

Novelty preference in face perception by week-old lambs (*Ovis aries*)

Orsola Rosa Salva¹, Simona Normando²,
Antonio Mollo³ & Lucia Regolin⁴

¹Center for Mind/Brain Sciences, University of Trento

²Dept. of Comparative Biomedicine and Food Science, University of Padua

³Dept. of Animal Medicine, Production and Health, University of Padua

⁴Dept. of General Psychology, University of Padua

An extensive literature has been accumulating, in recent years, on face-processing in sheep and on the relevance of faces for social interaction in this species. In spite of this, spontaneous preferences for face or non-face stimuli in lambs have not been reported. In this study we tested the spontaneous preference of 8-day-old lambs ($N = 9$) for three pairs of stimuli. In each pair, one stimulus was a face-like display, whereas the other presented the same inner features displaced in unnatural positions. One pair of stimuli was obtained from photographic images of ewes' faces, the other two pairs were schematic face-like stimuli. Lambs could differentiate the two stimuli obtained by photos of conspecifics, looking longer at the non-face stimulus ($p < 0.05$). We interpret this as a novelty preference, proving that few day-old lambs have already encoded the structural properties that define a face and recognize violations of those general properties.

Keywords: sheep; lamb; *Ovis aries*; novelty preference; face preference; face configuration; early learning

1. Introduction

The ability to detect and recognize faces, recognizing them from non-face objects, is a most relevant skill for social interaction in humans and in various non-human animals as well. Faces in fact signal the presence of conspecifics and provide information about relevant features for guiding any social interaction, such as age, identity, gender, emotional state and so on (e.g. see Brown & Dooling 1992, 1993; Candland 1969; Dawkins 1995, 1996; Guhl & Ortman 1953; Tibbetts 2002; Van der Velden et al. 2008). The presence of domain-specific circuits and processing modalities selectively devoted to the elaboration of faces is a much-debated issue. Existing evidence indicates that faces might be processed by dedicated mechanisms

in humans and non-human animals (e.g. Farah et al. 2000; Perrett et al. 1992; Kanwisher 2000; Kendrick et al. 2001; Tate et al. 2006; see Nelson 2001; Tovée 1998 for a critical approach). This is consistent with the striking face-processing abilities typically displayed by human beings, which seem to be at least in part available very early in life. For example, human newborns are spontaneously attracted by faces (either schematic or photographic images of faces), preferring them to similar non-face objects (Farroni et al. 2005; Johnson 2005; Morton & Johnson 1991; Macchi Cassia et al. 2004). Moreover, human infants are able to individually recognize photographed faces and process various aspects of such stimuli (e.g. see Farroni et al. 2006, 2007; Leo & Simion 2009; Turati et al. 2006, 2007). Similar evidence of early or experience-independent predispositions to pay attention to faces has been observed even in non-human primates and domestic chicks (Sugita 2008; Rosa-Salva et al. 2010, 2011, 2012). Face-naïve non-human primates also proved able to individually recognize faces on the basis of the precise spatial configuration of inner features (Sugita 2008). This is called configural processing and is considered one of the hallmarks of specialized face processing (e.g. Maurer et al. 2002). Configural face processing can be used to refer both to a sensitivity to first-order spatial relations among face features (i.e. a stimulus is recognized as a face because two eyes are aligned above the nose in a triangular configuration and the nose is above the mouth) as well as to a sensitivity to second-order relations (i.e. two individual faces are discriminated from each other based on the precise metric distances between face features and on their interrelations). The spontaneous preference for faces known in human newborns and in some non-human animals (Morton & Johnson 1991; Rosa-Salva et al. 2010, 2011; 2012; Sugita 2008) seems to imply a sensitivity to first order relations. However, it has been theorized that human newborns' predisposition for paying attention to faces could actually be determined by a more general preference for observing whichever pattern characterized by a higher number of elements in its upper part. Such a general preference is termed "up-down bias" and is supposed to be associated with low-level aspects of the visual stimulation (see Turati et al. 2002 for evidence supporting this view in human infants and Farroni et al. 2005 for conflicting evidence). On the contrary, the up-down bias does not seem to have a role in domestic chicks' face preference (Rosa-Salva et al. 2010). Moreover, in the case of domestic chicks and Japanese monkeys such preference has been demonstrated to be experience-independent, whereas in the case of human newborns the existing evidence leaves open the possibility that an early learning mechanism might be involved. Human newborns seem to be endowed with the ability to process and recognize (i.e. learn) various features of face stimuli, such as second-order information (Leo & Simion 2009), facial emotional expressions (Farroni et al. 2007) and individual face identity (based on either the inner or the outer face features, Turati et al. 2006, 2007). This

face-learning ability of human newborns could be enhanced by their predisposition to pay preferential attention to faces with respect to similar stimuli (Morton & Johnson 1991). Indeed, it has been theorized that one of the functions of such predisposition would be to determine an increased exposure to face stimuli during early development and the consequent specialization of brain areas and processing mechanisms selectively devoted to face recognition (Johnson 2005).

Faces are a relevant social stimulus also for sheep: the mere sight of same-breed unfamiliar conspecific faces reduces isolation stress in adult sheep (da Costa et al. 2004; see also Parrot et al. 1988; Bouissou et al. 1996). In line with that, it has been proved that adult sheep are able to learn and subsequently recognize not less than 50 conspecific faces, with the memory for the learned faces persisting for at least 2 years. After learning to recognize faces presented as frontal views, sheep also generalized to profile views of the same individuals (Kendrick et al. 2001). The existence of neurons in the temporal cortex of sheep, which fire in response to the vision of faces, has been known since 1987 (Kendrick & Baldwin 1987). These neurons also play a role in learning and memory for individual faces (Kendrick et al. 2001).

Human adults recognize familiar faces mainly by configural processing of the inner part of the face, whereas the inner and the outer parts of the face are at least equally important for discriminating unfamiliar faces (e.g. Ellis et al. 1979). Human newborns are able to recognize experimentally familiarized faces on the basis of either inner or outer face features, but the outer part of the face enjoys an advantage over the inner one (Turati et al. 2006). However, the interpretation of this result with respect to the scenario offered by the adult data is complicated by the difficulty to estimate the degree of familiarity that newborns acquire for “experimentally familiarized” faces. In adult sheep, the face outline plays the predominant role in the recognition of both familiar and unfamiliar faces. However, only when dealing with familiar faces, sheep are capable of recognizing the configuration of inner face features in the absence of the face outline (Peirce et al. 2000). Thus, in sheep as in human adults, familiarity is a most relevant factor in determining configural processing of inner face features, whereas recognition of the face outline seems to be much more experience-independent.

In spite of the extensive literature on face-processing in sheep (e.g. see Kendrick 1991, 1994; Kendrick et al. 1995, 1996; Peirce et al. 2000), spontaneous attention for face vs. non-face stimuli in newborn lambs has not been systematically tested yet. The importance of aspects of lambs’ faces in mother-offspring recognition had been demonstrated already at the end of the ‘70s (Alexander & Shillito Walser 1977; Walser & Alexander 1980). Moreover, lambs recognize their mother during the first weeks of life and visual cues provided by the general

appearance of the ewe could play a role, along with auditory and olfactory cues, in the recognition process (Shillito & Alexander 1975; Nowak 1990, 1991). However, according to Kendrick (1998) young lambs might be unable to identify individual conspecific on the basis of face appearance when younger than one month of life. To the best of our knowledge no study has ever investigated the early ontogenetic development of sheep's ability to encode aspects of face configuration, such as the first order relations that define a face with respect to a non-face. In the light of the fact that adult sheep find it more difficult to recognize the inner structure of faces, rather than the face-outline, it would be interesting to investigate when sensitivity to the configuration of inner face features appears during development, in line with studies on human newborns (Turati et al. 2006). The present study represents the first attempt to investigate the presence of spontaneous face preferences in lambs, which would reveal sensitivity (either innate or facilitated by early and predisposed learning mechanisms) to the inner structure of faces. The aim of the present study was to assess the presence of early preferences for face or non-face stimuli in newborn lambs, in order to evaluate similarities with the social predispositions found in other species and to assess the ontogenetic development of social responses to faces in sheep. In order to do so we employed both schematic and photographic images of faces, comparable to those previously used with human babies and domestic chicks. Moreover, this is also the first study that ever tested face perception in lambs at a very early age: both in terms of age and in terms of visual experience, the lambs tested in the present study do not differ markedly from the human newborns that typically participate to developmental psychology experiments.

2. Materials and methods

Subjects and rearing conditions: Nine lambs (2 females, 7 males), aged 5.5 ± 3.32 days at the beginning of the experiment and belonging to the Padua University farm, were involved in this study. They were eight Foza lambs and one crossbred. They were housed with their dams in outdoor fenced group pens ($6\text{m} \times 4\text{m}$, maximum 6 adult sheep per pen), each consisting in a covered and an uncovered area. Food was distributed daily between 07:45 and 08:30 a.m., and consisted in hay and concentrated sheep food. Clean chopped straw was added twice a week to the bedding, whereas complete bedding removal and replacement with clean chopped straw was carried out once a month. The sheep were sheared once a year in May. The Foza breed is a traditional (and also unfortunately almost extinct) autochthonous sheep breed of the Veneto region (North East of Italy).

Stimuli and apparatus: Three pairs of stimuli were used (Figure 1). In each pair, one stimulus was a face-like display, whereas the other presented the same inner features displaced in unnatural positions:

1. Ewe face *versus* non-face stimulus with upside down inner features (both obtained from a colour photographic image of a Foza ewe's face unfamiliar to the test subjects);
2. Schematic face stimulus *versus* schematic non-face stimulus with upside down inner features;
3. Schematic face stimulus *versus* schematic non-face stimulus controlled for the up-down asymmetry in the distribution of features.

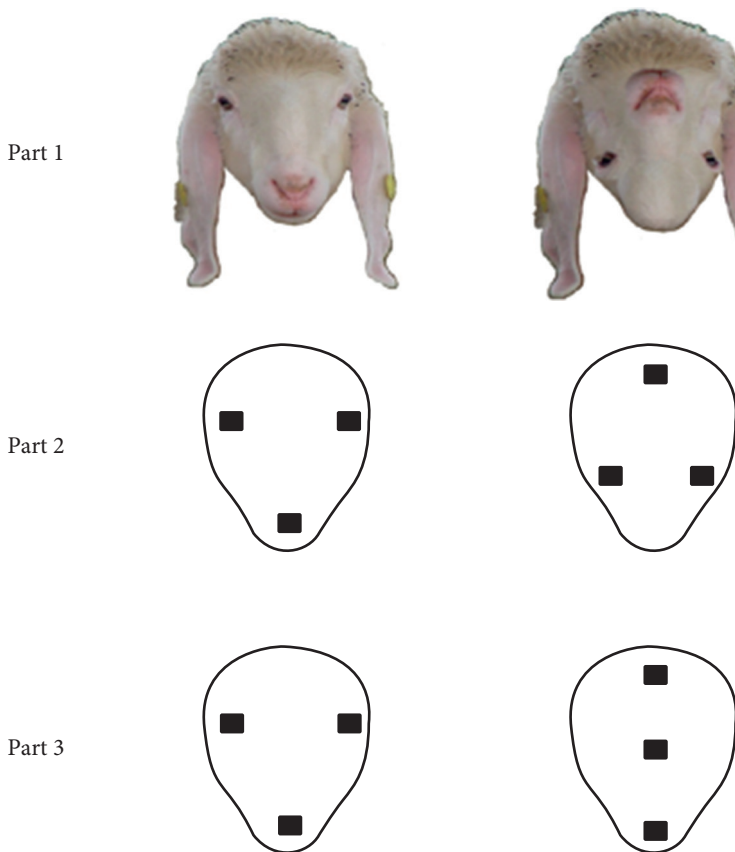


Figure 1. Pairs of stimuli used in the study: pair 1 = ewe face *versus* non-face stimulus with upside down inner features; pair 2 = schematic face stimulus *versus* non-face stimulus with upside down inner features; pair 3 = schematic face stimulus *versus* top-heavy non-face stimulus

It is worthwhile to point out that both the photographic stimuli in pair 1 presented the same and similarly oriented external facial features (i.e. face outline, hair, ears). In the non-face stimulus these external features conflicted in orientation with the upside-down configuration of inner features, whereas they were consistent with the inner configuration of features in the canonical ewe face stimulus (external features such as hair and ears were absent from the four schematic stimuli in pair 2 and 3).

The test apparatus was a 160 cm (length) 120 cm (width) 120 cm (height) pen with solid walls made of wood, covered with a heavy, black, plastic sheet. The stimuli were affixed on the inside surface of the short wall (which was covered by a rectangular screen of black, opaque, rigid plastic) at a distance of 33 cm one from the other. The lower edge of the stimuli was at about 30 cm from the ground. The pen was thus virtually divided in two halves (right and left), called choice sectors, corresponding to the two stimuli. The two photographic stimuli comprising pair 1 were about 38.5 cm high \times 26.5 cm wide (including the ears), roughly the same size as the face of an ewe of the same breed as the lambs. The schematic face-stimuli of pairs 2 and 3 were 28 \times 19.5 cm. The size difference between photographic and schematic stimuli was due to the presence of the ears, while the size of the proper face outline was comparable across the various configurations.

Procedure: Before each test trial, the lamb was separated from the mother for 60 seconds. Then, at the beginning of the trial, the lamb was placed in the centre of the test apparatus facing the stimuli.

The behaviour of each lamb toward each pair of stimuli was observed over a set of six 4-minute-long trials (two trials for each stimuli pair, the positions of the two stimuli were swapped in the two trials; the order of the six trials was randomized between subjects).

All the trials were videotaped for offline analysis by an observer unaware of the aims of the experiment. The measures collected in each trial were: the time (in seconds) the lamb spent looking at each of the two stimuli and the time the lamb spent in each of the two choice sectors.

For each pair of stimuli, we then calculated the ratio of time the lamb spent looking at the face stimulus over the total time spent looking at any of the two stimuli, according to the formula:

$$\frac{\text{Time spent looking at the face stimulus}}{\text{(time spent looking at the face + time spent looking at the non-face)}}$$

Moreover, we also calculated an index representing the time spent looking at each stimulus over the total test time. In this measure, the number of seconds spent by the subject looking at a given stimulus was divided by the total number of seconds in which the animal was clearly visible in the videotape during the two trials in

which that stimulus was presented. This measure allowed us to run comparisons between stimuli that were not presented in the same trial (i.e. stimuli belonging to different pairs).

The ratio of time spent in each choice sector was calculated according to the same formula described for the percentage of looking time.

2.1 Statistical analyses

The ratio of time spent near the face stimulus and the ratio of time spent looking at it were analysed using a one-sample t-test in order to check whether they differed from chance level (i.e. from the value of 0.5). In order to assess whether lambs' behaviour changed over test time, the value of these indexes in the first and the second trial were compared using paired-sample t-tests. However, only the data pertaining to eight lambs were compared over test times (due to technical failure in video recording, data from the first trial of one lamb were unavailable).

Also the index representing the overall time the lambs looked at stimuli that were not presented during the same trial were compared using paired t-test.

In all the tests alpha was set as = 0.05.

3. Results

On the whole the lambs spent from zero to 223 seconds in one of the two choice sectors, and from three to 83 seconds looking one stimulus during a single trial.

No significant effects could be detected in any dependent variable for comparisons involving the two pairs of schematic (i.e. non photographic) face stimuli (Figure 1, pair 2: time spent looking at the face $t_8 = -1.227$; $p = 0.225$; time spent near the face $t_8 = -1.120$, $p = 0.295$; pair 3, $t_8 = -0.440$, $p = 0.672$ $t_8 = -0.441$, $p = 0.692$). However, when stimuli obtained by photos of conspecifics (see Figure 1, pair 1) were used, the percentage of time spent looking at the face-like stimulus was significantly lower than chance level (i.e. lambs looked longer at the non-face stimulus with upside down inner features) ($t_8 = -2.449$, $p = 0.040$; mean 0.436; SEM 0.025) (the age of the lambs when tested with the stimuli of pair 1 was 8.4 days \pm 5.52 days; this differs from the age of the lambs at the beginning of the experiment because not all the lambs were tested with this pair of stimuli right at the beginning of the experiment). At the individual level, 7 out of 9 lambs spent less than 50% of testing time looking at the face stimulus of pair 1, whereas 2 subjects spent more than 50% of testing time looking at the face (however, one of the two spent only 51% of testing time looking at the face) (see Table 1 for individual data).

Table 1. Individual data are reported representing the ratio of time spent by each lamb looking at the face stimulus of Pair 1 (a score of 0 indicates that the subject observed only the non-face stimulus; a score of 0.5 indicates that an equal amount of time has been spent observing the two stimuli; a score of 1 indicates that the subject observed only the face stimulus)

Subject number	Ratio of time looking at the face
1	0.415
2	0.510
3	0.287
4	0.391
5	0.541
6	0.467
7	0.475
8	0.467
9	0.375

Lambs, hence, could tell the difference between the two stimuli obtained by photos of conspecifics, preferring the non-face stimulus. There was no significant difference in the percentage of time spent looking at the photographic face-like stimulus (and, conversely, in the percentage of time spent looking at the photographic non-face stimulus with upside down inner features) between the first and the second test trial ($t_7 = -1.09$, $p = 0.312$).

On the contrary, for this same pair of photographic stimuli (pair 1) the ratio of time spent in the two choice sectors was not significantly different from chance level ($t_8 = -1.022$, $p = 0.337$). The fact that lambs' preference for the non-face stimulus was evident only in the looking time, suggests that this could be a more sensitive measure for this kind of test. Future studies on newborn lambs' face perception and social preferences should thus concentrate on the analysis of this dependent variable.

When the overall ratio of time looking at stimuli not presented in the same trial was analysed, the lambs looked significantly more at the photographic non-face stimulus with upside down inner features than at each of the other stimuli ($t_8 = 3.478$, $p = 0.008$ for the non-face stimulus of pair 3; $t_8 = 2.478$, $p = 0.038$ for the non-face stimulus of pair 2; $t_8 = 3.328$, $p = 0.010$ and $t_8 = 2.671$, $p = 0.028$ for the face stimulus in pair 3 and 2 respectively).

It is interesting to note that we observed, in our data, non-significant trends that were remarkably consistent across stimuli and dependent variables, and which were in line with the significant preference demonstrated for the non-face-like

stimulus of pair 1. In fact, for pair 1, we observed a non-significant trend in favour of the non-face stimulus also for the dependent variable “ratio of time spent in the two choice sectors” (mean 0.47; SEM 0.03). Similar trends were observed also for pairs 2 and 3, both with regard to the time spent near the two configurations (pair 2 mean 0.44, SEM 0.04; pair 3 mean 0.47, SEM 0.06) and for the time spent looking at the configurations (pair 2 mean 0.47, SEM 0.02; pair 3 mean 0.49; SEM 0.02). Even though these trends are not significant nor strongly pronounced, they are remarkably consistent across stimuli and dependent variables.

4. Discussion

Contrary to our initial expectations based on previous evidence from other young vertebrates (Rosa-Salva et al. 2010; Sugita 2008), we did not observe any evidence of a spontaneous face preference. Rather, the young lambs tested in this study showed a preference for looking at the photographic non-face stimulus with upside down inner features, both in comparison to the photographic image of an un-manipulated ewe’s face and in comparison to schematic stimuli. One plausible explanation for this result is a preference for novelty, demonstrating that during the first week of life animals had learnt the normal configuration of face features (face structure) typical of conspecifics. It must be pointed out that the two stimuli composing pair 1 (i.e. photographic images of the manipulated and un-manipulated ewe face) were identical with regard to the face outline and to the shape of the inner features. The two images differed only in the spatial arrangement of such inner features. The more straightforward way to account for lambs’ preference is to assume that they encoded the first-order relations and the correct orientation of internal features defining canonical faces. Such an early learning would be consistent with the evidence available on human newborns’ capability to encode and retrieve various aspects of face images (Farroni et al. 2006, 2007; Leo & Simion 2009; Turati et al. 2006, 2007) and would point to the presence of predisposed learning/attentional mechanisms facilitating the processing of highly relevant social stimuli. The privileged processing of such stimuli is likely to be involved in successful social interaction. In human developmental literature it has long been debated whether newborn babies would be capable of overcoming the so called “externality effect”, which would lead them to pay attention only to the highly salient external face features, preventing babies from encoding the inner part of the face (e.g. Hainline 1978; Haith et al. 1977; Milewski 1976). Recent evidence on newborns’ face-processing abilities contributed to clarifying this issue (see above and see also Turati & Simion 2002). In fact, recent studies showed that the inner face features are perceptually available to human newborns, even though the outer

face features enjoy an advantage over the inner ones (Turati et al. 2006). The present study indicates that also week-old lambs are not impaired by any “externality effect” and are able to focus on the inner configuration of face features. In fact, both the stimuli forming pair 1 had identical external face outlines and differed only in the configuration of inner features. This is particularly remarkable considering that adult sheep prioritize outer face features over inner ones, even though their recognition performance can be based also on the configuration of inner features (Peirce et al. 2000).

It should be noted that, in the study by Peirce et al. (2000), adult sheep based recognition of unfamiliar conspecifics’ faces on the external features, processing the internal features only when discriminating among familiar individuals. This suggests that sensitivity to second order relations differentiating individual faces might only extend to the faces of well-known individuals. On the contrary, in the present study, newborn lambs reacted differently to stimuli obtained from unfamiliar sheep faces on the basis of a difference in orientation and position of the internal features (i.e. affecting also first order relations). Thus, lambs might be sensitive to the first order relations that define faces with respect to non-face objects, regardless of the familiarity with any individual face.

Lambs’ sensitivity to the inner configuration of face features did not extend to schematic face stimuli (such as those of pairs 2 and 3). Based on the available evidence it is not possible to determine the precise reason for this lack of preference between schematic face and non-face stimuli. A plausible hypothesis would be that the oversimplified appearance of schematic stimuli could have prevented lambs from recognizing the schematic configurations as faces. Given the importance of external face features in face recognition for adult sheep (Peirce et al. 2000), the absence of elements representing the ears could have been a crucial factor. However, the presence of trends in favour of the non-face stimulus in pairs 2 and 3, may suggest that lambs preferentially focus on the schematic non-face stimulus, even though this effect could be less pronounced than for pair 1. Thus, on the grounds that non-significant results should be interpreted with great caution, it is necessary to stress that the absence of significant preference for schematic stimuli cannot be the basis for firm conclusions.

An important consideration is that, when the outline and visual texture of the stimuli were naturalistic enough (as in pair 1), lambs revealed remarkable generalization abilities. In fact, images of pair 1 were obtained from the face of an unfamiliar individual. If lambs had simply memorized the appearance of the individual faces experienced in their social group, they should not have been particularly attracted by the non-face stimulus with respect to the face of an unfamiliar individual. In order to account for the preference observed in the present study, we must hypothesise that lambs formed a representation of the appearance

of faces *in general* and recognized that the non-face stimulus did not correspond to such a representation. An intriguing possibility raised by this consideration is that the ability to form a general representation of faces' appearance would emerge earlier in lambs' development than the ability to perform individual face recognition. In fact, lambs may not identify individual conspecifics on the basis of face appearance when younger than one month of life (Kendrick 1998). Based on this developmental pattern, it seems that, for newborn lambs, detecting the presence of faces in their visual field is a crucial ability, whose adaptive value early in life for guiding successful social interaction might be even higher than that of individual face recognition. Consistent with that, in human newborns and domestic chicks, a face detection mechanism (CONSPEC) is hypothesised to pre-exist and direct the action of a subsequent learning mechanism (CONLERN), which would support individual face recognition (Morton & Johnson 1991). We propose that, in the very first days of postnatal development, lambs' attention could be directed toward the general structure of conspecific faces, rather than to the identity of individual faces. This would result in learning of such a general face structure, as revealed by the novelty preference observed in the present study. Individual identity might be encoded in a subsequent stage of development (see Kendrick 1998), possibly on the basis of the general knowledge of face structure that is acquired in the first days of life.

In line with the idea that lambs' looking preference for the photographic non-face stimulus was not only driven by the mere detection of a visual pattern that had never been encountered before (i.e. by a "novelty effect" in its stricter meaning), is also the fact that the percentage of time spent looking at the non-face stimulus of pair 1 did not decrease the second time the lambs were exposed to it (i.e. during the second test trial). Moreover, the overall ratio of time the lambs looked at the photographic non-face stimulus with upside down inner features was significantly greater than the time they spent looking at the schematic non-face configurations of pairs 2 and 3, which could be considered novel stimuli as well. This is consistent with the fact that lambs not only recognized the non-face stimulus as "never encountered before", but also recognized it as an "impossible" face. This stimulus, in fact, represents a severe violation of the structure of a most salient part (the face) of the biological objects present in the environment experienced by the lambs. It is interesting to note that Porter & Bouissou (1999) found that 3–4 week-old lambs consistently responded with increased avoidance and reduced interest when exposed to a mosaic obtained from images of conspecifics, rather than to the image of an unfamiliar lamb or ewe and to the silhouette of an ewe, from which the mosaic was composed. It has also been shown (Regolin et al. 2011) that naive newly hatched chicks can differentiate two-dimensional representations of geometrically possible 3D objects from those of impossible ones, showing spontaneous

preferences towards the structurally possible ones. The above mentioned findings, together with those of the present study, suggest that very young animals having limited or no visual experience can detect when the structure of a visual stimulus presents violations of the fundamental principles and visual configurations that characterize the stimulus' category. In the study of Regolin et al. (2011) chicks proved to be able to detect violations in the spatial relations that define a possible physical object, whereas in the study of Porter & Bouissou (1999) 3–4 week-old lambs responded to gross violations to the possible structure of biological objects. In the present study we found that much younger lambs can recognize more subtle violations occurring in the inner structure of a face, even though the normal outline of the stimulus was preserved. In Porter & Bouissou (1999) and Regolin and co-Authors (2011) a preference for the "possible" stimuli was observed, whereas in the present study the lambs looked longer at the "impossible" non-face stimulus. This may be attributed to species or age differences. For instance, in dogs, a species in which the early developmental phases have been studied in detail, avoidance and approach tendencies vary with time during the socialisation phase of puppy development, resulting in puppies being more or less likely to approach a novel object depending on their age (Lindsay 2000).

In the study of Regolin and collaborators (2011) chicks were tested prior to any visual experience, proving that they are biologically predisposed to discriminate possible from impossible objects. In both the study of Porter & Bouissou (1999) and in the present work, there was not such a strict control of visual experience. Thus, the results obtained with lambs can be ascribed either to biological predispositions or to learning occurring during the first week of life. Future studies should be devoted to clarify this issue. In any case, the present work testifies an early sensitivity to facial structure, suggesting that the processing of faces is an important aspect of social interaction in this species, starting from the very early stages of postnatal development.

5. Conclusions

In the present study, 8-day-old lambs could differentiate the two stimuli obtained by photos of conspecifics (pair 1), looking longer at the non-face stimulus with upside down inner features. This is likely to reflect a novelty preference. We hypothesise that such novelty preference could be determined by the fact that the non-face stimulus violates the structural properties that define canonical faces.

The precise interpretation of these results in terms of the role of experience is still preliminary, until further experiments testing naive subjects (e.g. same age lambs deprived of experience and newborns) will be conducted. In particular, such studies

should try to disentangle the role of maturational vs. experiential factors, by independently manipulating chronological ages and visual exposure to various kinds of face-stimuli. Future studies are also required to clarify the role of different violations to face structure in lambs' looking behaviour. The present study tested only a restricted range of stimuli. Future research could overcome this limitation by testing a broader spectrum of configurations and by manipulating both internal and external face features of realistic (photographic) face stimuli. For example, this could be done by employing a photographic face stimulus in which both the external and the internal features are consistently upside down (i.e. a normal face presented upside down) and a stimulus with upside down external features and conflicting normally oriented inner features. Moreover, since one of the limitations of the present study is the difficulty in interpreting the absence of significant preference for schematic stimuli, future research could be devoted to developing and testing schematic face-like configurations presenting a more ecologically-valid outline (e.g. ear-like shapes).

Despite its partial limitations, to the best of our knowledge, the present study is the first demonstration that lambs as young as 8 days already recognise the general structural properties that define faces, even though they do not identify individual conspecifics on the basis of face appearance when younger than one month of life (Kendrick 1998).

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Authors' addresses

Orsola Rosa Salva (corresponding author)
CIMEC (Center for Mind/Brain Science),
University of Trento
corso Bettini 31, I-38068
Rovereto (TN)

orsola.rosasalva@unitn.it

Antonio Mollo
Dept. of Animal Medicine,
Production and Health
University of Padua
v.le dell'Università 16
Agripolis, Legnaro PD
Italy

antonio.mollo@unpd.it

Simona Normando
Dept. of Comparative Biomedicine and Food
Science, University of Padua, v.le
dell'Università 16 Agripolis,
Legnaro PD, Italy

simona.normando@unipd.it

Lucia Regolin
Dept. of General Psychology
University of Padua
via Venezia 8
35131 Padova
Italy

lucia.regolin@unipd.it

Author's biographical notes

Orsola Rosa Salva is a research fellow at the Center for Mind/Brain Sciences (CIMEC) at the University of Trento. **Simona Normando**, **Antonio Mollo** and **Lucia Regolin** are professors, respectively, at the Department of Comparative Biomedicine and Food Science, at the Department of Animal Medicine, Production and Health and at the Department of General Psychology of the University of Padua.