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Bill covering and nape feather ruffling as indicators of calm states in the Sulphur-crested cockatoo (*Cacatua galerita*)

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Declarations of interest: none

Keywords

Animal sentience; Calmness; Facial expression; Positive emotions; Emotional expression

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Abstract

Parrots are highly social birds that are recognized for their primate-like cognitive abilities but their way to express emotions remain overlooked. Herein we explored potential facial indicators of emotions in cockatoos. We predicted that facial feather ruffling is an indicator of a cockatoo's emotional state and hypothesized that specific facial feather positions would be present more during positive valence and low arousal situations. We observed feather position on the crest, cheek and nape during the daily routine of a group of five captive, non-breeding, Sulphur-crested cockatoos. The data show that cheek and nape feather ruffling occurred significantly more during activities associated with low arousal levels and positive valence such as maintenance behaviours, positive and quiet social contact and resting. Our data suggest that ruffling feathers over the bill (i.e. cheek feather ruffling) and nape ruffling may provide visual indicators of calm/relaxed states in cockatoos. Subtle movement of facial feathers may be an effective close-ranged visual signal to communicate birds' affective states or their intention to engage in specific activities. This work provides a novel approach to assessing the positive welfare of captive cockatoos and to understanding emotional communication in non-mammalian species.

1. Introduction

Positive emotions have been recognized as adaptive as negative ones and as primary component of animal well-being (Mendl, Burman, and Paul 2010; Panksepp 2004; Boissy et al. 2007). Despite their importance, positive emotions have been less studied than negative ones because they are more subtle and difficult to assess. Emotions are subjective experiences composed of cognitive processes, neurophysiological and behavioural responses (Boissy et al. 2007). In mammals, movement of facial muscles provides species-specific repertoires of facial expressions, which are one of the most studied and reliable behavioural tools to access the emotional world of animals (Waller and Micheletta 2013). As birds lack a complex facial musculature (Diogo et al. 2008), they have been discarded from this field of research. However, birds do have the capacity to move their facial feathers due to the contractile properties of the feather-bearing integument (Homberger and de Silva 2003). According to anecdotal observations, facial/head feather movement including the crest may communicate emotions or moods, like play mood in cockatoos (Kaplan 2015). In the few other crested-birds studied so far, crest displaying was mainly observed in contexts of high arousal levels like intra or interspecific aggression, courtship or defence from predators (Kumar 2010; Graves 1990; Goodwin 1956; Ruiz-Rodríguez, Martín-Vivaldi, and Avilés 2017).

Emotions are both characterized by their valence (positive or negative) and arousal level (high or low) (Mendl, Burman, and Paul 2010). Two types of positive emotions or states are commonly distinguished. Those characterized by high arousal levels such as joy, excitement, consummatory or appetite motivational states and, those characterized by low arousal levels such as calm, relaxed, safeness, social bonding or post-consummatory behaviours (Mendl, Burman, and Paul 2010; Richardson et al. 2016; Carver 2001). In a previous experiment on a group of captive blue-and-yellow macaws (*Ara aranauna*), we followed the birds' routine activities and their associated facial display. We showed that crown and nape ruffling were associated with activities with positive valence and low arousal levels, like quiet positive social interactions, maintenance or resting (Bertin et al. 2018). As these behavioural categories are commonly associated with post-consummatory behaviours and positive welfare in mammals or birds (Mattiello et al. 2019; Riters, Kelm-Nelson, Spool, 2019; Mendl, Burman, and Paul 2010; Richardson et al. 2016; Luescher 2006), we aimed to expand this research on emotional communication in Psittaciformes by following the routine activities of a group of cockatoos. Identifying indicators of positive welfare or calmness may help improve the well-being of the millions of parrots and cockatoos (two families of the order Psittaciformes) kept in captivity as pets, or for conservation programs.

Herein we provide a first exploration of potential facial indicators of emotions of Sulphur-crested cockatoos - highly social Australian native birds living in stable family groups and forming large feeding or resting flocks (Styche 2000). We observed a group of non-breeding captive cockatoos in their aviary and recorded their crest, cheek and nape feather ruffling during their routine daily activities. According to our previous findings on macaws, we hypothesized that there would be a higher probability to observe feather ruffling (i.e. erection of feathers), except for the crest, in activities associated with low arousal levels and positive valence. The cognitive abilities of Psittaciformes showed striking convergence with mammals (Emery 2016) and the present work provides new insights into facial emotional communication systems across vertebrates.

2. Material and methods

2.1. Birds and housing conditions

We observed five hand-reared Sulphur-crested cockatoos (*Cacatua galerita*) (2 males, 1 female and 2 undetermined sex, between 3 and 4 years old), not exposed to the public but part of a free-flying show (i.e. unrestrained outdoor flight), at the Zooparc de Beauval (Saint

Aignan, 41110, France). These birds were housed in an aviary with an indoor area (250 cm x 520 cm x 260 cm) freely connected to an outdoor area (250 cm x 850 cm x 260 cm) and mixed with one citron-crested cockatoo (*Cacatua sulphurea citrinocristata*). The aviary contained several tree branches, perches and cords. Enrichment was provided daily (cardboard and journal paper). Birds were fed daily with fresh fruits and vegetables, germinated seeds (wheat, corn, sunflower, rice, and oat), millet seeds, oyster shells, and a commercial mix for exotic birds.

2.2 Behaviour and feather postures

To determine during which activity feathers were ruffled we used a focal sampling method with a handheld video camera recorder (Sony HDRP PJ410) capturing 24 images per second. Each day, we followed one focal bird's behaviour for twenty minutes, and successively followed another bird, in a random order, until all the five birds had been observed. These observations were repeated during three consecutive weeks until 5 hours of recording per bird had been obtained. As birds were trained for free flight daily in the morning, we observed the birds in the afternoon between 2 and 5 PM, outside of any disturbance. The experimenter was familiar to them and moved around the aviary very quietly only when necessary.

We used a scan sampling method to analyse the videos. Every 5 s, the experimenter recorded the bird's feather position and behavioural activity: locomotion (walking, flying, climbing on the grid); alimentation (ground-foraging and eating or drinking); chewing (actively cutting and/or chewing pieces of paper, branches, cardboards, cords or the grid); maintenance (preening, scratching, stretching); social contact (allopreening, perched in body contact without or with interactions i.e. gently touching the conspecific with the beak or the feet; resting (the bird is perched, the body is immobile with little or no movement of the head). Agonistic interactions such as threat displays were extremely rarely observed.

We determined three areas where feathers can move independently from one another: the crest, the cheek and the nape (Fig. 1). For the crest and the nape, when ruffled, individual feathers can be distinguished. For the cheek, the feathers were over the bill when ruffled and we considered there to be two possible positions: “lower” when part of the lower mandible was covered and “upper” when any part of the upper mandible was covered in addition to the entire lower mandible (Fig. 1 and supplementary data). When some parameters were unobservable, the scan was not included. We obtained a mean total number of 3247.6 ± 114.6 scans per individual (minimum: 2915; maximum: 3566). The same experimenter conducted all observations. We assessed observer reliability for the occurrence of feather ruffling and activities by rescoring twice 20 min of video per bird. Intra-observer accordance was 96 % (percentage of scans where the scans were scored the same).

2.3 Statistical analyses

For each behavioural category, we calculated the mean proportion of ruffled feather scans per bird for the crest, the nape and the two categories of cheek feather positions. As the data were not normally distributed, we used the function aovp of the lmPerm package in R 3.4.2, to run permutation tests on the proportion of scans containing ruffled feathers during each activity. Activity type was considered a fixed factor while the individual was considered as a random factor. Two activity types were defined according to their presumed arousal levels (high or low). Behavioural categories without locomotion including: “maintenance”, “social contact” and “resting” were grouped and considered low arousal and positive valence activity type. These three relatively motionless behavioural categories are commonly considered quiet activities with low arousal levels and indicators of positive welfare across vertebrates (Mattiello et al. 2019; Riters, Kelm-Nelson, Spool, 2019; Mendl, Burman, and Paul 2010; Richardson et al. 2016; Luescher 2006). Behavioural categories with active behaviours and locomotion including “locomotion”, “alimentation” and “chewing” were grouped and considered high arousal activity type. These behavioural categories might be associated with consummatory behaviours and/or appetite motivational states with neutral or positive emotional valence (Mendl et al. 2010) but the precise valence remains understudied so far in birds. As agonistic interactions were rarely observed this category was not included in the analysis. With our limited sample size, post-hoc analyses lead to a drastic loss of statistical power and a high risk of type II error. However, a descriptive view of the data on behavioural categories is represented in the form of median and interquartile distribution ranges. To evaluate correlations between the proportions of ruffled feather scans observed on the different areas we used Spearman correlations (N=5).

2.4 Ethical note

The Zooparc de Beauval (41110, Saint Aignan) kindly provided access to their birds. Only video-recorded observations were conducted. These birds were trained since weaning to perform unrestrained outdoor flights with their animal caretakers and the observer spent several months in presence of the birds beforehand. No signs of avoidance behaviours to the presence of the observer or the animal caretakers were observed.

3. Results

Crest displaying was rarely observed and did not show any significant variation according to the bird’s activity type (Median [1st quartile-3rd quartile], lower arousal level vs. higher arousal level, 0 [0-0] vs. 0 [0-0]; $df = 1$; Mean Square (MS) < 0.01; $P = 0.38$) (Fig. 2A). The proportion of scans where feathers ruffling was observed was significantly higher during activities with low arousal level (maintenance, social contact, resting) than during activities with higher arousal level (locomotion, alimentation, chewing) for the two positions of cheek feathers (lower mandible: 0.31 [0.05-0.80] vs. 0.05 [0.01-0.06]; $df = 1$; $MS = 0.29$; $P = 0.001$; upper mandible: 0.48 [0.28-0.94] vs. 0.03 [0.01-0.06]; $df = 1$; $MS = 1.45$; $P < 0.001$) (Fig. 2B) and for nape feathers (0.84 [0.66-0.91] vs. 0.05 [0.02-0.09]; *df* = 1; *MS* = 3.13; $P < 0.001$) (Fig. 2C).

We found no significant effect of the random factor individual on the fixed effect activity type for the crest (*df* = 4; *MS* = 0.06; *P* = 1), the cheek (lower; *df* = 4; *MS* = 0.02; *P* = 1; upper; *df* = 4; *MS* = 0.12; *P* = 1) or the nape (*df* = 4; *MS* = 0.06; *P* = 1).

We found a positive correlation between nape feather ruffling and both lower (*rho* = 0.53, $P < 0.01$) and upper mandible cheek position (*rho* = 0.89, $P < 0.01$) but not between the two cheek feather positions lower and upper (*rho* = 0.29, *P* = 0.11). Two few crest displaying events were recorded to perform correlations.

4. Discussion

This study is the first to show variation in facial feather displays according to cockatoos' activity and potential emotional state. Cheek and nape feather ruffling occurred significantly more frequently during activities with low arousal levels and positive valence; suggesting that calm or relaxed states may be indicated by bill covering and nape feather ruffling.

Previously we found that activities with low arousal levels were associated with facial and nape feather ruffling in blue-and-yellow macaws (Bertin et al., 2018). In the current work with Sulphur-crested cockatoos we found, as hypothesized, a higher probability of ruffling feathers over the bill and nape ruffling during low arousal positive valence activities such as maintenance behaviours, social contact and resting. In the same direction, finches adopt a more spheroid body posture by ruffling their feathers when clumping or resting, which may be an effective signal inducing appeasement, clumping or allopreening in birds (Morris 1956; Moynihan and Hall 1955). In our study, the activity "resting" was particularly associated with nape ruffling and ruffling feathers over the upper mandible. Although speculative, this position may provide a cryptic shape during resting by covering the black bill and decreasing its contrast with the white plumage. The primary functions of a bird's feathers are flight and thermoregulation of the body (Morris 1956). In addition to these functions, more subtle and localized feather movements may provide social information about a bird's arousal level or intention to engage in specific activities.

In the context of presumed higher arousal level activities such as locomotion, foraging, actively interacting with enrichments, eating and drinking, nape and cheek feather ruffling occurred significantly less. These behavioural categories might be associated with consummatory behaviours and/or appetite motivational states with neutral or positive emotional valence but this remains understudied so far in birds so caution must be taken. In cockatoos, crest raising is probably more characteristic of states of high arousal levels as it was reported in contexts of alertness, agonistic interactions or play readiness in cockatoos (Kaplan 2015). Accordingly, we did observe crest raising when birds were excited after a free flight or during the rare agonistic interactions we witnessed (pers. obs).

As we observed a stable group of healthy birds kept in a particularly enriched environment, we cannot rule out that in other situations head feather ruffling, in combination with specific body postures could also signal sickness or negative emotions in parrots. Our sample size was low and the inter-individual variability was important therefore, additional investigations with larger, diverse samples will be required to determine with precision the function of bird facial displays. At term, it would be of interest to observe more extreme emotional valences and different sensory channels (acoustic, visual) to understand better parrots' emotional language. For example, contact calls or long distance calls may carry information about parrots' intention to engage in specific activities and/or their emotional states (New Zealand kea parrot, *Nestor notabilis*; Schwing, Parsons and Nelson 2012).

So far, avian visual communication is almost exclusively studied in ultimate, evolutionary contexts such as sexual selection and focused on conspicuous signals like bright colours or ornaments (e.g., Wachtmeister 2001; Gomes et al. 2017). Our study is complementary and calls attention to the overlooked function of more subtle visual displays (non-conspicuous facial feather movements). In social groups of birds emotion expression is probably adaptive, contributing to social cohesion by regulating approach and avoidance behaviours. Head feather displays may have similar function to facial expression in mammals, which convey close-range public information regarding individuals' intention to engage in specific activities or emotions (Waller and Micheletta 2013).

5. Conclusion

As the Psittaciformes are highly social with primate-like cognitive capacities (Olkowicz et al. 2016; Gutiérrez-Ibáñez, Iwaniuk, and Wylie 2018), they are very popular as companion animals. However, captive parrots and cockatoos are particularly sensitive to feather plucking or stereotypic behaviours, which are signs of negative welfare (van Zeeland et al. 2009). Wild parrots normally spend a large amount of their diurnal time engaged in comfort, affiliative or resting behaviours (Rowley 1987; Bergman and Reinisch 2006). These behavioural categories are commonly considered as reflecting calm and relaxed states and low level of threat in birds and vertebrates (Mattiello et al. 2019; Riters, Kelm-Nelson, Spool, 2019; Mendl, Burman, and Paul 2010; Richardson et al. 2016; Luescher 2006). Therefore, assessing these positive low arousal states in captive birds could help to evaluate their well-being and prevent damaging behaviours. Low arousal positive affect states have been less studied due to practical limitations in assessment. Our data show that subtle facial feather movements may provide reliable tools to assess calm or relaxed states. As for mammals, species-specific repertoires of facial expressions could provide useful tools to better assess well-being of captive birds and, more broadly, to better understand emotional communication across vertebrate species.

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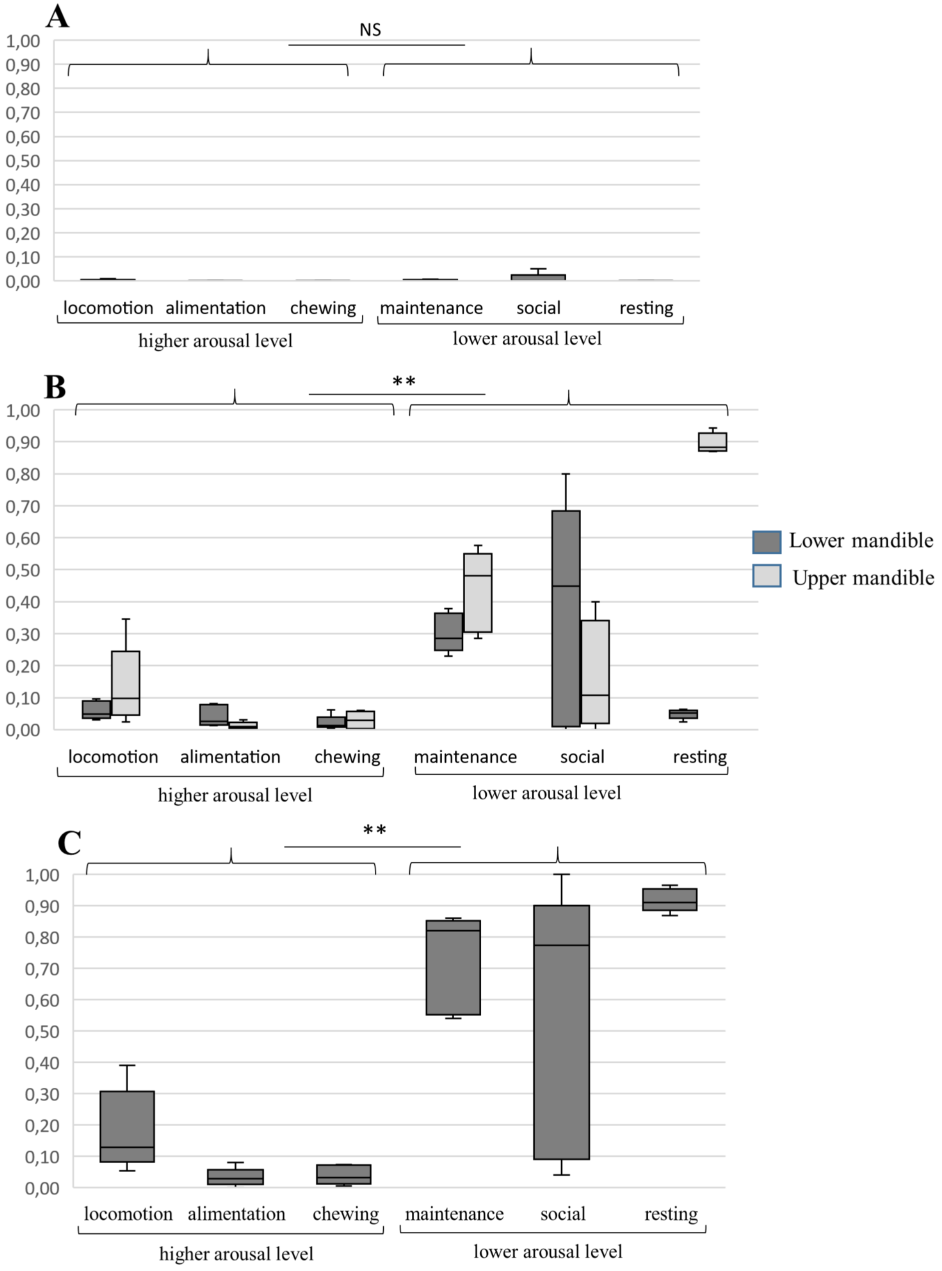
Figure captions

Fig 1. Repertoire of head feather displays: Photographic representation of the position of crest, cheek and nape feathers.

Fig 2: **Median and interquartile distribution ranges of the proportions of scans where feathers ruffling was observed** on A) the crest, B) the cheek, C) the nape. The proportions of scans are represented for the behavioural categories: locomotion (total mean ± SE number of scans = 226 ± 26), alimentation (215 ± 57 scans), chewing (1038 ± 115 scans), maintenance (322 ± 51 scans), social contact (84 ± 40 scans), resting (1356 ± 115 scans). Higher arousal level *versus* lower arousal level, NS = not significant, **: $P < 0.01$.

	Crest feathers	Cheek feathers	Nape feathers
Ruffled		 Lower mandible  Upper mandible	
Sleeked			


A
NS
1,00
0,90
0,80
0,70
0,60
0,50
0,40
0,30
0,20
0,10
0,00
locomotion
alimentation
chewing
maintenance
social
resting
higher arousal level
lower arousal level
B
**
Lower mandible
Upper mandible
C
**