. Thus, in several species, females appear to have evolved traits which are attractive to males and can act as probabilistic signals of ovulation to maximize reproduction while balancing its associated costs. Across human and non-human primates (hereafter, primates), there is evidence that female traits influence male behaviours, suggesting common evolutionary pathways and underlying mechanisms for sexual signalling [3,4].

Among the different female traits, there is a growing interest in the potential role of red skin colour in primate sexual communication. Intra-cycle variation in oestrogens induces ovulation and also affects some chromatic (redness) and achromatic (luminance) parameters of skin colour [5,6]. Circulating oestrogens bind to receptors in the skin, causing an increase in blood flow and consequently a decrease in the perceived skin luminance (i.e., darkening of the skin) [7,8]. Increase in blood flow can modulate the ratio of oxygenated/deoxygenated blood in the skin vessels which may influence perceived redness. Primate studies provide evidence that facial skin colour varies across the cycle in mandrills [9], contains information about the probability of ovulation in rhesus macaques [10,11], and advertises pregnancy but not ovulation in Japanese macaques [12,13]. Moreover, red skin colour appears to be attractive to males suggesting a role in mate attraction, at least in macaques [14].

Cheek and lip colour also correlate with female attractiveness in human [15–18]. Skin colour may thus be involved into human mate attraction, although the colour of the stimuli was artificially manipulated in previous studies, which may impair the ecological validity of the results. Studies of the potential signalling function of red skin colour in women yielded mixed results. Oberzaucher et al. [19] described that cheeks were redder around ovulation compared to the end of the cycle while Samson et al [20] could not replicate these findings. Recently, Burris et al. [21] found no intra-cycle variation in cheek colour. Interpretation of the informative role of skin colour in ovulatory signalling is however constrained by some methodological limitations. While most studies used photography to analyse skin colour, which provides accurate measurements, they did not always correct lighting conditions across photography sessions using colour standards, which may have altered measurements [22,23]. Human studies usually rely on a restricted data set to assess intra-cycle difference: e.g. 2 samples from mid and late cycle, which can underestimate or overestimate cycle effects [but see 21]. Finally, human studies often failed to confirm ovulation with sex hormone profiles (with the exception of Burriss et al. 2015, ovulation tests), especially when studying perceptions of intra-cycle variation. Taken together, these methodological limitations constrain our understanding of the potential role of female red skin colour in sexual signalling in humans.

２．研究の目的

To determine if women display a colourful trait that may play a role in ovulatory signalling, there is a fundamental need for more studies of the relationship between fine-scale variation in trait expression and the probability of ovulation. Such studies would benefit from objective and quantitative methods, inspired by primate studies, using standardized photography, regular biological sampling, and hormonal estimation of the ovulation date [23–26]. Following this premise, this study aims at investigating whether cheek and lip colour contain information about intra-cycle variation in the probability of ovulation in

women.

３．研究の方法

Participants: In total, 18 women participated in the study. All participants were naturally cycling and not taking hormonal contraceptives for at least 3 months prior to and during the study. I collected digital photographs and saliva samples every two days, excluding weekends and national holidays, for the duration of one complete menstrual cycle (i.e., from the beginning of their menstruations until the next ones) between September 2018 and June 2019, to limit the effect of tanning. I collected a total of 204 photographs and saliva samples (mean par participant = 11.3 ± SD 1.5, range = 8-13).

Cheek & lip colour: Participants removed face and lip make-up a minimum of 30 min before sampling. Participants sat in front of a beige background and adopted a neutral expression. The camera was placed 2m from the participant's chair and held at the same height as the participant's face. I standardised photographs such that colour measurements are comparable across all photographs [23–25]. Cheek colour was measured from a pair of points and lip colour was measured from the whole lip skin (Figure 1). CIELAB values were extracted using Colourworker software (Chrometics Ltd. available at: http://www.colourworker.com/) which provided luminance (L*) and red-green ratio (a*, hereafter redness) values.

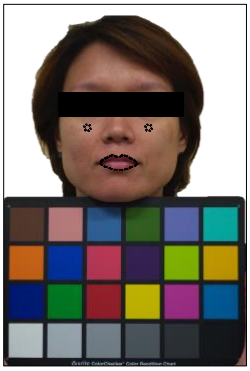

Fig 1. Picture of a participant face showing the area used for cheek and lip colour analyses.

Timing of ovulation: Saliva samples were analysed for oestradiol and progesterone using Salimetrics enzyme immunoassays kits. The onset of the luteal phase was defined as the sample with a progesterone concentration at least 2 standard deviations greater than the mean of the 2-3 preceding baseline values [26]. Ovulation was considered to have occurred when a mid-cycle peak of oestradiol was detected around the onset of the luteal phase. I considered the day of peak oestradiol as the most likely day of ovulation and labelled it as *day 0*. The day directly preceding the estimated ovulation day was labelled as *day -1*, the day directly following it as *day +1*, and so on. Ovulation could not be determined (i.e., abnormal hormone variations) for 3 out of the 18 participants.

Statistical analyses: I used photographs of 15 participants showing ovulatory cycles to analyse intra-cycle variation in cheek and lip luminance and redness (N = 165 photographs, mean per participant = 11.0 ± SD 1.4, range = 8-13). This study tests for a possible quadratic effect of the days relative to ovulation on cheek and lip colour: higher effect toward the estimated ovulation and lower effect toward the beginning and end of the cycle, using general linear mixed-effects models (LMMs) for cheek and lip colour (luminance and redness respectively). Two different mechanisms can be expected concerning the effect of participant identity: On one hand, we can expect that the relationship between the timing of ovulation and colour would be similar across participants. On the other hand, this relationship may vary between participants. I thus constructed different set of models to take account for and test this possibility.

４．研究成果

A first results indicate that the relationship between the timing of ovulation and colour appears similar

across participants, meaning that this mechanism is well conserved at the population level.

Concerning cheek colour, check colour (luminance and redness) did not vary according to the probability of ovulatıon and is mostly explained by inter-individual differences (80 %). Concerning lip colour, lip redness did not vary according to the probability of ovulation and is mostly explained by inter-individual difference (80 %). However, I found that lips became darker around ovulation and variation in lip luminance is less explained by inter-individual differences (50%). Yet, the effect of the timing of ovulation is rather small and day-to-day variation were very small (0.21 units, while the threshold for perception is set at 2 units, [27]).

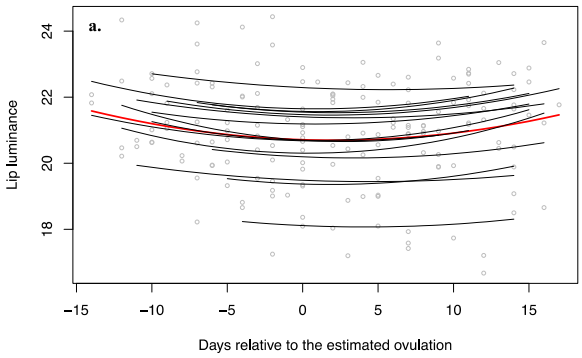

Fig 2. Relationship between lip luminance and the days relative to the estimated ovulation. Raw data are presented as grey circle. The red line presents the global model prediction; the black lines show prediction for each participant

Discussion

Using objective methods to analyse fine-scale and intra-individual changes in cheek and lip colour according to the timing of ovulation, I found a weak evidence for a relationship between lip luminance, but nor redness, and the timing of ovulation in women. Cheek colour may not be related to the timing of ovulation in agreement with a previous study [21].

Variation in lip luminance is likely imperceptible (at least in this sample), which is not really surprising since we may have noticed this about our own species. It should be noted again that the timing of ovulation explained only 2% of the variance in the data, which is quite a weak effect. This could suggest a correlation effect without causation between lip luminance and the timing of ovulation. However, a biological relationship does exist between skin luminance and variation in circulating oestrogens in humans, although presently weak in this sample, as in non-human primates [5,6]. Thus, humans could have inherited the biological bases and mechanisms of expression for female red skin colour from a primate ancestor. This doesn't necessarily imply that lip luminance plays or does not play an active role in concealing ovulation or in mate choice in our species, i.e., the expression of red skin could have been maintained because it does not impose costs on women. However, investigating the possible different forms (traits) and functions (e.g., signalling/concealing the timing of ovulation) of female red skin colour in human and non-human primate species is necessary to better understand their evolution, i.e., to unveil the different socio-ecological constraints on sexual communication and mate choice. For example, in the present study, while lip luminance is unlikely an ovulatory signal it could still play a role in mate attraction and mating decision, if darker lips are attractive regardless of being informative about the timing of ovulation. Further studies should assess men and women responses toward inter-individual variation in lip colour to determine if this is the case.

The differences in red skin traits (face, lips, and sexual skin) and signalling functions probably result from the different socio-environmental constraints on mating across species. Concealing the reproductive status may have evolved in species facing higher male monopolization or pair-bonding, lower intra-sexual competition, and higher costs on signalling; while higher infanticide risks and intra-sexual competition, limited mating opportunities, and lower costs on signalling may have favoured exaggerated

or multimodal signalling [28,29]. However, these proposed effects do not appear to fully explain the inter-species differences observed in female red skin colour functions, as species with similar socio-ecology express traits that may be involved in signalling or not signalling ovulation [11,13]. More studies using longitudinal and ecologically valid designs are needed to better understand the possible evolutionary pathways and underlying mechanisms leading to the evolution of female red skin colour in primate species including humans. Researches duplicating the present study design with a greater sample size would especially help to clarify the link between lip luminance, ovulation, and potentially mate choice in humans.

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５．主な発表論文等

〔雑誌論文〕　計2件（うち査読付論文　1件／うち国際共著　2件／うちオープンアクセス　1件）

１．著者名 L Rigaill	４．巻 online
２．論文標題 Information content of cheek and lip colour in relation to the timing of ovulation in women	５．発行年 2019年
３．雑誌名 BioRxiv	６．最初と最後の頁 online
掲載論文のDOI（デジタルオブジェクト識別子） https://doi.org/10.1101/859801	査読の有無 無
オープンアクセス オープンアクセスとしている（また、その予定である）	国際共著 該当する

１．著者名 L Rigaill, JP Higham, S Winters, C Garcia	４．巻 73
２．論文標題 The redder the better? Information content of red skin coloration in female Japanese macaques	５．発行年 2019年
３．雑誌名 Behavioral Ecology and Sociobiology	６．最初と最後の頁 103
掲載論文のDOI（デジタルオブジェクト識別子） https://doi.org/10.1007/s00265-019-2712-x	査読の有無 有
オープンアクセス オープンアクセスではない、又はオープンアクセスが困難	国際共著 該当する

〔学会発表〕　計7件（うち招待講演　0件／うち国際学会　3件）

１．発表者名 L Rigaill
２．発表標題 Sur mes levres : Des informations sur la probabilite d ' ovulation transmises du bout du levres ?
３．学会等名 Societe Francophone De Primatologie
４．発表年 2019年

１．発表者名 L Rigaill
２．発表標題 Read my lips: Does lips colouration contain information about the timing of ovulation in women?
３．学会等名 European Federation for Primatology - Primate Society of Great Britain（国際学会）
４．発表年 2019年

１．発表者名
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２．発表標題
Sealed lips don ' t deceive: Lip coloration informs about ovulation probability

３．学会等名
International Symposium on Primatology and Wildlife Science（国際学会）

４．発表年
2019年

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L Rigaill

２．発表標題
La coloration des levres: un indice de l ' ovulation chez l ' humain?

３．学会等名
Societe Francophone De Primatologie

４．発表年
2018年

１．発表者名
L Rigaill

２．発表標題
Read my lips: when the red gets redder

３．学会等名
International Symposium on Primatology and Wildlife Science（国際学会）

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2018年

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L Rigaill

２．発表標題
Women lips coloration as a signal of fertility and quality

３．学会等名
Primate Society of Japan

４．発表年
2018年

１．発表者名 Kessler SE, Rigaill L, Street SE
２．発表標題 Levels of selection: Untangling kin and individual signatures in vocalizations
３．学会等名 American Association of Physical Anthropologists
４．発表年 2018年

〔図書〕　計0件

〔産業財産権〕

〔その他〕

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６．研究組織

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