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**RELEVANCE OF VISUAL INFORMATION FOR THE ASSOCIATIVE
LEARNING IN DOGS**

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*To my husband, Gabriele,
and my beloved animals
for their constant support and unconditional love.
I love you all.*

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SUMMARY

Despite some experiments have been carried out to investigate dog's visual cognitive abilities and to study the mechanisms underlying how they promptly modify their behaviour while interacting with humans, it is still not clear to which features of the stimuli they mainly attend when solving a task. In addition to physical proprieties, there are different factors that modulate the saliency of a visual stimulus in dogs, such as the previous experience and training received.

To investigate whether during the associative learning some aspects of visual information have different salience during the associative learning and the role played by previous experiences, the project was developed around three independent studies.

The purpose of the first study was to assess the visual processing of global and local levels of hierarchical stimuli in domestic dogs. Fourteen dogs were trained to recognise a compound stimulus in a simultaneous conditioned discrimination procedure and were then tested for their local/global preference in a discrimination test. As a group, dogs showed a non-significant trend for global precedence, although large inter-individual variability was observed. Choices in the test were not affected by either dogs' sex or type of stimulus used for training. However, the less time a dog took to complete the training, the higher the probability that it chose the global level of test stimulus. Moreover, dogs which showed a clear preference for the global level in the test were significantly less likely to show positional responses during discrimination training.

These differences in the speed of acquisition and response patterns may reflect individual differences in the cognitive requirements during discrimination training. The individual variability in global/local precedence suggests that experience with using visual information may be more important than predisposition in determining global/local processing in dogs.

The second study, composed by two experiments, investigated the relevance of visual stimuli using more complex images: human face pictures. Dogs exhibit characteristic looking patterns when looking at human faces but little is known about what the underlying cognitive mechanisms are and how much these are influenced by individual experience. In Experiment 1, seven dogs were trained in a simultaneous discrimination procedure to assess whether they could discriminate a) the owner's face parts (eyes, nose or mouth) presented in isolation and b) whole faces where the same parts were covered. Dogs discriminated all the three parts of the owner's face presented in isolation, but needed fewer sessions to reach the learning criterion for the eyes than for both nose and mouth. Moreover, covering the eyes region significantly disrupted face discriminability compared to the whole face condition while such difference was not found when the nose or mouth was hidden. In Experiment 2, dogs were presented with manipulated images of the owner's face (inverted, blurred, scrambled, grey-scale) to test the relative contribution of part-based and configural processing in the discrimination of human faces. Furthermore, by comparing the dogs enrolled in the previous experiment and seven 'naïve' dogs we examined if the relative contribution of part-based and configural processing was affected by dogs' experience with the face stimuli. Naïve dogs discriminated the owner only when configural information was provided, whereas expert dogs could discriminate the owner also when part-based

processing was necessary. The present study provides the first evidence that dogs can discriminate isolated internal features of a human face and corroborate previous reports of salience of the eyes region for human face processing. Although the reliance on part-perception may be increased by specific experience, our findings suggest that human face discrimination by dogs relies mainly on configural rather than on part-based elaboration.

For a more applied comprehension of the phenomenon and to understand what happens in a more natural situation, the third study explored the characteristic of dog's attention to natural visual stimuli (humans) during a training session in which different type of exercises and levels of difficulty were requested. Moreover, the quality and quantity of training dogs had received during their lives was taken into account to investigate a possible influence on their attention to humans. As in the second study, the specific effect of training emerged also in the third. Having received a specific training modified dogs' attention towards the caregiver. The variation of attention pattern did not emerge in a baseline condition but only when the caregiver asked the dog to perform some obedience exercises evidencing that the training had a very context-related effect.

In conclusion, dogs seem to acquire more quickly and spontaneously global/configural information of a visual stimulus and when an effect of previous experience such as training is present, this effect is specific and strictly context-related.

RIASSUNTO

Nonostante alcuni esperimenti abbiano indagato quali siano le abilità cognitive visive del cane ed esplorato i meccanismi alla base della sua prontezza nell'adeguare il comportamento durante l'interazione con l'uomo, non è ancora chiaro a quali caratteristiche degli stimoli visivi i cani prestino maggiore attenzione mentre risolvono un compito. Oltre alle proprietà fisiche, sono molti i fattori che possono modulare la salienza di uno stimolo visivo, come per esempio l'esperienza pregressa e l'addestramento ricevuto.

Il presente progetto è stato sviluppato su tre studi indipendenti, al fine di studiare quali aspetti dell'informazione visiva abbiano maggior rilevanza durante l'apprendimento associativo e quale ruolo giochi l'addestramento.

Il primo studio ha esplorato le caratteristiche della processazione (globale e locale) di stimoli geometrici gerarchici nel cane domestico. Quattordici cani sono stati addestrati a distinguere uno stimolo composto, applicando una procedura di discriminazione simultanea condizionata e la loro preferenza per il livello locale/globale è stata verificata con un test di discriminazione visiva. Il gruppo di cani ha dimostrato una tendenza non significativa per la precedenza globale, sebbene sia stata riscontrata un'ampia variabilità individuale. Le scelte eseguite durante il test non sono state influenzate né dal genere dei cani, né dal tipo di stimolo usato durante l'apprendimento. Tuttavia, minore era il tempo impiegato per completare la fase di apprendimento,

maggiore era la probabilità che il cane scegliesse il livello globale dello stimolo visivo durante il test. Inoltre, i cani che hanno dimostrato una preferenza per il livello globale dello stimolo visivo durante il test hanno manifestato, con minor probabilità, risposte posizionali durante l'apprendimento. Queste differenze, emerse sia nella velocità di apprendimento della procedura che negli schemi di risposta durante il test, potrebbero rispecchiare l'esistenza di prerequisiti cognitivi diversi tra i soggetti. La variabilità individuale, riscontrata nella precedenza globale/locale di processazione, suggerisce che l'esperienza nell'uso delle informazioni visive potrebbe essere più importante della predisposizione nel determinare quale sia la tipologia di processazione (globale/locale) usata dai cani.

Il secondo studio, composto da due esperimenti, ha indagato quale sia la rilevanza degli stimoli visivi utilizzando immagini più complesse, ossia fotografie di volti umani. I cani esibiscono schemi di attenzione caratteristici quando guardano i volti umani, però si conosce poco dei meccanismi cognitivi sottostanti e quanto questi siano influenzati dall'esperienza individuale. Nel primo esperimento, sette cani sono stati addestrati applicando una procedura di discriminazione simultanea per verificare che fossero in grado di discriminare: a) le parti del volto del proprietario (occhi, naso o bocca) presentate singolarmente; b) le facce intere dove le stesse parti erano state coperte. I cani sono riusciti a discriminare tutte e tre le parti della faccia del proprietario presentate singolarmente, ma, per gli occhi, hanno avuto bisogno di un minor numero di sessioni per raggiungere il criterio di apprendimento stabilito rispetto a naso e bocca. Inoltre, la discriminabilità dei visi è stata inficiata di più quando la regione degli occhi non era visibile, che non quando erano nascosti naso o bocca. Nel secondo esperimento, per testare il contributo relativo della processazione basata sulle parti o sulla

configurazione nella discriminazione di facce umane, sono state usate delle immagini del viso del proprietario manipolate in diversi modi (invertite, sfuocate, 'scrambled' - ossia suddivise in parti e riarrangiate in modo casuale - e in scala di grigi). Inoltre, confrontando i sette cani coinvolti nel primo esperimento con sette cani 'naïve' è stato esaminato se il contributo relativo della processazione basata sulle parti o sulla configurazione sia stato influenzato dall'esperienza che hanno avuto i cani con gli stimoli raffiguranti le facce. I cani *naïve* sono riusciti a discriminare il proprietario solo quando l'informazione configurazionale era conservata, mentre i cani esperti sono riusciti a discriminare il proprietario anche quando era necessario processare le immagini basandosi sulle parti. Questo studio prova, per la prima volta, che i cani riescono a discriminare gli elementi interni di un viso umano presentati singolarmente e conferma la salienza della regione degli occhi per la processazione di facce umane. Sebbene un'esperienza specifica possa incrementare la capacità di basarsi sulla percezione delle parti, i risultati suggeriscono che, nel cane, la discriminazione di volti umani si basa principalmente sull'elaborazione della configurazione che delle parti.

Per una comprensione più applicata del fenomeno e per capire cosa succede in un contesto più naturale, il terzo studio ha esplorato le caratteristiche dell'attenzione del cane a stimoli naturali (uomo) durante una sessione di addestramento, in cui era richiesta l'esecuzione di esercizi di diverso tipo e difficoltà. Inoltre, sono state prese in considerazione la quantità e la qualità di addestramento ricevuto nel corso della vita dei soggetti per indagare la loro eventuale influenza sulle caratteristiche dell'attenzione prestata all'uomo. Come emerso anche nel secondo studio, è stato riscontrato un effetto specifico dell'addestramento. Aver ricevuto un addestramento specifico influenza l'attenzione prestata dai cani al proprietario. L'attenzione non è variata, infatti, in una

condizione di base, ma solo quando il conduttore ha chiesto al cane di eseguire alcuni esercizi di obbedienza, mettendo in luce che l'addestramento ha avuto un effetto contesto-specifico.

Per concludere, dai risultati ottenuti nel corso dei tre esperimenti del progetto, sembra che i cani acquisiscano più velocemente e spontaneamente le informazioni visive globali e configurazionali. Quando è presente un effetto dell'addestramento, questo è specifico e strettamente legato al contesto.

CHAPTER 1

General introduction

Dogs have been selected to live in human environment (Topál et al. 2009) and have showed unique ability to cooperate with humans thanks to their readiness to receive communicative signals from them. They look towards humans in communicative context (Kubinyi et al. 2007), respond to human cues (Hare et al. 2002; Udell et al. 2008; Kaminski et al. 2012), understand a threatening vs a friendly approach (Vas et al. 2005), respond to human play signals (Rooney et al. 2000) understand particular human gestures like pointing (Hare et al. 2002) or follow human eye/head direction (e.g. Soproni et al. 2001), know when a human communication is intended for them (Kaminski et al. 2012), utilize signals toward humans in order to carry out their own goals (Miklósi et al. 2003) and learn from humans (Topál et al. 2006; Huber et al. 2009; Range et al. 2011).

To investigate dog's visual cognitive abilities and study the mechanisms underlying how they promptly modify their behaviour while interacting with humans, many experiments were carried out, demonstrating that dogs are able to solve a lot of visual tasks concerning a variety of stimuli: discriminate between black/white stimuli (Araujo et al. 2004; Frank 2011), between object that differ only in size (Milgram 2003; Tapp et al. 2003), categorize natural visual stimuli (Range et al. 2008), carry out inferential reasoning by exclusion (Aust et al. 2008), and, based only on visual images of heads,

discriminate species (Autier-Dérian et al. 2013) and their owner from an unfamiliar person (Huber et al. 2013).

However, it is still not clear which features of the stimuli used in those studies are more crucial for dogs and to which they mainly attend when solving a task. In natural situations visual processing leads to select which parts of the stimuli are to be perceived, attended to and processed. Therefore some features of a visual stimulus could gain higher attention than others. For instance, humans looking at hierarchical stimuli process the global configuration prior to the local details (e.g. Navon 1977) and different patterns have been noticed in other species (e.g. Hopkins and Washburn 2002; De Lillo et al. 2005; Truppa et al. 2010). Little is known about dogs, they focus more on the eye area when looking at human face pictures (Somppi et al. 2014), attend to the head to use information about the persons' movements and to maintain attention toward the owner (Mongillo et al. 2010), and mainly rely on the external part of the head while discriminating their owner's face picture (Huber et al. 2013).

In addition, there are different factors that modulate the saliency of a visual stimulus in dogs. First, the cues a person is giving: there is an effect of ostensive cues (e.g. Pongrácz et al. 2004; Lit et al. 2011) on dogs' gaze towards their handler, since they may turn him into salient stimulus for the dog. Second, the training received by dogs during their life: it can increase dog attention towards human demonstrator (Range et al. 2009a) or decrease it when dogs are trying to find the solution in problem solving tasks (Marshall-Pescini et al. 2008). Third, the relationship between the dog and the handler: while observing human actions, attention seems to be greater when the familiar person observed is also the main caregiver, that is a person that shares with it the greatest part of the daily activities (Horn et al. 2013).

To investigate whether some aspects of visual information have different salience

during the associative learning and the role played by previous experiences, the project was developed around three independent studies. In the first, dogs were trained to discriminate simple geometrical pictures and the visual processing of global and local levels of hierarchical stimuli was assessed. In the second study dogs discriminated more complex pictures, representing photographs of human faces. The aim was to investigate whether some face parts could be more relevant for face processing, the relative contribution of part-based and configural processing in the discrimination of human faces and the influence of specific training on the reliance on such mechanisms. For a more applied comprehension of the phenomenon and to understand what happens in a more natural situation, the third study explored the characteristic of dog's attention to natural visual stimuli (humans) during a training session in which different type of exercises and levels of difficulty were requested. Finally, the quality and quantity of training dogs had received during their lives was taken into account to investigate a possible influence on their attention to humans.

CHAPTER 2

Hierarchical stimulus processing by dogs (*Canis familiaris*)

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2.1 Introduction

In most natural situations, the task of visual processing is that of accounting for a given input, but it is also that of selecting which parts of such an input are to be perceived, attended to and processed. Since Navon's first experiments (Navon 1977), a central issue in humans' visual perception has been hierarchical processing of wholes and their component parts. Evidence supporting the hypothesis that humans tend to process first the global form of hierarchical visual patterns has been reported in several studies (Kinchal and Wolf 1979; Lamb et al. 1990; Kimchi 1992; Kimchi 1998; see also Wagemans et al. 2012, for a recent review on conceptual and theoretical foundations). This global precedence in processing images is viewed as a flexible, economical mechanism, probably emerging in humans during the evolution of visual cognition.

Accordingly, other conditions being constant, non-human primates show a greater tendency to local precedence: this is evident in monkeys (Fagot and Deruelle 1997; Deruelle and Fagot 1998; Hopking and Washburn 2002; Spinozzi et al. 2003; De Lillo et al. 2005; Spinozzi et al. 2006) more than in apes (Fagot and Tomonaga 1999; Hopkins and Washburn 2002). Comparative studies in other species have been conducted in pigeons (Fremouw et al. 1998; Cavoto and Cook 2001; Fremouw et al. 2002; Goto et al. 2004) and fishes (Truppa et al. 2010) although, to the best of our knowledge, the phenomenon has never been studied in mammals other than primates.

Within the same species, the relative efficacy of global and local processing can be modulated by varying the experimental procedure (i.e., duration of stimulus presentation, size of global form, size and density of local element, primed allocation of attention at one particular level).

The effect of individual characteristics on global/local precedence is also well documented in humans.

Greater local than global bias has been reported in women (Roalf et al. 2006), children and adolescents (e.g., Sherf et al. 2009), the elderly (e.g., Lux et al. 2008) and in people with neurological disorders. However, the role of individual characteristics on global/local precedence has not yet been studied in animals. Notably, the domestic dog has been proposed as a valuable animal model for Alzheimer's Disease (Adams et al. 2000) an Attention Deficit Hyperactivity Disorder (ADHD; Hejjas et al. 2007), two conditions affecting global precedence in humans (Slavin et al. 2002; Song and Hakoda 2012). In this respect, analysis of the relative readiness to process global/local aspects in healthy adult dogs is necessary for future studies in dogs affected by such disorders.

Given its history of domestication, the dog is a good candidate for comparative studies on visual cognition. A substantial body of literature shows that dogs can use visual information to engage communicative processes with humans (e.g., Hare et al. 2002; Miklósi 2007; Topál et al. 2009; Horn et al. 2012; Buttelmann and Tomasello 2013). In this context, analysis of visual signals must prevail over the sensory modalities, since olfactory communication is limited in humans and human auditory signals are mainly semantic and need specific learning by dogs. The sophisticated interspecific social skills of dogs are thought to be a case of convergent evolution with humans (see Miklósi and Topál 2013, for a recent review). If this is so, a global advantage in processing visual information may have emerged in dogs.

To date, our knowledge about canine vision mainly concerns dogs' ability to detect light, colours and motion (Miller and Murphy 1995; Murphy et al. 1997; Pretterer et al. 2004); very little is known about their higher-order processing of visual information. Most data on visual cognition in dogs come from behavioural experiments on bi-dimensional images. Although little is known about dogs' ability to perceive elementary shapes (Miller and Murphy 1995), there is an increasing number of studies on their

use/inspection of 2-dimensional images representing social stimuli in particular faces. Dogs extract important features from such images, since they can associate visual and auditory information (i.e., the picture and the voice of their owner; Adachi et al. 2007), differentiate individual facial cues of dogs and humans (Racca et al. 2010; Huber et al. 2013), identify various emotional states of the same person (Nagasawa et al. 2011) and use life-sized images of pointing humans to solve simple communication tasks (Pongráz et al. 2003). More impressively, Range et al. (2008) trained dogs to classify natural visual stimuli (dog/landscape pictures) according to a perceptual response rule. The spontaneous 2-dimensional image discrimination ability of dogs has been tested with a novelty preference paradigm (Racca et al. 2010) and contact-free eye movement tracking (Somppi et al. 2012). Dogs inspect images by focusing on the informative regions of a figure (Somppi et al. 2012) and their gaze behaviour varies according to the type of image (Guo et al. 2009; Racca et al. 2010; 2012; Somppi et al. 2012). It has also recently been observed that reducing the informational richness of visual stimuli decreases dogs' discriminative ability when they are presented with pictures of human heads (Huber et al. 2013). Interestingly, in that study only 20% of the dogs were able to discriminate between a picture of their owner and that of another familiar person, when the internal parts of the face were presented instead of the full head. The above authors argued either that dogs use global features to discriminate human faces, or that they receive little help from internal facial features. Overall, these findings indicate that parts of an image or their position may be important factors in dogs' spontaneous allocation of visual-spatial attention and visual discriminative ability. Although other mechanisms may be involved, the spontaneous allocation of attention to a particular level of a stimulus seems to be a key factor in explaining differences in global/local processing (De Lillo et al. 2011).

The purpose of the present study was to assess the visual processing of global and local dimensions of hierarchical stimuli in domestic dogs. In the absence of previous studies on dogs, our experimental procedure was adapted from that of studies on other non-human animals. Since comparative studies typically use stimuli with global shapes formed by the spatial arrangement of small local shapes, similar Navon-type stimuli were used in our experiments. We first trained dogs to discriminate a compound stimulus characterized by a clear-cut two-level hierarchy and then tested them for their local/global preference in a visual discrimination test. As a further control on dogs' ability to extract information from local shapes, in the last phase of the procedure the dogs were re-trained to discriminate between two stimuli differing only at local level.

2.2 Methods

2.2.1 Subjects

Dogs' characteristics which are known to affect global/local precedence in humans (i.e., age, sex and health status) were carefully checked for the present study. The sample was composed of 14 adult family dogs 4.4 ± 2.2 years old and balanced for gender; Table 2.1 lists their characteristics. All dogs were recruited from University of Padova students and employees, who took part in this study on a voluntary basis. Prior to inclusion, the dogs underwent physical and behavioural veterinary examinations, to exclude overt medical conditions, which might have influenced the study negatively.

Table 2.1 Characteristics of dogs and S+ assigned to each dog

Name	Sex	Age (years)	Breed	Size (cm)	S+
Amy	F	2	Golden Retriever	55	X
Kim	F	3	Crossbreed	60	O
Lana	F	2	Crossbreed	56	X
Molly	F	3	Crossbreed	42	X
Stasi	F	6	Crossbreed	40	O
Unca	F	2	German Shepherd	55	O
Spigola	F	8	Crossbreed	40	O
Ares	M	2	Crossbreed	62	X
Charlie	M	6	West Highland White Terrier	38	O
Cuzco	M	3	Border Collie	60	X
Kobe	M	7	Beagle	41	O
Oliver	M	5	Crossbreed	45	X
Rey	M	6	Border Collie	57	X
Rino	M	7	Cocker Spaniel	43	O

F = female, M = male; size is expressed as height at the withers; X = S+ presented in Fig. 2.2A, O = S+ presented in Fig. 2.2B

2.2.2 Experimental setting

The test apparatus (Fig. 2.1) consisted of a rectangular wooden panel (140 x 150 cm) with two symmetrical vertical metallic tracks mounted on it at 14 cm from the side edges. Rectangular folders (35 x 23 cm) made of two overlapping transparent acrylic panels and containing the visual stimuli, were made to slide along the tracks. To allow the dogs to see and touch the stimuli properly, the height of presentation was adjusted

for each animal, so that the centre of the stimulus was level with the dog's eyes.

A dog mattress was placed at a distance of 130 cm from the apparatus, a chair for the experimenter was placed beside the mattress, and a plastic bowl, used as a reward zone, was placed 100 cm behind the mattress.

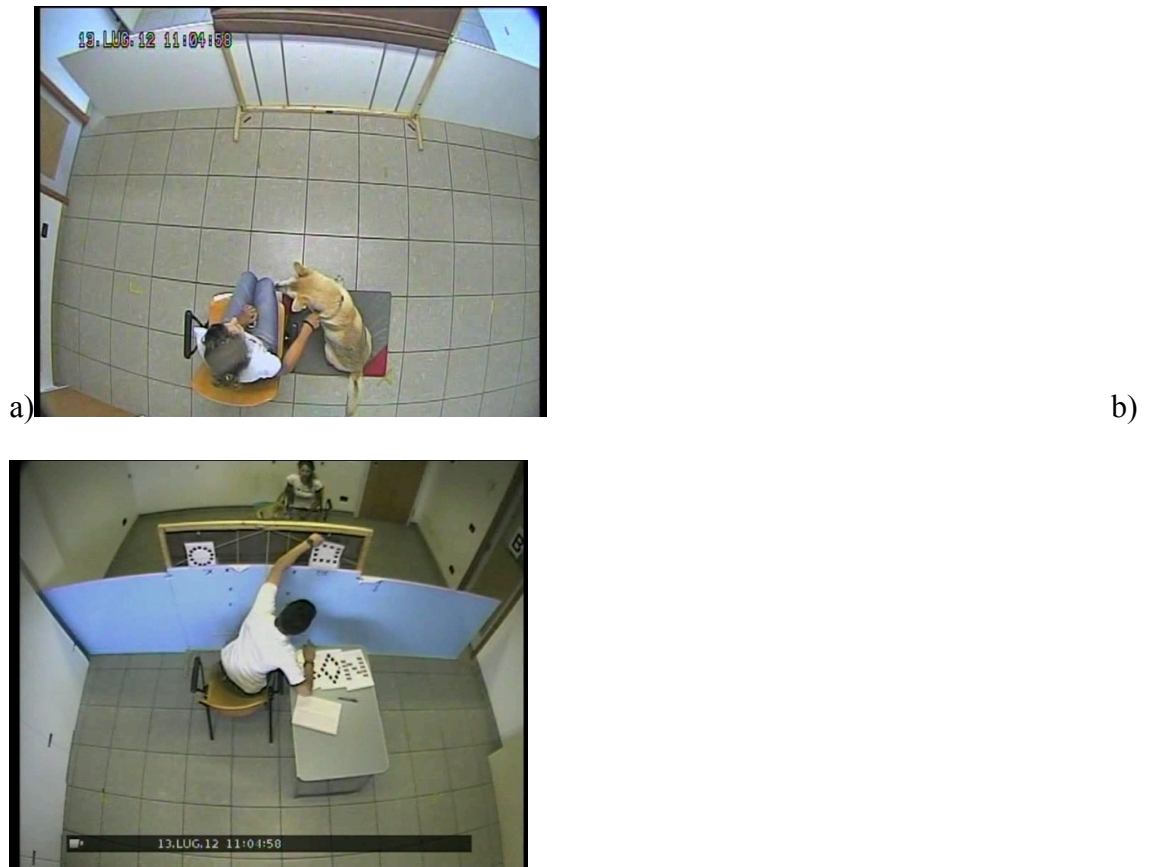


Fig. 2.1 Video stills: (a) front part of apparatus during presentation of two stimuli in discrimination phase; dog is gently restrained by operator in starting position; (b) back of apparatus during inter-trial interval, with operator preparing stimuli for next trial.

The experimental stimuli were 2-dimensional hierarchical compound images (Fig. 2.2), composed of 13 identical figures (local elements) spatially arranged to form one larger figure (global element). The density of local shapes within a stimulus was similar to that used for primates (Fagot and Tomonaga 1999; Spinozzi et al. 2003). The size of the

shapes was established according to current knowledge of canine visual acuity (Miller and Murphy 1995; Murohy et al. 1997). Depending on the experimental phase (see below), the stimuli could be either consistent (Fig. 2.2A, 2.2B, 2.2C) or inconsistent (Fig. 2.2D, 2.2E, 2.2F) between their global and local elements. The stimuli were printed in black ink on white A4 sheets of paper, the total black area being identical across all stimuli (87.50 cm²). Stimuli were created with Adobe® Illustrator® CS4 (14.0.0, © Adobe Systems Inc. 1987-2008).

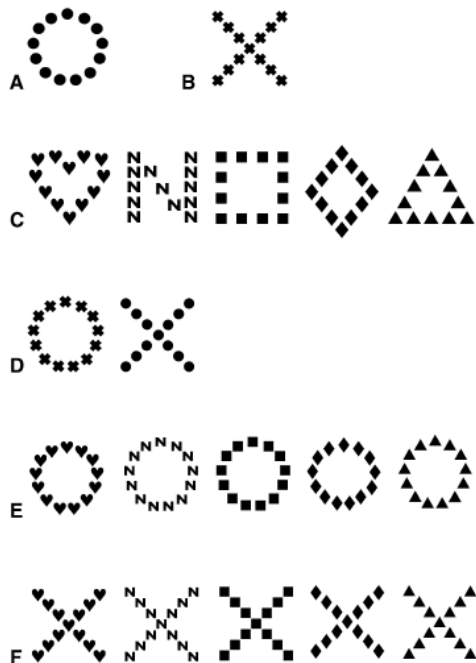


Fig. 2.2 Representations of stimuli used in various training and test phases. A or B = S+ used throughout study; C = set of S- used in consistent training; D = stimuli used in test trials; E = set of S- used in local training for dogs trained with A; F = set of S- used in local training for dogs trained with B.

2.2.3 Experimental procedure

The experiment consisted of a pre-training phase, a consistent training phase, the test, and a local training phase. The dogs underwent sessions of 20 (pre-training and training phases) or 25 (test) trials, for a maximum of four sessions per day, with inter-session intervals of at least 30 minutes. On average, the dogs were involved in the experiment for 4.2 ± 0.9 days a week.

One operator sat behind the apparatus, unseen by the dog, and controlled the presentation of the stimuli. The experimenter sat on the chair and handled the dog. At the beginning of each trial, the dog was told to sit on the mattress and was gently restrained by its collar by the experimenter. When the dog was sitting and visually oriented towards the apparatus, the experimenter said “Ok!” and the two stimuli were presented. To avoid any unintentional influence on the dog’s choice, the experimenter closed his eyes, waited three seconds, and then told the dog to “Go!” and released it. If the dog approached and touched the positive stimulus (S+), the experimenter actuated a click and rewarded the dog, while the stimuli were removed. If the dog touched the negative (S-) stimulus (or the empty folder in the pre-training phase), the experimenter said “Up!”, the stimuli were removed, and the dog was called back to the starting position for the next trial. If the dog did not approach the stimuli within 60 seconds, or moved away from the apparatus, the stimuli were removed, the dog was called back to the starting position (if it had moved) and the trial was repeated.

The learning criterion to complete one phase successfully and proceed to the next one was set at 85% correct choices in three consecutive sessions (i.e., 51 correct trials out of the last 60).

In each training session, the side of presentation of S+ was semi-randomised, with the constraint that it could not be presented on the same side for more than three consecutive trials and that right/left presentations were balanced within the session.

2.2.4 Pre-training

The dogs were first conditioned to approach and touch with the snout a single stimulus which was leaning on a wall after hearing the “Go!” signal. One out of two possible S+ was chosen (Fig. 2.2A and 2.2B) (see Table 2.1). The literature shows that global or

local information bias can be altered by varying the features of the stimulus, such as the spatial arrangement pattern of its elements (e.g., Kimchi 1992). To reduce the possibility of biased results due to the particular aspect of a given pattern, two positive stimuli were used, with very distinctive distribution of local elements around the centre of the image, i.e., a cross and a circle. Once the dogs had learnt to touch the stimulus reliably and without hesitation when the “Go!” signal was given, standardised sessions of 20 trials were begun, as described in the general procedure. Only S+ was presented in these trials; the folder on the opposite side was empty. When the dogs had achieved the learning criterion, they were admitted to the next phase.

2.2.5 Consistent training

The dogs were trained to recognise a consistent stimulus (S+) in a simultaneous conditioned discrimination procedure. Sessions involved 20 trials, during which the consistent S+ and one of the five consistent S- were presented, as described above. For any given dog, the S+ was the same as that used in the pre-training phase; the set of S- was the same for all dogs (Fig. 2.2C) and each of the S- of the set was presented four times within the session. Upon reaching the learning criterion, the dogs moved on to the next phase.

2.2.6 Test

The dogs underwent sessions of 25 trials each, 20 of which were identical to those described in the consistent training phase. They had to maintain the 85% correct responses criterion in the trials; otherwise they had to repeat the previous training phase. The remaining five trials were tests, presented once every five trials, starting from trial nine. In the test trials, the dogs were presented with two inconsistent test

stimuli (Fig. 2.2D), of which one (G) showed the same global element as S+ and local elements never seen before. Conversely, the other stimulus (L) was composed of the same local elements as S+, forming a global element never seen before. The dogs were always rewarded in the test trials, regardless of their choice. Four test sessions were performed, for a total of 20 trials. Right/left presentations of G and L were balanced within trials.

2.2.7 Local training

This phase was performed after the test phase, to ascertain that the dogs were able to use the local elements of the compound forms to discriminate between stimuli and ensuring that their choices in the test trials were not affected by any inability to perceive the local elements.

The procedure was identical to that of the consistent training phase, with the exception that S- (Fig. 2.2E or 2.2F) differed from S+ only at local level.

2.2.8 Data collection and statistical analysis

All experimental phases were video-recorded by CCTV (WV-GP250, Panasonic, Osaka, Japan) for subsequent data collection.

Data on the duration of sessions and response latency (time between the dog's release and its choice of stimulus) were extracted from videos with The Observer^{®XT} software (Noldus Information Technology, The Netherlands). In each training session, mean latency was calculated as the mean of data of trials 1, 10 and 20, and the number of S+, S-, and left and right choices was collected. For the test phase, mean latency was measured as the mean of all 20 test trials, and the side and type (G or L) of the test stimulus chosen in each trial were recorded.

To assess whether the use of different S+ affected the speed of learning in the consistent training, an independent samples Student's t-test was used to compare the number of sessions needed to reach the learning criterion between the two groups of dogs that used a different S+.

To assess whether an overall prevalence for G or L was present in our sample, we performed a right-tailed Student's t test on the dogs means for the type of choice (0 = L, 1 = G) expressed in the 20 test trials, testing the null hypothesis H_0 that the mean was equal to or lower than 0.5. Also, we computed the probability that the true mean for the type of choice was in the range between 0.501 and $+\infty$. A binary logistic regression model (Allison 2001) was then used to analyse whether the logit of choices for G in the test phase was significantly affected by factors such as dogs' sex, side of presentation of G, type of S+ used, and speed of learning in consistent training. The dependent variable was a dichotomous categorical variable (1 = choice of G; 0 = choice of L); explanatory variables were dogs' sex (female/male), side of presentation of G in each test trial (left/right), type of S+ used (X/O) and number of sessions required to reach the learning criterion in the training phase. The dog's identification number was added to the model as a random effect.

All statistical analyses were performed with Statistical Analysis System software (SAS Institute Inc. SAS/STAT® 9.2 User's Guide, Cary, NC: SAS Institute Inc., 2008). Statistical significance was set at 5% for all tests.

2.3 Results

Sessions lasted on average 7.6 ± 2.4 min in the training phases and 8.4 ± 1.9 min in the test phase.

The dogs showed a great degree of variability in the speed of acquisition of the task in the consistent training phase. The number of sessions needed to reach the learning criterion in this phase ranged from 5 to 36, average 16.7 ± 10.4 . No difference was detected in the number of sessions needed to reach the learning criterion between the two groups of dogs, which used different S+ ($t_{12} = -0.977$, $P = 0.348$). The average response latency in the trials of this phase was 4.0 ± 2.8 s.

In the test phase, all the dogs maintained the learning criterion of 85% correct responses. The average response latency of test trials was 9.9 ± 22.2 s. As a group, dogs chose the G test stimulus 164 times vs. 116 choices for the L test stimulus; a right-tailed t-test could not reject, at a level of significance $P < 0.05$, the null hypothesis that the mean of choices expressed by dogs in the 20 test trials was less than or equal to 0.5 ($t_{13} = 1.25$, $P = 0.11$). The probability that the true mean for the type of choice was greater than 0.5 was 81%, suggesting that a tendency towards a global precedence may exist. The binary logistic regression model indicated that choices in the test phase were not affected by dogs' sex, side of presentation of G or type of S+ used for consistent training. A significant effect was detected for speed of acquisition of the consistent training; specifically, a lower number of sessions to reach the learning criterion was associated with a higher probability of choosing G in the test trials (Table 2.2).

Table 2.2 Results of the binary logistic regression model showing the effect of dogs' sex, side of presentation of G, type of S+ used and number of sessions to reach the criterion in the consistent training on G choices in test trials.

Effect	Levels	G choices (mean ± SD)	OR	90% CI	P
Sex	Male	12.7 ± 5.2	0.606	0.178-2.067	0.501
	Female	10.7 ± 5.9			
Side of G presentation	Right	5.8 ± 3.0	0.927	0.588-1.461	0.783
	Left	5.9 ± 3.3			
Type of S+	O	11.7 ± 4.6	0.580	0.169-1.995	0.468
	X	11.7 ± 6.7			
Number of sessions to criterion	None (continuous predictor)		0.924	0.876-0.976	0.017

G = test stimulus featuring the same global element as S+, OR = odds ratio, CI = confidence interval, X = S+ presented in Fig. 2.2A, O = S+ presented in Fig. 2.2B

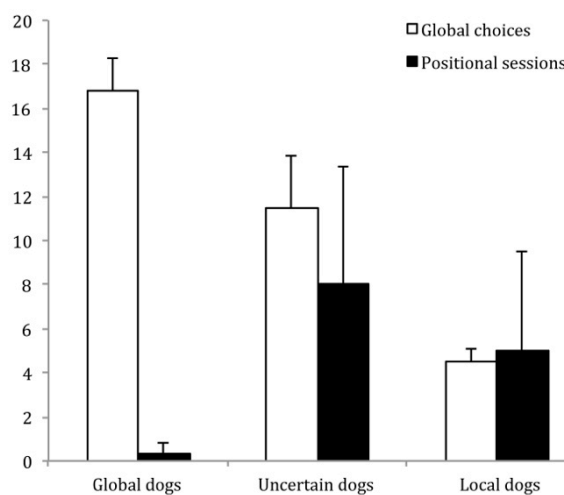
Considered individually, six dogs chose G significantly above chance level (i.e., 15 or more global choices, two-tailed $P < 0.05$, binomial test), four chose L significantly above chance (15 or more local choices), and the remaining four did not show any significant preference. Accordingly, they were classified as 'global', 'local' or 'uncertain' dogs respectively.

A binary logistic model was then used to examine whether global, local and uncertain dogs had used a positional response modality in the training phase. The dependent variable of the model was a dichotomous categorical variable, which identified each

consistent training session as positional (i.e., the dog showed 15 or more same-side responses in the 20 trials) or non-positional. The predictor was the dog's classification based on test choices (global, local, uncertain).

The analysis revealed the significant effect of the predictor in the dogs' likelihood of showing positional sessions in consistent training ($F_{2,234} = 9.25$, $P < 0.001$).

Specifically, global dogs were less likely to show positional sessions than both uncertain dogs (odds ratio: 9.12, 95% confidence interval: 4.5-91.5) (Fig.2.3).



choices in test and positional sessions (15 or more same-side responses during 20 trials) in consistent training performed by dogs which showed 15 or more global choices in test trials (global dogs), 15 or more local choices in test trials (local dogs) or fewer than 15 global or local choices (uncertain dogs).

Fig. 2.3 Mean number (\pm SD) of global

Lastly, all dogs reached the learning criterion in local training (average 5.7 ± 3.0 sessions), demonstrating that choices in the test phase were not influenced by their incapacity to perceive or discriminate stimuli, which differed only at local level. Response latency in this phase was on average 3.7 ± 2.7 s.

2.4 Discussion

We studied global or local precedence in processing hierarchical visual stimuli in dogs. The dogs were initially trained in a simultaneous conditioned discrimination procedure to recognise a stimulus made of several local elements arranged to form a larger global figure. In a subsequent test, they showed inter-individual variability in responses, although a non-significant trend to prefer the stimulus containing the reinforced global element emerged. All the animals could then easily rely on local elements, when required to do so in local discrimination training, indicating that the results of the global/local test were not due to their inability to perceive local elements.

In this study, we found no effect of type of training stimulus on the likelihood that our subjects would choose the global or local stimulus in the test phase. In a similar study, Truppa et al. (2010) found no evidence that stimuli like those we used had an effect on global/local precedence in redbtail spiltfin fish (*Xenotoca eiseni*).

We found no evidence of the effect of sex on the likelihood of choosing the global or local level of a learned stimulus. To the best of our knowledge, the effect of sex on global/local precedence has not been investigated in non-human animals, and even in humans there are few direct examinations of gender differences (Roalf et al. 2006; Müller-Oehring et al. 2007; Kimchi et al. 2009). Although it is suggested that gender differences may arise depending on the nature of the task and its visual context, Kimchi et al. (2009) showed that, generally, men and women do not differ in global and local processing. Our results indicate that this may also be the case in dogs.

Despite a trend towards a general global advantage in processing hierarchical visual stimuli, our results were characterised by wide inter-individual variability. It is difficult to examine this finding from a comparative standpoint, since individual variability in global/local processing is seldom discussed in non-human animals. However, limits to

inter-specific comparisons may also derive from substantial procedural differences. Primate and pigeon studies often rely on visual matching to sample tasks (MTS). We initially tried to use such a procedure with dogs, but found various difficulties in training them on MTS, an obstacle also reported by others (e.g., Milgram et al. 1994). We therefore opted for a procedure similar to that used on redbtail splitfin fish by Truppa et al. (2010), which relies on the initial discrimination learning of a given probe stimulus and subsequent presentation of test stimuli. One implication of this procedure is that the dogs' choices in the test were the result of previous learning and perception, rather than of a purely perceptual process. However, this allows us to formulate hypotheses on the neuropsychological mechanisms associated with acquiring global/local information and may help to explain the variability we observed.

The variability in our results was not limited to global/local choices in the test, but also characterised the speed of acquisition of the initial discrimination training. Slower learners were also more likely to show persistent responses to the same presentation side within a given session. One explanation is that some dogs quickly learned to execute a motor response upon presentation of a stimulus, as described by Guthrie and Horton (1946) in cats, and were more resilient in abandoning such ineffective responses. However, it is hard to explain how an ineffective motor response *per se* could lead to a different precedence in processing hierarchical visual stimuli. The variable performance in discrimination training may thus reflect individual differences in the cognitive requirements of the task. Hoar and Linnell (2013) showed that, in humans, increasing the cognitive load of a global/local task results in disruption or inversion of the global advantage. Moreover, the recruitment of different attentional processes has been indicated as one of the main determinants of global/local bias (Deruelle and Fagot, 1998) and individual differences in attentional control can predict

the speed of learning even in simple visual discrimination tasks (Schmittmann et al. 2012). In the present study, non-global dogs were more resilient towards inhibiting motor responses, but eventually had to attend to task-relevant visual information about the stimuli in order to obtain food rewards. Therefore, completing the task may have imposed a higher attentional demand on some of the dog, which in turn led to the absence of global advantage in the test. Notably, relationship between individual differences in subjective cognitive demand and the likelihood of using a positional response modality in a visual discrimination task has been reported in both laboratory (Milgram et al. 1994) and pet dogs (Huber et al. 2013). Lastly, we have previously shown that a slight reduction in the attention paid by a dog to a human partner, stemming from the impossibility of perceiving details about the person's head, resulted in the inability of the dogs to acquire or use information about that person's movements (Mongillo et al. 2010), further supporting the role of attention in processing global/local information in dogs.

Our results also warrant an ecological consideration. It is often claimed that dogs are visual generalists, i.e., they lack specialisation for particular visual niches, reflecting the ability of the species to exploit its sight in a variety of conditions (Pretterer et al. 2004). The response patterns shown by our dogs in discrimination training and the associated variability in the test suggest that experience in using visual information may be more important than predisposition in determining global/local processing, although this would also allow better adaptability to varying environmental conditions.

2.5 Conclusions

In conclusion, the present study suggests that dogs may show a tendency for global advantage when looking at hierarchical visual stimuli. However, the large variability

observed indicated the relevance of factors acting at individual level on the phenomenon. Among such factors, we are currently investigating the role of attention in the processing of hierarchical images by dogs. Beyond its importance for our understanding of canine visual cognition, the importance of this topic extends to the veterinary and human medical fields. Specifically, the recent description of a canine equivalent of human ADHD and interest in dogs as models for this disorders, prompts studies aimed at better characterization of deficits in attention and related processes in dogs.

**Part-based and configural processing of owner's face
in dogs**

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3.1 Introduction

Dogs are largely exposed to human faces and their aptitude to look at them is evident in many different situations (Call et al. 2003; Miklòsi et al. 2003; Virányi et al. 2004; Schwab and Huber 2006; Mongillo et al. 2010). Dogs are also very skilful in processing human faces presented as two-dimensional stimuli: they discriminate human faces from those of other species (Autier-Dérian et al. 2013), their owner's from another known person's face (Huber et al. 2013) and even different face expressions (Nagasawa et al. 2011). Moreover, dogs exhibit characteristic looking patterns when viewing human face pictures, including both an eye bias (Somppi et al. 2014) and a left gaze bias (Guo et al. 2009). Some insight about how exactly the processing of human faces is carried out comes from eye tracking studies. For example, there seems to be no difference in looking time between novel and familiar pictures of human faces when the stimuli are presented upside-down, indicating the presence of an inversion effect, which deteriorates discriminative responses (Racca et al. 2010). Other recent studies found that dogs inspect 2D face images by focusing on their informative regions (Somppi et al. 2012) and that facial inversion and familiarity with the person affect the scanning behaviour of dogs (Somppi et al. 2014); in particular the eye region of upright faces gathers longer total duration and greater relative fixation duration than that of inverted stimuli and faces belonging to known persons are more fixated than those belonging to strangers. These findings suggest that dogs are likely to recognize human faces in photographs and this hypothesis is also supported by Adachi et al. (2007) who demonstrated that dogs formulate expectations regarding the visual aspect of the owner's face looking longer when the 2D image of the face presented contradicted the auditory stimulus (an unfamiliar voice).

Since dog's scanning behaviour is affected by facial inversion (Guo et al. 2009; Racca

et al. 2010; Somppi et al. 2014) and in humans inverted facial image has to be processed mainly element by element (Yin 1969; Tanaka and Farah 1993) another crucial unsolved issue is whether dogs can process a face by its elements, and even most important, whether they can perceive and discriminate face elements at all. To date no data are available, except from a study by Huber et al. (2013) where it was found that the discrimination of human faces is harder when only the inner parts of the face (eyes, nose and mouth) are visible. To this respect it would be also important to investigate whether some features could be more relevant for face discrimination in dogs, since in human literature it has been established that there is a hierarchy of features in terms of their diagnostic value to face processing (Shepherd et al. 1981). In particular the eyes are the most important feature involved in individual identification (McKelvie 1976), receive more visual attention than other areas of the face (Keating and Keating 1993) and are perceptually more discriminable than nose or mouth (Sergent 1984). Eyes could be the most relevant feature also for dogs, since it is the region they mostly look at when viewing human faces (Somppi et al. 2014).

Our knowledge about mechanisms underlying face processing comes primarily from human studies, most of which support the holistic nature of the process, whereby faces are perceived as whole, rather than as the sum of their component parts. One aspect that has traditionally been tackled by these studies is the extent to which configural information (i.e. the spatial relationship between parts) as opposed to information about the parts themselves contributes to the processing of faces. Indeed, while face discrimination has proven to be configuration-dependent (Tanaka and Farah 1993), to the point that *configural* and *holistic* are sometimes used interchangeably, (e.g. Young et al. 1987; McKone and Yovel 2009), others have stressed that discrimination also necessitates information about face parts (Cabeza and Kato 2000). Previous approaches

have examined the importance of part and configural information by selectively removing the possibility to rely on such information, for instance by examining the ability to discriminate faces basing on parts only (Davies et al. 1977), or through systematic manipulation of face image to reduce or eliminate some aspects of the information (Parr et al. 2006). More or less sophisticated manipulations have been used in different species and in the present study, as a first approach, we chose two that reduce as specifically as possible the elaboration of configural or elemental information, respectively inversion and blurring, (e.g. Goldstein 1965), and one that allows to alter both of them, that is scrambling. Inversion is the upside-down presentation of stimuli and, while not removing information, it impairs configural processing (Sekunova 2008), making a face harder to discriminate by both humans (Yin 1969; Rossion and Gauthier 2002) and other primates, (e.g. Parr et al. 1998; Neiworth et al. 2007; Parr and Heintz 2008). The inversion effect on face visual inspection has been already tested in dogs (Somppi et al. 2014; Racca et al. 2010) but an active (approach and touch) discrimination tasks has never been used to this aim. However, active choice would give a more incontrovertible evidence of dogs' ability to discriminate faces and add some possible explanations of the differences in gazing patterns observed. As opposed to inversion, blurring affects part-based more than configural processing, at least at intermediate levels of blurring (Costen et al. 1994). Notably, this does not seem to affect face processing abilities in humans and macaques (Dahl et al. 2009), while face processing by chimpanzees is impaired when individual features are blurred through pixilation (Parr et al. 2006). Scrambling affects mainly configural processing, but even part perception is affected to an extent that depends on the magnitude of the manipulation itself, (e.g. Tanaka and Farah 1993; Matsukawa et al. 2004). Visual discrimination is impaired by scrambling in humans (Tanaka and

Farah 1993) and rhesus monkeys (Keating and Keating 1993) when looking at human faces; in contrast, pigeons are still able to discriminate cartoon characters (Cerella 1980; Watanabe 2001) and photographs of people (Aust and Huber 2001) even if scrambled in tiny fragments.

Another controversial issue regards the extent to which face processing abilities are due to experience. Accumulating evidence suggests for neonates an ability to specifically process faces (Pascalis and de Schonen 1994; Turati 2004; Turati et al. 2006; 2008) and a face-specific heritability for holistic processing has been demonstrated in twins (Zhu et al. 2010). Nevertheless, the acquisition of fine face-processing abilities requires years of exposure to faces (as reviewed in de Haan et al. 2001) and experience is required in order to apply established mechanisms to different face subsets (Pascalis et al. 2002; Pezdek et al. 2003; Kelly et al. 2009). The importance of experience is especially evident in the processing of hetero-specific or other-race faces. Face processing by humans improves after specific training or after exposure to other-race individuals (Birgham et al. 1982; Slone et al. 2000; McKone et al. 2007) and a disadvantage in the discrimination of human faces by chimpanzees was cancelled out or indeed overturned by intensive exposure to humans (Martin-Malivel and Okada 2007). Differences in visual processes underlying conspecific or heterospecific face discrimination are reported in both humans and monkeys who show different patterns of eye movement depending on the species' affiliation of the faces (Dahl et al. 2009). Species-specificity in inspecting conspecific versus human face images was reported also in dogs (Guo et al. 2009; Racca et al. 2010; Somppi et al. 2014). Prior experience about certain face category could influence the distribution of dogs' gaze fixations directed at the specific face region, reflecting a different viewing strategy/sensitivity to sample relevant facial information from different species (Guo et al. 2010). Therefore, it may be that the level

of experience with heterospecific faces influences the relative recruitment of configural and part-based mechanisms. Besides, specific training could result in the use of strategies not normally used in natural conditions e.g., focusing on a single local region of the human faces, as argued for chimpanzees by Pascalis and Bachevalier (1998).

In the present study we conducted two experiments to assess the mechanisms underlying human face processing by dogs. In Experiment 1 we examined whether dogs can discriminate human face parts presented in isolation and if so whether one of them could be more relevant for face discrimination. Experiment 2 investigated the relative contribution of part-based and configural processing in discrimination of human faces and the influence of specific experience on the reliance on such mechanisms.

3.2 Experiment 1

Human and nonhuman primates studies suggest that the eyes are the most important facial feature involved in face processing. Even if dogs demonstrated to discriminate pictures representing different expressions of their owner and their owner's from another person's face, their ability to perceive face parts is supposed, but not yet clearly proven. Therefore the preliminary aim of this experiment was to investigate the ability of dogs to perceive and discriminate internal face parts (eyes, nose, mouth) belonging to the owner, presented in isolation. Moreover, the role of face parts for face discrimination was assessed by training dogs to discriminate their owner's whole face with one of the three parts covered (eyes, mouth or nose covered) and finally to discriminate the normal whole face as a control condition. By comparing the performances of these trainings we assessed whether any of the parts was more important than the others for the discrimination of the human face.

3.2.1 Methods

3.2.1.1 Ethics statement

Owners participated in the experiments of the present study on a voluntary basis; they signed a consent form and agreed to have their portraits published in this paper. This study was performed in compliance with relevant laws in Austria and gained the approval of the Ethics Committee of the University of Veterinary Medicine, Vienna (No. 10/04/97/2013).

3.2.1.2 Subjects

Dogs and their owners were recruited from dog owners living in or around Vienna to participate in this study. All dogs were pets, living with the owner and had daily contact with humans. Dogs had basic obedience training and they had been working with the touch screen (although with a slightly different apparatus), but had neither seen the visual stimuli used in this experiment, nor had been trained with other pictures that included human faces or parts of them. Dogs were on normal diet and they were unleashed during the entire procedure. Of the 12 dogs enrolled, seven completed all phases and were included in the study ($N = 7$; 4 females, 3 males; mean age \pm SD = 3.4 ± 2.1). Due to a strong side bias the training of the remaining five dogs was terminated after 800 trials.

3.2.1.3 Experimental setting

The study was conducted in an experimental room of the Clever Dog Lab at the Messerli Research Institute of the University of Veterinary Medicine of Vienna (size: 2.5 m x 1.5 m; Fig. 3.1A). The testing apparatus consisted of a touch screen (40 x 31 cm; Fig. 3.1B) fixed to the wall in a flexible way so that its height could be adjusted to

the height of the dog. It was built up of a commercial flat screen (resolution 1024 x 748 pixel) fixed on a metal plate. Dogs' responses were recorded by special pressure sensors that were connected with two separate acrylic glass panes (each 15 x 23 cm), which were fixed in front of the screen. The pressure sensors were linked to a remote control, which was connected via an interface to the computer. A laptop was used to control the presentation of stimuli, the provision of food and the registration of responses. Reinforcement was administered in the form of small commercial dog food pellets, delivered by an automated feeding device (MannersMinder, Premier Pet, LLC, 14201 Sommerville Ct., Midlothian, VA 23113, USA) that was placed on the floor on the opposite side of the touch screen. Owners were always present in the experimental room during the experiment; they sat on a chair from where they could not see the stimuli, thus preventing them from unintentionally influencing the dogs' choice. The experimenter was also present in the room to control the correct progression of the procedure but she was unaware of which stimuli were being presented to the dog.

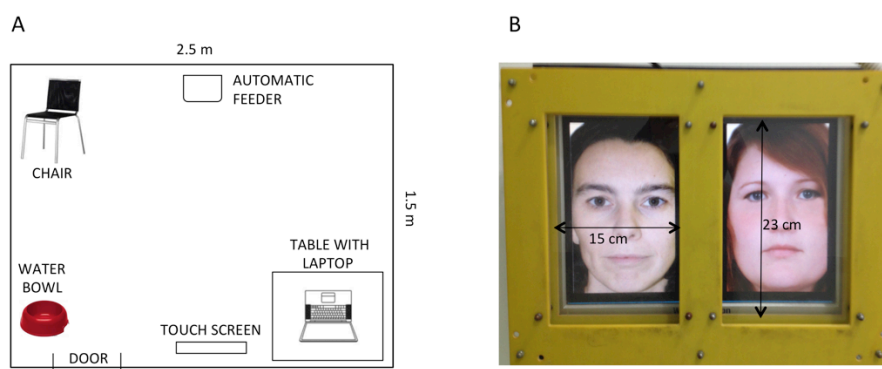


Figure 3.1. Experimental setting and detail of the touch screen.

Details of the experimental setting showing (A) a schematic representation of the experimental room, illustrating the position of the touch screen, the laptop, the automatic feeder, the water bowl and the owner's chair and (B) a photograph of the

touch screen, with dimensions of the hemi-screens; the pictures shown in the screen exemplify the presentation of stimuli, in this case the whole, uncovered faces of the owner and the stranger.

3.2.1.4 Stimuli

The stimuli were made from a picture of the owner's face and a picture of a stranger person's face of the same gender as the owner. Since all participating owners were women, all pictures consisted of female faces. As the study tried to answer basic questions, only one picture of the owner and of a stranger were used throughout the experiment. This allowed a greater standardization of the stimuli, avoiding the introduction of variability that could have influenced discrimination processes (e.g. different expressions, poses, colours, shading, etc.). Moreover, testing for individual recognition was not the aim of the present experiment, therefore generalization to a set of pictures was unnecessary. To standardize their appearance as much as possible, pictures were taken in a photographic setting with a professional camera (Canon EOS 6D, Canon, Japan) and people were previously asked to wear no makeup or jewellery and to look straight into the camera with a neutral facial expression. The pictures were then processed using Adobe Photoshop CS4 Extended (11.0 Adobe Systems Inc. 1990-2008) to adjust lightning, contrast, size and to add a homogenous white background. The same software was used to create the stimuli of Experiment 1 and 2. The size of the pictures was adjusted to match that of the real heads as much as the width of the screen allowed (14.8 cm). Seven types of stimuli were created from this picture: three were a rectangular crop of the eyes, the nose or the mouth region, which appeared as a rectangular area on a white background; these regions had the same area across all people and maintained the same size as in the whole face (eyes = 32,3 cm²; nose or

mouth = 9,61 cm², Fig. 3.2A). Other three stimuli represented the whole face, where images of sunglasses, of a clown-nose or of a scarf were superimposed to cover either the eye region, the nose region or the mouth region, respectively (Fig. 3.2B). The last stimulus was the picture of whole face with no parts covered (Fig. 3.2C).

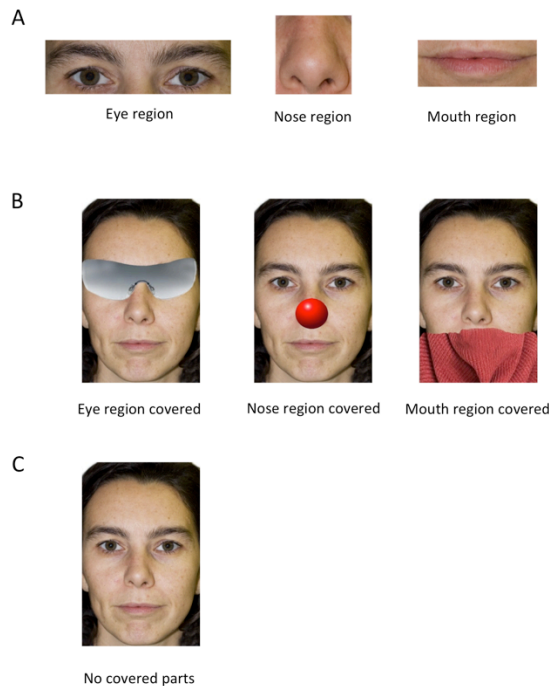


Figure 3.2. Example of stimuli used in the Experiment 1, representing (A) face parts presented in isolation and (B) the whole face with single parts covered and with no parts covered (C).

3.2.1.5 Procedure

The presentation of the stimuli, their position (randomly left or right) and the data collection (session duration, choice) were done using the software DogIT (written by Dietmar Schinnerl, Graz, Austria). All sessions consisted of 20 trials, in which one positive (the owner's face or face part, S+) and one negative stimulus (the stranger's face or face part, S-) were simultaneously presented to the dog at a distance of approximately 100 cm. The touching (with the nose) of S+ was followed immediately by a short high-pitched tone, disappearance of both stimuli from the screen and provision of food reward. The touching of S- was immediately followed by a short low-

pitched tone and the screen turned into red for 3 s. Wrong choices were followed by correction trials (the presentation of the same stimuli and in the same position as in the previous trial, until the correct response was delivered). Correction trials were not taken into account when summing up the number of trials per session or the number of correct choices within a session. The learning criterion to successfully complete a phase and proceed to the following one was set at 85% correct choices in three consecutive sessions (i.e. 51 correct trials out of the last 60).

The owners came with their dogs to the sessions twice a week. On a single day, dogs completed 6 sessions in 30 to 40 min, with a 5-min break after the third session.

3.2.1.6 Pre-training

All dogs were already trained to choose the stimulus by touching the monitor with their nose, but they were used to a slightly different apparatus, the one described in Range et al. (2008). Therefore, dogs were accustomed to the new apparatus and the new feeder, by training them with simple shapes (circle or square) on a black background, in a two-way conditioned discrimination procedure until they reached the learning criterion (see above). This required an average of 4.7 ± 2.1 (mean \pm SD, range 3-8) sessions.

3.2.1.7 Training phases

The dogs underwent six training phases, one for each stimulus type (i.e. eye, nose or mouth regions only and eye, nose or mouth regions covered). Once dogs reached the learning criterion with a given stimulus type, they proceeded to the next training phase with a different stimulus type. Three dogs started with the isolated parts and then proceeded to the faces with covered parts; the other four dogs started with the faces with covered parts and then proceeded to the isolated parts. The overall sequence was

different for each dog (Table 3.1). As a control condition, all dogs underwent a last additional training aimed at discriminating the whole face with no covered parts. The experiment was terminated as soon as the dog completed the control condition.

Table 3.1. Sequence of isolated and covered face regions presented to each dog in the training phases of Experiment 1. Once dogs reached the learning criterion with a given stimulus type, they proceeded to the next stimulus until the sixth training phase.

Order of presentation						
Do						
g						
ID	1st	2nd	3rd	4th	5th	6th
1	E-R	N-R	M-R	E-R covered	M-R covered	N-R covered
2	M-R	E-R	N-R	N-R covered	E-R covered	M-R covered
3	N-R	M-R	E-R	M-R covered	N-R covered	E-R covered
4	E-R covered	N-R covered	M-R covered	M-R	N-R	E-R
5	M-R covered	E-R covered	N-R covered	N-R	E-R	M-R
6	N-R covered	M-R covered	E-R covered	M-R	N-R	E-R
7	E-R covered	M-R covered	N-R covered	E-R	M-R	N-R

E-R = eyes region, N-R = nose region, M-R = mouth region.

3.2.1.8 Data collection and statistical analysis

Data regarding the duration of sessions and the choice (S+ or S-) made by dogs at each trial were recorded. The total number of sessions to reach the learning criterion in each phase was considered as variable to investigate the difficulty encountered by dogs to acquire the tasks.

A linear mixed model was used to assess whether any of the owner's isolated face parts

was more easily discriminated than the others. The total number of sessions required to reach the learning criterion was used as a dependent variable. The type of stimulus (eyes, nose, mouth) was used as a within-subjects factor, and, to control for an effect of the order of presentation of the different stimulus types, this was also included in the model, as was the interaction order*stimulus type. To account for the repeated measures, the dog's identity was fitted in the model as a random factor. The procedure was followed by pairwise contrasts, with Bonferroni correction for multiple comparisons. A linear mixed model was also used to assess the relative relevance of face parts for the discrimination of the owners' face. Again, the number of sessions to criterion was used as the dependent variable, on which a natural logarithm transformation was applied to obtain a normal distribution. The explanatory variable was the type of stimulus (covered eye region, covered nose region, covered mouth region, no part covered). Bonferroni-corrected pairwise contrasts were performed between performances with one part covered vs. performance with none of the parts covered, which was taken as a control condition. Since the face with no covered parts was invariably the last stimulus that was presented, the order of presentation could not be fitted in this model; however a separate model was built, where data from the face with no covered parts was excluded, to assess the effect of the order of presentation of faces with a covered part. The dog's identity was fitted in the models as a random factor, to account for the repeated measures.

All the analyses were performed with Statistical Analysis System software (SAS Institute Inc SAS/STAT 9.2 User's Guide. Cary, NC: SAS Institute Inc; 2008) and the statistical significance was set at 5%. Data are presented as mean \pm SD unless otherwise stated.

3.2.2 Results

The duration of training sessions ranged from 2.2 to 13.1 min with an average of 4.7 ± 1.6 min.

Dogs showed a certain inter-individual variability in the number of sessions needed to acquire the task with both isolated parts (min-max: eye region = 12-19, mouth region = 12-36, nose region = 21-34) or whole faces (min-max: eye region covered = 4-21, mouth region covered = 3-14, nose region covered = 4-24, no part covered = 3-7).

When dogs were presented with isolated face parts, their performance was significantly affected by the type of stimulus ($F_{2,5} = 11.97$, $p = 0.012$) and not by the order of presentation ($F_{5,5} = 0.80$, $p = 0.59$) or by the order*stimulus type interaction ($F_{8,5} = 4.25$, $p = 0.064$). Specifically, discrimination of the eye region required fewer sessions compared to both the mouth and the nose region, while no significant difference was found between the nose and mouth regions (Fig. 3.3A).

The type of stimulus also had an effect on the dogs' performance when whole faces were presented ($F_{3,24} = 3.59$, $p = 0.028$), since discrimination was significantly faster for the face with no covered parts than when the eyes region was covered, but not than when the nose region or the mouth region was covered (Fig. 3.3B). No effect was found for the order of presentation of faces with covered parts ($F_{5,3} = 0.96$, $p = 0.549$), or for the order*type of stimulus interaction ($F_{10,5} = 0.198$, $p = 0.978$).

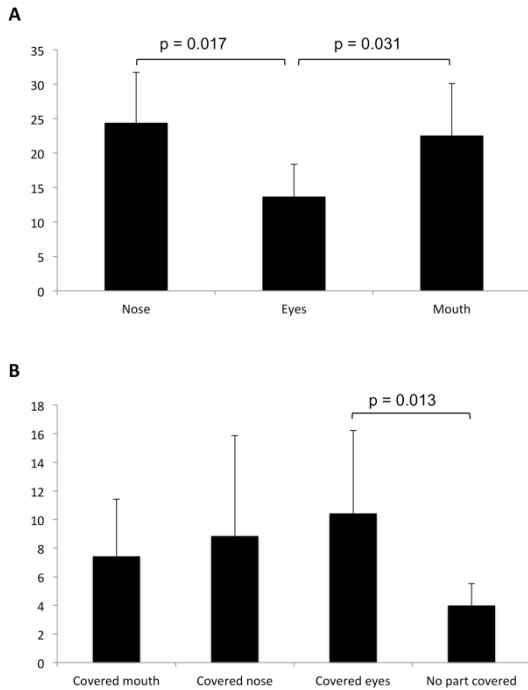


Figure 3.3. Sessions needed to reach the learning criterion in the training phases of Experiment 1.

Mean \pm SD number of sessions needed by dogs to reach the learning criterion when discriminating between (A) the owner's and stranger's face isolated parts and (B) faces with covered parts. Bonferroni corrected pairwise comparisons after generalized linear mixed model.

3.2.3 Discussion

This first experiment revealed an ability of dogs to discriminate all the three internal parts of the owner's face presented in isolation, with an advantage for the eye region over both the nose and the mouth regions. Discrimination of the eye region could have been easier merely because it covers a bigger area and is richer in features and details, such as colours and shapes. Alternatively, or in addition, eyes may have been easier to discriminate because they are the most salient feature of the face.

The dogs' performance with faces in which the parts were covered provides indication for choosing between these two hypotheses, which are not mutually exclusive since quantity of details could be embedded also in salience. The dogs were readily able to discriminate the owner's whole faces in the control condition and no difference in discriminability was found between this condition and those where the nose or mouth

regions was hidden. It would not be correct to conclude that these regions do not convey useful information but simply we could not reliably measure their effect with our experimental design. Conversely, masking the eyes region significantly disrupted face discriminability compared to the whole face condition. If the mere quantity of unspecific perceptual details and information were the only reason of difference in discriminability we would expect also the absence of nose or mouth regions information to have an effect on the ease of face discrimination. Moreover, the face with eyes covered is still very rich in perceptual details and carries substantial information, including some external cues (face profile, hair), which dogs can effectively use to discriminate between human faces (Huber et al. 2013). However, if this was the case no difference in discriminability would have been found whatever internal face region was masked. Therefore the eye region seems to have a special role in human face processing of dogs, corroborating the findings of Somppi et al. (2014) and supporting the hypothesis for a role of the eyes region in a global mechanism of face processing (Dahl et al. 2009; Gothard et al. 2009; Hirata et al. 2010).

3.3 Experiment 2

In the Experiment 1 dogs discriminated both the face parts presented in isolation and the whole faces with one part covered, showing that they can use the information of the parts to discriminate the human faces presented in the pictures. This second experiment examined the relative contribution of part-based and configural processing in the discrimination of the owner's face from a stranger's face by manipulating the type of information available. Furthermore, we assessed the influence of specific experience on the reliance on such mechanisms by comparing dogs enrolled in the first experiment and a new group of dogs, naïve to the procedure and to the pictures.

3.3.1 Methods

3.3.1.1 Subjects

The same seven dogs that completed Experiment 1 participated in Experiment 2. In addition, to verify whether there could be an influence of the training that dogs underwent during Experiment 1 on performance in Experiment 2, other seven dogs were recruited (naïve group, 6 females, 1 male; age = 4.9 ± 1.9) and compared with the seven dogs that completed Experiment 1 (expert group). Naïve dogs had analogous obedience training and the same experience with the touch screen procedure as the expert group. The overall sample was composed of 14 adult family dogs of 4.1 ± 2.1 years of age.

Experimental setting and general procedure

The experimental setting and the general procedure were the same as in Experiment 1.

3.3.1.2 Stimuli

The stimuli used in the training phase of naïve dogs were a photograph of the owner's face in frontal view, realized in the same conditions as for the Experiment 1 and the same photograph of the stranger used in the first experiment (Fig. 3.4A). Test stimuli (Fig. 3.4B) were a grey-scale, a blurred (filter blurring $r = 8.0$ pixel), an inverted (180° rotation) and a scrambled (randomly rearranged squares of 2.7×2.9 cm; $102,1 \times 109,6$ pixel) version of the same photographs used in training for both groups. The grey-scale manipulation was added to assess the importance of specific experience in the discrimination, since expert dogs did not receive training to this respect.

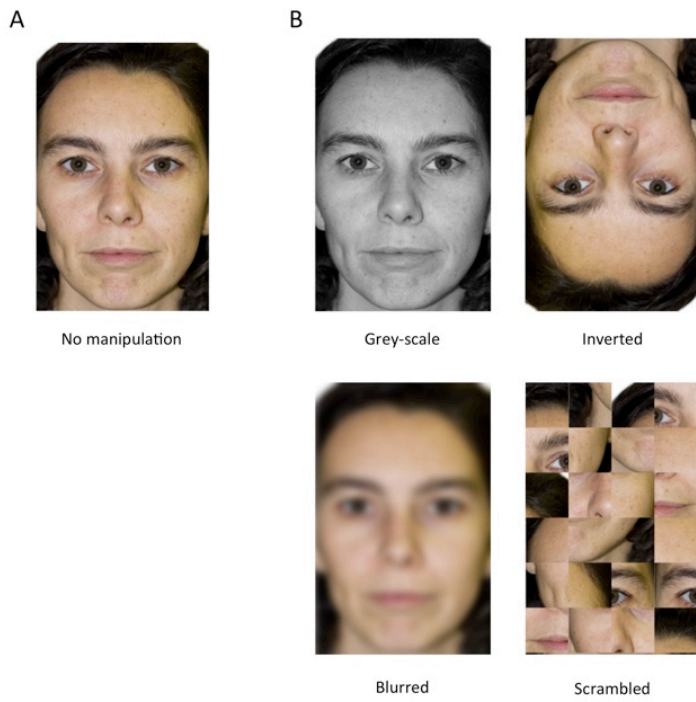


Figure 3.4. Example of stimuli used in Experiment 2, representing (A) the whole face in frontal view without manipulations and (B) the whole face with manipulations used in the test trials

3.3.1.3 Training

Prior to starting Experiment 2, the seven dogs belonging to the naïve group underwent the pre-training phase and the control condition training, in which whole faces with no manipulation were presented, as described in Experiment 1. Once the learning criterion of 85% correct choices in 3 consecutive sessions was reached, naïve dogs proceeded to the test phase. In contrast, dogs of the expert group started with the test phase as soon as they had completed Experiment 1.

3.3.1.4 Test

Test sessions were made up of 16 training trials and 4 test trials. In training trials, non-manipulated photographs of the owner's face and of the stranger's face were presented. Only if the dogs performed sufficiently well in the training trials (85% correct or more), the sessions were included in the analysis of test performance. All tested dogs fulfilled this requirement. In test trials, the four test stimuli belonging to the owner (S+) and the stranger (S-) were presented in random order, once every five trials, beginning with trial number five. Dogs were always rewarded in the test trials regardless of their choice and no correction trials were administered. Twelve test sessions were performed in two different days, for a total of 48 test trials for each dog, i.e. 12 test trials for each of the four test stimulus types.

3.3.1.5 Data collection and statistical analysis

Data regarding the duration of sessions, the choice (S+ or S-) made by dogs at each trial, and the side (left, right) of the chosen stimulus were recorded. A paired sample *t*-test was run to analyse the differences between expert and naïve dogs in the mean number of sessions required to acquire the learning criterion in the whole face training

phase. A logistic regression model (Allison 2001) was then used to analyse whether the probability of choosing the owners' face picture in the test phase was significantly affected by the image manipulation and by the dog's experience in the procedure. The dependent variable was a dichotomous categorical variable representing the dog's choice at each presentation (1 = owner's face; 0 = stranger's face), whereas the explanatory variables were the experience group (expert or naïve) and the type of manipulation (grey-scale, blurred, inverted, scrambled); moreover, the side of presentation of owner's face (left or right) was added to the model as a fixed effect and the dog ($N = 14$) was added as a random effect.

To assess whether a prevalence for the owner's face or the stranger's face was present in our sample, we performed a right-tailed Student's *t*-test on the dogs means for the choice (1 = owner's face; 0 = stranger's face) expressed in the 12 test trials of each of the four manipulations, testing the null hypothesis H_0 that the mean was equal to or lower than 0.5. Also we computed the probability that the true mean for the choice was in the range between 0.501 and $+\infty$. On the basis of the results obtained by the logistic regression model, the right-tailed Student's *t*-test was performed on the overall sample in the test manipulations in which no experience effect was found, otherwise was performed separately for the two groups (expert and naïve).

3.3.2 Results

Sessions of the training phase of naïve dogs had an average duration of 5.1 ± 2.3 min. As expected, naïve dogs reached the learning criterion in the non-manipulated face training phase in significantly more sessions than expert dogs had done in the corresponding phase of Experiment 1 (4.0 ± 1.5 vs. 18.7 ± 7.5 ; $t_{12} = -5.058$, $p < 0.001$). Sessions of the test phase had duration of 6.2 ± 1.7 min. The binary logistic regression

model indicated that the side of presentation of S+ and S- did not affect the dogs' choices in the test phase. In contrast, a significant effect was found for the type of manipulation, the experience group and the interaction between manipulation and group (Table 3.2).

Table 3.2. Binary logistic regression model showing the effect of side of presentation, experience group, type of manipulation and interaction between group and type of manipulation on choices of the owner's face (S+) in the test trials of Experiment 2.

Effect	OR	95% CI	p
Experience group	2.555	1.452-4.495	0.0012
Type of manipulation	2.214	1.386-3.535	<0.0001
Experience Group * Type of manipulation	-	-	0.0041
Side of presentation of S+	1.102	0.783-1.550	0.5787

OR = odds ratio, CI = confidence interval.

Comparing the two groups within each type of manipulation (Fig. 3.5), expert dogs showed a higher probability than naïve dogs of choosing the S+ in the blurred ($F_{1,651} = 10.83$, $p = 0.001$) and in the scrambled condition ($F_{1,651} = 12.81$, $p < 0.001$), while no statistically significant difference was found in the inverted condition ($F_{1,651} = 3.10$, $p = 0.079$). The two groups performed almost identically in the grey-scale condition ($F_{1,651} = 0.02$, $p = 0.899$).

In the grey-scale condition, a right-tailed t -test could not reject the null hypothesis that the mean of choices expressed by dogs as a group in the 12 test trials was less than or

equal to 0.5 ($t_{13} = 3.08$, $p = 0.004$) indicating that all dogs significantly chose the owner above chance level. In the blurred condition both expert and naïve dogs chose the owner significantly above chance level (expert: $t_6 = 22.91$, $p < 0.001$; naïve: $t_6 = 2.90$; $p = 0.014$), whereas only the expert group chose the owner above chance level in both the inverted (expert: $t_6 = 3.06$, $p = 0.011$; naïve: $t_6 = 1.51$; $p = 0.091$) and the scrambled condition (expert: $t_6 = 2.56$, $p = 0.021$; naïve: $t_6 = -2.20$; $p = 0.965$).

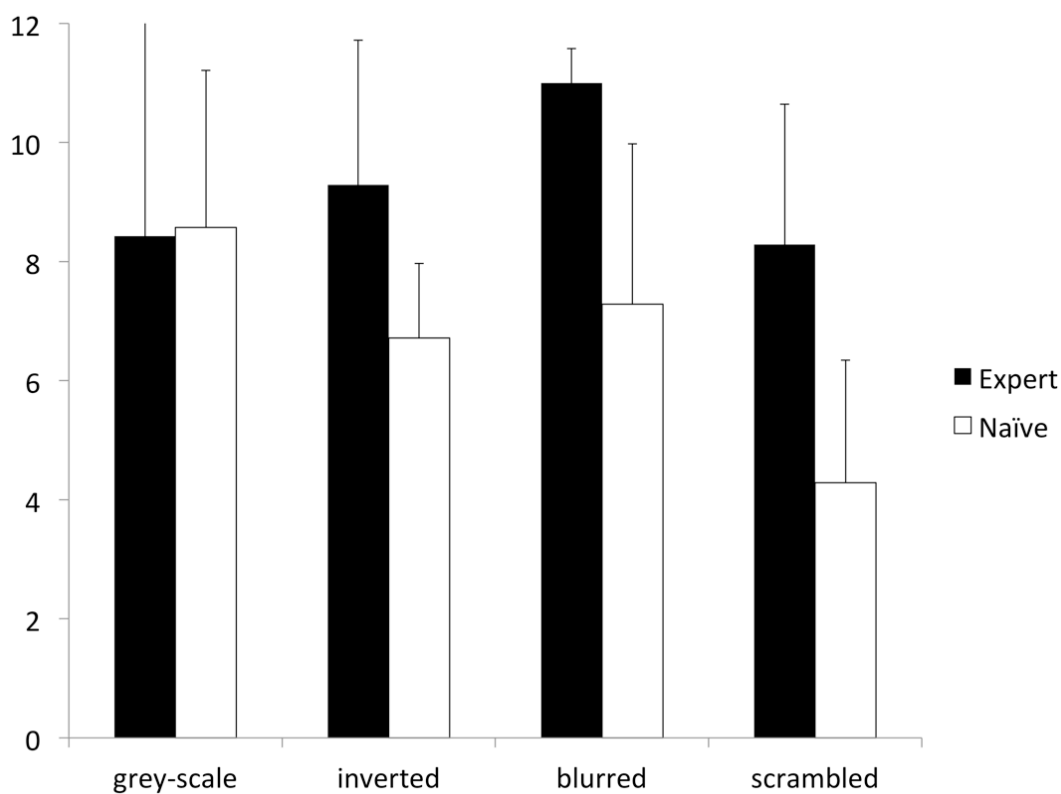


Figure 3.5. Choices in the test trials of Experiment 2 by expert and naïve dogs.

Mean \pm SD number of owner's face choices done by expert and naïve dogs with each type of manipulation in test trials of Experiment 2. Error bars represent the standard deviation from mean.

3.3.3 Discussion

The aim of this experiment was twofold: to investigate in pet dogs a) the relative importance of configural and part-based processing and b) the influence of specific experience on the reliance on such mechanisms in the discrimination of human faces. Naïve dogs were able to discriminate the picture of their owner's face from that of a stranger only in the grey-scale and in the blurred condition, both of which provided configural information. Conversely, their performance dropped to chance level in the case of the inverted and the scrambled condition. Scrambling necessarily disrupts configural information and only the facial part information is available, even if not fully preserved (eyes, mouth and nose were all cut in the random rearrangement of the tiles). However, also inversion has been shown to facilitate processing of face parts (Tanaka and Farah 1993), at the expense of the more efficient configural processing of upright faces. The performance of our naïve dogs therefore indicates that face discrimination could rely primarily on configural processing, at least without specific experience.

Expert dogs had been trained in Experiment 1 to discriminate their owners' isolated face parts and, accordingly, their performance in Experiment 2 was better than that of naïve dogs in those conditions that could be solved by part-based processing, namely scrambling and inversion. In this last condition, experience affected the dogs' ability to choose the owner only with a non-significant trend. However, this was sufficient to differentiate between groups, as expert, but not naïve dogs, were able to select the owner's face above chance level. Training experience had also an effect on the ability to discriminate faces by relying on configural information as shown by the dogs' performance in the blurred condition. While both naïve and expert dogs discriminated the owner above chance level, training, even if mainly planned to prime dogs' attention on face parts, allowed experienced dogs to perform near to perfection in the blurred

condition. No significant differences were found between naïve and expert dogs in the grey-scale condition thus indicating that the effect of training experience was condition-specific.

3.4 General Discussion

The present study provides the first evidence that pet dogs can discriminate isolated internal features of a human face. Actually, a number of recent studies focused on dog's discrimination or visual inspection of human faces without knowing if dogs' visual acuity certainly allows perception of feature details. Given our results, the specific pattern of face visual inspection and discriminability observed in those studies assumes higher or different value. For instance, the poor performance of dogs in discriminating human faces when only their inner parts (eyes, nose and mouth) are visible observed by Huber et al. (2013) cannot be explained in terms of deficiencies of visual acuity.

Among internal features, the eyes region may be the most salient for human face discrimination by dogs. This result is in line with observations made in other species. In humans, presenting whole faces with the eyes concealed impairs the identification of kin (Dal Martello and Maloney 2006) and gender (Roberts and Bruce 1988) more severely than if other facial features are concealed. Similarly, individual conspecific recognition is impaired in chimpanzees when eyes are masked and in rhesus monkeys when both eyes and mouth are masked (Parr et al. 2000). Finally, Kyes and Candland (1987) found a visual preference for the conspecific's faces in which the eye region was visible in baboons. Overall these studies indicate that eyes are more important than other internal face features in face processing by primates. In dogs, the salience of internal face features was poorly investigated and, to the best of our knowledge, there is no study comparing salience or discriminability between internal features of the face.

Using eye movement tracking, Somppi et al. (2014) provided the only clear evidence that the human eyes region is a very salient feature for dogs. In agreement with our findings, this region is attracting nearly half of the relative fixation duration of the whole face area (hair and ears excluded). Whether the eyes region is at the first place in the hierarchy of face features saliency remain an open question. External features have been shown to contribute significantly to human face discrimination for humans (Ellis 1986; Bruce et al. 1999; Frowd et al. 2007), baboons (Martin-Malivel and Fagot 2001), dogs (Huber et al. 2013) and sheep (Peirce et al 2001). As previously cited, dogs seem to easily discriminate human face pictures when also the external cues (face profile, hair) are provided while performing very poorly when only the internal features of the face were visible (Huber et al. 2013). While this seems to be in contrast with our results about eyes salience, methodological issues may account for this difference. First, our stimuli were adjusted in size to match that of the real heads and, not fitting entirely within the screen, external features were poorly represented in the pictures. Specifically, the hair outline was always absent, while face profile and ears were unevenly present. Second, the dogs of the present study were trained to discriminate internal features in three out of six training phases whereas in the other three phases internal or external feature could have been rewarded. Accordingly, our procedure draws the dogs' attention to the internal face features thus reducing salience of external features. Analogous effects of attention allocation on internal features salience are documented in humans while looking at other-race faces (Hills and Lewis 2011; Hills et al. 2013).

Besides salience, lower physical properties (e.g. color, contrasts, shading) and spatial arrangement of facial features have an influence on face processing. The dogs of our naïve group were able to discriminate their owner face when configural information of

internal features were readily available (i.e. grey-scale and blurred condition) while manipulation of even basic first-order spatial relationship (eyes are above the nose, which is above the mouth, etc.) by rotating faces 180° made them failing the discrimination. That means, even if dogs can discriminate single features, as proved by Experiment 1, this is not sufficient to allow discrimination of a face, when information about features configuration is varied. In humans, the relevance of configural information has been demonstrated by showing that even alterations of single parts are easier to detect when presented within the context of the face than when such parts are shown in isolation (e.g., Davies and Christie 1982; Tanaka and Farah 1993). Decrement of face discrimination abilities in inverted and scrambled conditions has been demonstrated, even if to a different extent, in many species, such as humans, (e.g. Yin 1969), primates (reviewed in Parr 2011), sheep (Peirce et al. 2001) and pigeons (Matsukawa et al. 2004). In dogs, a deteriorative effect of the inversion on visual inspection of human face pictures has been previously found in a free viewing task (Somppi et al. 2014) and using a visual paired comparison paradigm (Racca et al. 2010). In this regard our results suggest that inversion affects the dog's ability to discriminate the owner's face, supporting what was indirectly suggested by comparison between familiar and novel face pictures (Racca et al. 2010). Since all lower physical properties are unvaried in inversion manipulation, dogs seem to rely mainly on configural information when discriminating their owner's face. Moreover, configural information seems somehow to over-rule individual feature details as supported by the readiness of our naïve dogs to discriminate faces when features were blurred through pixilation.

The configural face bias observed in dogs may be grounded in an overall preference for global over local information in the processing of visual stimuli. In a previous study

(Pitteri et al. 2014), although a large inter-individual variability was detected, dogs demonstrated a tendency to prefer the global over the local information when looking at hierarchical visual stimuli. The great interest in the eye area shown by dogs when looking at faces (Somppi et al. 2014) is also, to some extent, indicative of configural face processing, since the eye region may actually provide more configural information than other features. That is because its central position may lead to an extraction of information about the whole face (Schwarzer et al. 2005). Notwithstanding, the present study does not permit to clarify if the crucial role of first-order spatial relationship of internal features is limited to face pictures. Racca et al. (2010) failed to prove specific inversion effect for faces (of either dogs or humans) and there is no other evidence of face-specific configural processing by dogs. However, the authors discuss the lack of this finding to the very conservative methodology used for assessing the inversion effect and so dissimilarity of cognitive strategy in processing face by dogs warrants further investigation.

The role of specific experience on human face processing by pet dogs was the third aim of the present study. In contrast to the 'naïve' group, the 'expert' dogs were able to identify the owner in all test conditions, suggesting a facilitative effect of training on the dogs' ability to process human faces. It could be argued that training have exerted its facilitative effect by the simple exposition to the face pictures or their parts thus increasing the dogs' general familiarity with the stimulus and therefore their ability to discriminate the owner in different conditions. Nonetheless, the lack of an experience effect in the grey-scale condition suggests that training did not result in a general, unspecific improvement of their ability to discriminate the owner's picture, since the only unavailable information was the colour, a feature on which expert dogs had not been specifically trained on. The effect of training is well known in humans; training

improves face discrimination and, in particular, reduces the other-race effect (McKone et al. 2007). This effect is supposed to be a consequence of training on attention being directed to those features of other race faces that are useful for identification (Hills and Lewis 2006). The distribution of eye movements is indeed critically affected by whether conspecific versus non-conspecific faces are shown (Dahl et al. 2009). This species specificity in face visual inspection has also been previously shown in dogs, who use a different gaze strategy while viewing human faces compared to dog faces (Guo et al. 2009; Racca et al. 2010; Somppi et al. 2012). It is then likely that training of our 'expert' dogs have modified their strategy for gazing at human faces, drawing their attention to more useful features as a consequence of previous training. Our results in the blurred condition imply that it is not only part-based processing that benefits from training, but that even the more readily used configural processing is easily enhanced by experience. Notably, even in humans the ability to use configural coding mechanisms appears to require expertise with a class of stimuli (e.g. Diamond and Carey 1986; Rhodes et al. 1989) and the relatively poor discrimination of faces from an unfamiliar race may well be the result of limited encoding of configural information for other-race faces (Fallshore and Schooler 1995; Rhodes et al. 1989).

The present study has some limitations that warrant consideration. Firstly, participating owners were all females, and, accordingly, all the stimuli used in these experiments represented female faces. Although there is no direct evidence suggesting that dogs process female and male human faces differently, the fact that dogs could generalize the discrimination of human facial expressions only to novel faces of the same gender warrants caution (Nagasawa et al. 2011). Another possible limitation of the study is that, while our naïve dogs had not undergone the same specific experience that the experts had, they still had experience of living with humans. To which extent such

exposure influenced the mechanisms observed in this study, cannot be determined from our data. Solid evidence for the importance of individual experience with the real 3D-referents of pictures for discrimination of the latter comes from pigeons (Aust and Huber 2010). It would be interesting to examine how dogs without or with very limited exposure to humans (e.g. feral dogs) would perform in the tasks presented in this study.

3.5 Conclusions

In summary, visual processing of human faces by pet dogs seems to rely on configural information more than on information about face parts. Despite the great exposure of pet dogs to human faces in daily life, their ability to use primarily internal face features to discriminate even very related individual seems insufficient. Also the saliency of eyes may emerge to facilitate the extraction of global information about the whole face, rather than to gain detailed information about single parts. Far from being exhaustive, the present results encourage further studies on cognitive mechanisms underlying face processing in dogs. Among others, the salience of external face features, the face-specific role of the spatial relationships between features, the role of a different extent of exposure to human faces and the con-/hetero-specific effect need to be addressed to advance our understanding of the evolution of face processing abilities in mammals.

CHAPTER 4

Attention towards the caregiver in workers and pet dogs during a standardized learning level evaluation

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unpublished

4.1 Introduction

Attention is the process that can select to which stimuli, among all present in the environment, animals have to respond and modify their behaviour in reaction to them (Zentall 2005). Domestic dogs pay a lot of attention to humans. In food-related actions, attention toward human is greater than that paid to conspecifics (Range et al. 2009b) and they readily modify their behaviour, most likely due to the domestication process (e.g. Hare et al. 2002; Riedel et al. 2008; Virányi et al. 2008) and the social environment pet dogs live in (Kubinyi et al. 2003; Miklósi et al. 2003). The extent to which a dog can concentrate selectively on specific aspects of human visual signals is important for obtaining information (Hare and Tomasello 2005; Miklósi and Soproni 2006; Pongrácz et al. 2005), communication (Range et al. 2008; Kaminski et al. 2012), social learning (Pongrácz et al. 2001; Kubinyi et al. 2003; Range et al. 2007) and in particular imitation (Topál et al. 2006); all of which rely crucially on a dogs' ability to maintain attention toward humans when the signals are emitted (Lindsay 2001; Range et al. 2009). In addition, dogs can select also acoustic information, since they demonstrated to formulate expectations regarding the visual aspect of images depending on the auditory stimulus (Adachi et al. 2007) and their response to obedience commands is predicted by the verbal information given by humans (Braem and Mills 2010).

Presumably as a result of their special evolutionary history of domestication, dogs are sensitive to a lot of different human-given cues, including e.g. pointing, head turning or glancing in a particular direction (e.g. Miklósi et al. 1998; Soproni et al. 2001; Udell et al. 2008). Furthermore, dogs are also able to recognise human attentive state since they discriminate when a person is facing them (Gácsi et al. 2004) or when is inattentive (Cooper et al. 2003; Brauer et al. 2004; Schwab and Huber 2006) and modify their

behaviour accordingly. The efficiency of dogs to discriminate between attentive and inattentive humans depends on the context, but in general they could rely on the orientation of the body, the orientation of the head and the visibility of the eyes (Gácsi et al. 2004); however it has been proven that eye contact during dog-human communication is crucial (Kaminski et al. 2012) and that head features are important during the visual search for familiar persons (Mongillo et al. 2010).

As a very complex phenomenon, attention towards humans is not just linked to the abovementioned aspects, but is also related to dog-human relationship. Spending active time with dogs have demonstrated to enhance the cognitive abilities of dogs (i.e. see McGreeve et al. 2012 for a review) but also the quality of the relationship between owner and dog (e.g. Haverbeke et al. 2010). This is further confirmed by the fact that among family members dogs have a particularly close relationship with the main caregiver (Topál et al. 1998). Indeed dogs pay more attention to their owners respect to an unfamiliar human when they are present simultaneously (Mongillo et al. 2010), but they only attend more to those familiar humans with whom they also had a close relationship (Horn et al. 2013).

Among activities that owners practice with their dogs, training has shown to have multiple effects on dog behaviour and attention. In particular, depending on type of methods used, training has an effect on dogs' behaviour and emotions (e.g. Hiby et al. 2004; Schilder and van der Borg 2004; Haverbeke et al. 2008). Furthermore, training improves dogs' abilities in problem solving tasks (Range et al. 2009a), modifies the way they approach a novel situation, e.g. being more successful and more proactive in interaction with novel objects (Marshall-Pescini et al. 2008) and makes dogs more confident in solving a task ignoring owners' misleading information (Prato-Previde et al. 2008). Moreover training can increase dog attention more towards human than dog

demonstrators in a problem solving task (Range et al. 2009a) or during an on leash walk outdoor (Bentosela et al. 2008); instead can decrease attention towards owners to gain a solution in a problem solving task, since dogs may become more independent (Marshall-Pescini et al. 2008).

Although attention toward owners has been studied in both experimental social-cognitive and in natural environments (Mongillo et al. 2014), there are still unexplored conditions. For example those studies that investigated attention in experimental setting have considered as parameters the percentage of looking time (Range et al. 2009a) or the seconds spent oriented toward the owner (Marshall-Pescini et al. 2008) but rarely deepened the characteristics of the attention considering other parameters such as frequency and length of gazes or latency (Marshall-Pescini et al. 2009). Moreover, it is not known whether training indirectly affects attention since it strengthens the relationship with the owner or it has a direct effect due to practice with that particular learning situation. To disentangle those two possible mechanisms dogs should be assessed for their attitude to pay attention toward the owner both when the 'learning situation' is on-going, for instance during a working session and in more spontaneous situations in which no exercise is requested. Although is known that dogs' attention toward the owner may predict the outcome of obedience tasks (Braem and Mills 2010), there is a lack of data exploring the characteristics of attention parameters towards the owner during training sessions, since the previous study explored attention in a not staged procedure and only a the instant in which the owner gave the signal of one selected exercise. Instead, attention could also vary depending on the type of exercise and on their level of difficulty (i.e. execute the exercise or maintain the exercise for a certain time). Therefore a standardized procedure composed of different exercises and levels of difficulty and finalised at evaluating the quality of learning was set up in the

present research. Moreover, as in literature it has been reported several times an effect of training on both dogs' performances and attention, a second aim was to evaluate whether dogs' attention toward humans was affected by the quality and quantity of training they had received during their lives. To this aim pet dogs and working dogs were compared for their performance and attention parameters in the present study.

4.2 Methods

4.2.1 Ethics Statement

All participants joined the study on a voluntary basis; they signed a consent form and agreed the experiments to be videotaped and the data to be collected from the videos. All caregivers were unaware of the specific aims of the test. The experiments were performed in compliance with relevant laws in Italy.

4.2.2 Subjects

Pet dogs and working dogs were recruited and the final sample was composed of 46 subjects. The recruitment of the working dogs was performed among subjects enrolled since at least one year in the same activity (i.e. Animal Assisted Interventions) to collect a homogeneous sample accordingly to the kind of work. Such activity was selected since the recruitment was easy (the Department had contacts with many local associations due to previous collaborations) but also for several characteristics beneficial for the aim of the study (a good communication between handler and dog as a prerequisite, attitude to work in many kind of settings, in unknown indoors, in presence of distractions). The pet group was recruited among students of the University of Padova and their acquaintances. The recruitment ended when two groups homogeneous for gender and age were found.

The working (WD) group was composed of 23 dogs (M = 8; F = 6; spayed F = 9) and age ranged from 1 to 10 years (mean \pm SD = 4.4 \pm 2.8). It was not possible to recruit the same number of males as females since working dogs were mostly females. Represented breeds included: Labrador Retriever (N = 5), Golden Retriever (N = 2), American Staffordshire Terrier (N = 2), Bolognese (N = 1), Bernese Mountain Dog (N = 1), Staffordshire Bull Terrier (N = 1), Springer Spaniel (N = 1), Flat Coated retriever (N = 1), Dogo Argentino (N = 1) and some were mongrels (N = 8).

The pet (PD) group was composed of 23 dogs (M = 8; F = 6; neutered F = 9) and age ranged from 1 to 10 years (mean \pm SD = 4.4 \pm 3.1). Represented breeds included: Labrador Retriever (N = 1), Cocker Spaniel (N = 1), Husky (N = 2), West Highland White Terrier (N = 1), German Shepherd (N = 1), Boxer (N = 1), Belgian Shepherd (N = 1), Beagle (N = 1), Miniature poodle (N = 1), and some of them were mongrels (N = 13).

In all working subjects, training was performed by qualified dog trainers. Among pets, dogs did not receive any type of professional training and were declared to be naïve to any specific task (N = 8) or to have received a basic training performed at home directly by the caregiver (N = 10). Five dogs attended few basic obedience lessons at a training school when they were 4-6 months puppies.

Each dog underwent a physical examination and a behavioural assessment before the tests, to exclude overt medical conditions and behavioural diseases.

4.2.3 Experimental setting

The study was conducted in the Laboratory of Applied Ethology of the Department of Comparative Biomedicine and Food Science, University of Padova, Italy.

Each dog-human pair underwent the experiment in a 5 x 5 m room (Fig. 4.1) where a

table was placed in the corner opposite to the entrance door. Before the test started, a closed box containing some dry dog food, a dog food bowl and a small ball were placed on the centre of the table, to avoid the dog reaching them.

At the beginning of the test, the caregiver and the dog entered the room with the experimenter, who was in charge to explain general instructions about the procedure and technical issues (audio-transmitter working principles). This preliminary phase lasted 2 minutes and during this period the dog was off leash and free to move and to familiarize with the room. After 2 minutes they went out and when the actual procedure started, the caregiver entered the test-room alone with the dog, while the experimenter provided the instruction from the adjacent room via an audio-transmitter.



Figure 4.1. Video stills: Experimental setting and example of one of the exercises, in which the dyad is performing the exercise *Stay food*.

4.2.4 Procedure

The test was composed of 5 consecutive episodes consisting of three basic obedience exercises (*Sit*, *Down*, *Stay*) and two exercises performed in presence of distraction (*Stay food* and *Stay toy*). The caregiver was instructed to give the dog an appropriate signal (by voice and/or by gesture according to how the dog was trained or used to) and do not touch the dog during the execution of the exercise. Each dog was asked to maintain the

position requested for at least 30 seconds. The timing was calculated by the experimenter in the room next to the testing-room and after 30 seconds informed the caregiver that the exercise was concluded. After each exercise, the dog could be rewarded in the way the caregiver preferred, such as giving food or social contact. The description of the exercises is reported in detail in Table 4.1.

Table 4.1. Description of the 5 consecutive exercises performed in the procedure.

Exercises	Description
1. <i>Sit</i>	the caregiver gave the signal to sit.
2. <i>Down</i>	the caregiver gave the signal to lay down.
3. <i>Stay</i>	the caregiver gave the signal to stay then moved two meters away.
4. <i>Stay food</i>	the caregiver filled the bowl on the table with some dry food; the caregiver gave the signal to stay, then put the bowl on the floor in front of the dog.
5. <i>Stay toy</i>	the caregiver took the ball from the table; the caregiver gave the signal to stay, then put the ball on the floor in front of the dog.

4.2.5 Data collection and statistical analysis

The test was video-recorded with a closed-circuit camera system (WV-GP250, Panasonic, Osaka, Japan) for subsequent data collection. Four cameras were used to follow the dog's movements across the whole laboratory and enlarge details. Data on the duration of the procedure, the moment in which the handler gave the specific signal for each exercise, execution quality and latency (the time between the caregiver signal and the execution of the requested behaviour) and dog's gaze orientation were extracted from videos with the Observer^{®XT} software (version: 10.5.572- © Noldus Information

Technology 1990-2011). Inter-rater reliability of data collection was assessed between the coding done by a second blind observer on 18 videos using Pearson's correlation ($r = 0.820, P < 0.001$).

Nonparametric analysis was done for those variables that did not have normal distribution (assessed with Kolmogorov-Smirnov test) nor could be obtained by arithmetical transformation.

The quality of execution of the exercises was evaluated at the instant in which the caregiver gave the signal and was classified as instant perfect execution (IPE) or not, according to whether the dog performed or not the behaviour requested (for details see Table 4.2).

The number of pets and workers who performed IPE were compared with Pearson's chi-squared test to investigate a possible effect of training on the instant execution. Moreover the latency of IPE (the time in between the signal and the perfect execution of the behaviour) was calculated and compared between groups with nonparametric Mann-Whitney U test. Another parameter which was taken into account to evaluate the quality of performance was the maintained perfect execution (MPE, for details for each exercise see Table 4.2) and in particular was calculated its maximum duration and compared between groups with nonparametric Mann-Whitney U test. Finally, in both WD and PD groups, dogs were discriminated depending on whether they performed the MPE for 30 seconds or not.

In the all procedure the attention paid by dogs to their caregivers was evaluated with two parameters: gaze frequency (GF) and gaze length (GL). The preliminary 2-minutes familiarization phase was also analysed and considered as a baseline condition of the attention paid to the caregiver without any request of exercises. An independent samples t test was run to verify if GL and GF differed between WD and PD in this

baseline condition.

To assess possible effects of both the group (WD vs PD) and of the type of exercise on the attention paid to the caregivers (dependent variable), univariate GLM on both attention parameters (GF and GL) was performed.

Attention parameters (GL and GF) were also compared between dogs who maintained MPE for 30 seconds or not in both PD and WD with nonparametric Mann-Whitney *U* test.

Table 4.2. Description of the criteria adopted to evaluate the quality of execution for each exercise.

Exercises	Criteria
1. <i>Sit</i>	IPE: the dog sat. MPE: did not change the posture requested.
2. <i>Down</i>	IPE: the dog laid in ventral decubitus. MPE: did not change posture requested.
3. <i>Stay</i>	IPE: the dog assumed the requested position (could be sit, lie down or stand still depending on caregiver's preference). MPE: the dog maintained the position assumed at the moment of the signal and did not move.
4. <i>Stay food</i>	IPE: the dog assumed the requested position (could be sit, lie down or stand still depending on caregiver's preference) and did not try to reach the food. MPE: the dog did not move and did not try to reach the food.
5. <i>Stay toy</i>	IPE: the dog assumed the requested position (could be sit, lie down or stand still depending on caregiver's preference) and did not try to reach the ball. MPE: the dog did not move and did not try to reach the ball.

IPE = instant perfect execution; MPE = maintained perfect execution

Concerning each exercise, other two parameters were evaluated: first, the number of subjects orientated toward the caregiver at the instant in which he/she gave the signal (IOC, instant orientation toward caregiver); second, the percentage of orientation (POC, percentage orientation toward caregiver) during the 3 seconds before and after that instant was extracted. POC were compared between WD and PD with nonparametric Mann-Whitney U test.

All statistical analyses were performed with PASW (Predictive Analysis SoftWare, 18.0 Syntax Reference Guide; SPSS, Inc., Chicago, IL). Statistical significance was set at 5% for all tests.

4.3 Results

The overall procedure lasted 244.3 ± 18.7 seconds (mean \pm SD).

In all exercises some caregivers of both groups lured the dog to gain the requested posture, therefore those cases were excluded from the analysis of IPE, latency of IPE and POC during the 3 seconds before and after the signal. Final number of subjects per group for each exercise resulted the following: *Sit*: WD = 23, PD = 19; *Down*: WD = 10, PD = 4; *Stay*: WD = 21, PD = 21; *Stay Food*: WD = 14, PD = 11; *Stay Toy* WD = 18, PD = 17.

Workers and pets did not perform differently immediately after the signal in any exercise except for *Stay Food* where workers outperformed pets (number of subjects who performed IPE: WD = 14; PD = 6; $t_2 = 6.750$, $P = 0.034$).

Mean latency (s) to IPE did not differ between groups in any exercise (*Sit*: WD = $1.9 \text{ s} \pm 1.4$, PD = $2.9 \text{ s} \pm 5.6$ $Z = 0.170$, $P = 0.878$; *Down*: WD = $0.5 \text{ s} \pm 1.0$, PD = $5.4 \text{ s} \pm 5.2$, $Z = 7.062$, $P = 0.078$; *Stay*: WD = $0.7 \text{ s} \pm 2.2$, PD = $1.7 \text{ s} \pm 3.8$ $Z = 1.505$, $P =$

0.132; *Stay Food*: WD = 0.2 s ± 0.5, PD = 3.7 s ± 8.7 Z = 1.915, P = 0.365; *Stay Toy*: WD = 2.5 s ± 3.6, PD = 7.2 s ± 8.7 Z = 1.462, P = 0.175).

Workers outperformed pets in the ability to maintain the behavior requested: in all exercises except for *Sit*, the mean MPE maximum duration was longer in WD (*Sit*: WD = 28.7 s ± 15.3, PD = 23.8 s ± 13.7 Z = -0.993, P = 0.320; *Down*: WD = 45.4 s ± 18.5, PD = 25.9 s ± 21.8 Z = -2.313, P = 0.019; *Stay*: WD = 45.1 s ± 22.6, PD = 28.2 ± 21.3 Z = -2.362, P = 0.018; *Stay Food*: WD = 28.8 s ± 23.3, PD = 13.9 ± 15.5 Z = -2.183, P = 0.029; *Stay Toy*: WD = 52.5 s ± 28.6, PD = 26.9 s ± 26.7 Z = -2.992, P = 0.003). In Table 4.3, the number of pets and workers that performed MPE for 30 seconds is reported.

Table 4.3. Number of dogs divided per group (i.e. pets and workers) that performed MPE for thirty seconds in each exercise.

Group	<i>Sit</i>	<i>Down</i>	<i>Stay</i>	<i>Stay food</i>	<i>Stay toy</i>
PD	6	7	11	4	10
WD	9	16	18	12	18

PD = pet dogs; WD = working dogs.

Regarding attention paid by dogs, in the 2-minutes familiarization phase no difference in both GL ($t_{44} = 1.419$; $P = 0.163$) and GF ($t_{44} = 0.613$; $P = 0.543$) between workers and pets was found.

During the exercises, the orientation at the moment in which the caregiver gave the signal (IOC) was showed in the most of dogs in all exercises: 91.3% of both workers and pets in the *Sit* episode; 82.6 % of workers and 60.9 % of pets in *Down*; 91.3% of workers and 80.0% of pets in *Stay*; 78.3 % of both workers and pets in *Stay Food* and 82.6% of workers and 69.6 % of pets during the *Stay Toy*. Moreover, POC was high

and did not differ between groups in any exercise (*Sit*: WD = 81.4 % ± 24.6, PD = 78.9 % ± 19.9 $Z = -0.863$, $P = 0.388$; *Down*: WD = 77.0 % ± 30.7, PD = 74.4 % ± 33.4, $Z = -0.253$, $P = 0.862$; *Stay*: WD = 86.6 % ± 21.4, PD = 72.6 % ± 27.0 $Z = -2.025$, $P = 0.050$; *Stay Food*: WD = 76.8 % ± 24.9, PD = 66.5 % ± 22.0 $Z = -1.489$, $P = 0.139$; *Stay Toy*: WD = 72.6 % ± 21.0, PD = 70.3 % ± 23.0 $Z = -0.122$, $P = 0.916$).

Taking into account the attention parameters, the univariate GLM indicated independent effects of group (WD vs PD) and type of exercise (*Sit*, *Down*, *Stay*, *Stay Food*, *Stay Toy*) on both GL (Table 4.4) and GF (Table 4.5). No effect resulted from the interaction between the two variables. Workers gazed longer and less frequently their caregivers during the all procedure, independently from the exercise.

Table 4.4. GLM model results showing the effects of group and type of exercise on gaze length.

Effect	Levels	mean ± SD (s)	F	<i>P</i>
Group	Workers	9.5 ± 0.6	24.749	<0.001
	Pets	5.5 ± 0.6		
Type of exercise	<i>Sit</i>	9.5 ± 9.5	8.310	<0.001
	<i>Down</i>	7.1 ± 8.2		
	<i>Stay</i>	10.7 ± 8.8		
	<i>Stay Food</i>	5.7 ± 3.8		
	<i>Stay Toy</i>	4.2 ± 2.0		
Group*Type of exercise			0.180	0.949

Table 4.5. GLM model results showing the effects of group and type of exercise on gaze frequency.

Effect	Levels	mean \pm SD (N)	F	P
Group	Workers	5.9 \pm 0.3	30.729	<0.001
	Pets	8.0 \pm 0.3		
Type of exercise	<i>Sit</i>	5.9 \pm 2.7	7.227	<0.001
	<i>Down</i>	7.2 \pm 3.7		
	<i>Stay</i>	5.8 \pm 3.3		
	<i>Stay Food</i>	7.4 \pm 3.2		
	<i>Stay Toy</i>	8.4 \pm 3.2		
Group*Type of exercise			1.193	0.315

In the all sample including both pet and workers, Duncan's *post hoc* test revealed that GL (Table 4.6) was shorter when they remained still in presence of distractors, i.e. food or toy, respect to when they performed the same exercise without distractors (shorter *Stay Food* and *Stay Toy* than in *Stay*); moreover GL was shorter in *Stay Toy* than in *Sit* whereas *Stay Food* almost reach significance in comparison with *Sit*. The GF (Table 4.7) was higher in presence of only one out of the two distractors and in respect to only two of the other exercises (higher in *Stay toy* than both in *Sit* and *Stay*).

Comparing the dogs who showed MPE for at least 30 seconds or not, differences in attention parameters were found only for the workers group and in particular in these exercises in which there was a distraction (food or toy). As showed in Figures 4.2 and 4.3, workers who maintained the execution for at least 30 seconds showed longer GL in *Stay* and *Stay Toy* (respectively: $Z = 2.043$; $P = 0.042$, $Z = 2.013$; $P = 0.046$) and longer GL but lower GF in *Stay Food* (respectively: $Z = 3.508$; $P < 0.001$, $Z = -3.508$; $P < 0.001$).

Table 4.6. Effects of the type of exercise on gaze length (s). Duncan's *post hoc* test showing multiple comparisons between exercises.

Exercise (1)	Exercise (2)	Mean difference (1-2)	95% CI		P
<i>Sit</i>	<i>Down</i>	2.4	-1.7	6.4	1.000
<i>Sit</i>	<i>Stay</i>	-1,1	-5.2	2.9	1.000
<i>Sit</i>	<i>Stay Food</i>	3,8	-0.2	7.9	0.083
<i>Sit</i>	<i>Stay Toy</i>	5,4	1.3	9.4	0.002
<i>Down</i>	<i>Stay</i>	-3,5	-7.5	0.6	0.163
<i>Down</i>	<i>Stay Food</i>	1.5	-2.6	5.5	1.000
<i>Down</i>	<i>Stay Toy</i>	3.0	-1.1	7.0	0.366
<i>Stay</i>	<i>Stay Food</i>	4.9	0.9	9.0	0.007
<i>Stay</i>	<i>Stay Toy</i>	6.5	2.4	10.5	<0.001
<i>Stay Food</i>	<i>Stay Toy</i>	1.5	-2.5	5.6	1.000

CI = confidence interval.

Table 4.7. Type of exercise effect on gaze frequency (N). Duncan's *post hoc* test showing pair comparisons between exercises.

Exercise (1)	Exercise (2)	Mean difference (1-2)	95% CI		P
<i>Sit</i>	<i>Down</i>	-1,4	-3.1	0.4	0.254
<i>Sit</i>	<i>Stay</i>	0.1	-1.6	1.8	1.000
<i>Sit</i>	<i>Stay Food</i>	-1.6	-3.3	0.1	0.100
<i>Sit</i>	<i>Stay Toy</i>	-2.6	-4.5	-0.9	<0.001
<i>Down</i>	<i>Stay</i>	-1.4	-0.3	3.1	0.185
<i>Down</i>	<i>Stay Food</i>	-0.2	-1.9	1.5	0.603
<i>Down</i>	<i>Stay Toy</i>	-1,3	-3.0	0.4	0.340
<i>Stay</i>	<i>Stay Food</i>	-1.6	-3.4	0.1	0.070
<i>Stay</i>	<i>Stay Toy</i>	-2.7	-4.4	-1.0	<0.001
<i>Stay Food</i>	<i>Stay Toy</i>	-1.1	-0.6	2.8	0.756

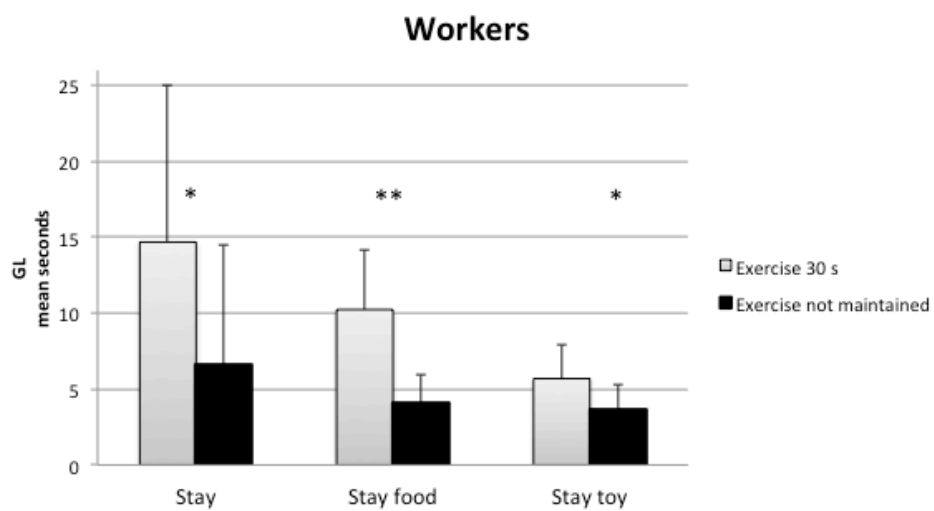
CI = confidence interval.

Figure 4.2. Differences in GF (numero al minuto? vedi comment di prima) between workers who maintained the position for 30 seconds or not in the *Stay Food* exercise.



* = $P < 0.05$; ** = $P < 0.001$

Figure 4.3. Differences in GL between workers who maintained the position for 30 seconds or not in the *Stay*, *Stay Food* and *Stay Toy* exercises.



* = $P < 0.05$; ** = $P < 0.001$

4.4 Discussion

The present study was aimed at exploring the characteristics of attention parameters towards the owner during a training session in which different type of exercises and levels of difficulty were requested and at evaluate whether dogs' attention toward humans was affected by the quality and quantity of training they had received during their lives. Interestingly, the present results confirmed both an effect of type and level of exercises on attention but also an effect of type of training received on attention parameters.

Regarding the performances of the exercises, both workers and pets were attentive to the handler when he/she gave the specific signal and immediately performed the behaviour requested in almost all exercises. This is in agreement with Braem and Mills (2010) who observed that half of dogs had their face turned towards their handlers at the moment of the first 'sit signal' and most of them performed the behaviour immediately. The only exception was for *Stay food* for which a specific training was necessary. The main differences between workers and pets in the performances came out when they were asked to maintain the exercise for at least thirty seconds: in this case the qualified training and the working experience were necessary to achieve the execution. Accordingly, among factors that can affect obedience in dogs, there is training history (Hiby et al. 2004) and the experience of the dog handler (Lynge and Ladewig 2005), both depending on having attended courses, which let both the dog and the handler be more prepared to perform harder exercises. The only one exercise pets were able to maintain as workers did was *Sit*, which is the most commonly known exercise by pet dogs as it is one of the behaviours more often spontaneously expressed. Further, the working experience had also an effect on the attention patterns. Workers had longer but less frequent gazes respect to pets in the exercise session procedure.

This means that they could sustain their attention towards the caregiver and be less distracted from the environment. Probably this higher attention let dogs performing better when the exercises was required to be maintained.

There are many other factors that can affect obedience performances in dogs: the verbal information preceding the command (Braem and Mills 2010), whether the command is recorded or pronounced directly by humans (Fukuzawa et al. 2002), restricted access to eye contact (Soproni et al. 2001) or of body movements (Fukuzawa et al. 2005). However, other than the visual or auditory information available, the performance is also affected by the difficulty of an exercise: on one hand some postures could be less spontaneous and harder to train and on the other hand some exercises could influence attention, since their execution require the inhibition of spontaneous behaviours e.g. the orientation towards distracting stimuli. Indeed, the present study evidenced that also the type of the exercises and their levels of difficulty have an effect on attention parameters. Independently from the working experience, in all dogs the attention varied according to the exercises type, in particular gaze length decreased in presence of distractors (food and toy) while gaze frequency was higher in presence of a toy but not with food respect to other exercises without distractors. Not surprisingly, the presence of distractors reduced the attention towards the caregiver, however they determined different results. In presence of food dogs alternated gazes between the handler and the bowl and the length of the gazes toward the caregiver was shorter, since attention was captured by the presence of food available. In presence of the toy, instead, the gazes towards the caregiver were not only shorter but also more frequent, resembling a pattern expressed in referential communication and defined *showing* behaviour (Miklósi et al. 2000). Therefore, the presence of a toy could be a condition that predicts an interaction with the owner and the gaze alternation between the caregiver and the toy

could be interpreted as an engagement of functional referential communication, since higher frequency of gazes at the owner in the presence of a toy was a behavioural pattern previously described in dogs in similar situation (Kaminski et al. 2012). Finally, *Down* was the only exercise that did not differ from any other one in both gaze length and frequency. One explanation could be that this exercise had an intermediate difficulty and attention patterns varied accordingly. However, it was also the exercise in which most of the handlers lured their dogs to obtain the correct posture. Luring could have attract dog attention at the very beginning determining an increment of mean gaze length, but then, for the rest of the time dog were distracted by the environment, not as much as in the presence of distractors but not focused on the owner as much as in the *Stay* or *Sit*. One hypothesis could be that is common among owners to ask dogs to lay down when they need the dog wait for them for some time, and dogs could have learned to not expect any other immediate signal from the caregiver and to wait until the release in a relaxed way, looking at the environment or lying down with the head on the floor. It could be interesting, in further studies, to analyse the type of visual signals given by the handlers, since they could have favoured longer gazes during *Sit* and *Stay*. There is a relation between attention and the ability to perform a task, since eye contact is fundamental when dogs have to execute a requested behaviour (Virányi et al. 2004) and a positive correlation between attention and success rate of dogs in finding hiding objects in a room was found (Peter et al. 2013). In the present study, workers who performed optimally, i.e. maintained the behaviour at least thirty seconds, had difference in attention patterns respect to workers that were not able to maintain the position, in particular in the three versions of stay exercise (with or without distractors). They gazed longer the caregiver when performed the stay or the stay in presence of toy and gazed longer and less frequent in presence of food. Therefore to maintain an

exercise with distractors, attention should vary respect to that observed for the overall sample, i.e. longer gazes with both distractors and a decrement of frequency in presence of food are needed. Probably, workers who can stay still in presence of food or toy for such duration have learned that the easiest way to gain them is to suppress their spontaneous orientation toward relevant stimuli such as food and toy. Moreover, to have success in presence of food they need also to reduce the frequency of gaze alternation since if they look at the food too often, the risk to fall in temptation to try to reach the food becomes higher. Also among pets there were dogs that maintained the exercise required for at least thirty seconds but no differences in attention parameters were found, as in workers. When the distractor was the food, differences could not have emerged because very few subjects maintained the position in presence of food. Regarding the toy distractor, pets could have had success in maintaining the exercise since they were referentially alternating the gaze between the toy and the caregiver while waiting and no longer gazes were exhibited. However, this type of attention pattern did not let them perform as workers.

The present is the first study comparing the same groups in both learning and not learning contexts and interestingly, in the familiarization phase, no differences were found between workers and pets. Therefore, the effect of qualified training on attention patterns emerged only during the working session, while in the baseline condition did not. It is possible that working experience could have modified attention only in the specific context of working routine. It has been argued that working experience can have an effect on the relationship between the caregiver and the dog, since working activity could develop a stronger attachment bond between them (Mariti et al. 2013) or more in general, since it implies more active time spent together and enhances the quality of the relationship between owner and dog (e.g. Haverbeke et al. 2010). By the

results of the present study, the effect of training on attention was very context-related to the learning evaluation procedure and no differences were found in the baseline condition. If training has an effect on the relationship, this could emerge in other contexts or affecting other parameters that were not taken into account in the present study. However, the effect on relationship is probably not related to the specific increment in attention patterns due to training.

4.5 Conclusions

In conclusion, training experience seems to produce specific effects on the ability of dogs to maintain a sustained attention towards the caregiver. This condition leads the dog to focus on him/her caregiver, to increase its resistance to distracting environmental stimuli and possibly to improve the performances in activities where distracters are present. Other than an effect on the general attention paid by the dogs to their caregivers, we can argue that training has a direct consequence on attention in specific contexts. In line with previous studies, the effect of training on attention parameters seems to be evident in challenging situation whereas its effect on dog-owner relationship may be due to other aspects more likely related to emotional and social processes.

CHAPTER 5

General discussion

To investigate the relevance of visual information during the associative learning, the present PhD project was developed around three independent studies. The first assessed the visual processing of global and local levels of hierarchical stimuli. The second investigated the relative contribution of part-based and configural processing in the discrimination of human faces and the influence of specific training on the reliance on such mechanisms. The third explored the characteristic of dog's attention to natural visual stimuli (humans) during a training session and the effect of training dogs had received during their lives on their attention to humans.

Dogs mainly attended to global rather than local information while discriminating hierarchical visual stimuli and this preference was affected by the speed of acquisition of the learning criterion during the training. This preference for global aspects was confirmed by the second study. Dogs discriminated the elements of a human face pictures and among them the eyes had a great relevance for the discrimination; nevertheless, they attended prior to the configural information to choose the owner. However, with specific training dogs could also rely on part-based processing to discriminate the owner from an unfamiliar person. The training had a very context-related effect, since all dogs were used to humans face and in particular to their owner's face, however, despite of this extensive experience, only a training that forced them to

focus on the elements of a face let them able to use easily this information during the discrimination.

The specific effect of training emerged also in the third study. When the visual stimuli were humans, having received a specific training modified dogs' attention towards the caregiver. The variation of attention pattern did not emerge in a baseline condition but only when the caregiver asked the dog to perform some obedience exercises evidencing that the training had a very context-related effect. Indeed, even if with differences depending on the presence of distractors, working dogs exhibited more advanced attention patterns than pets during the execution of the exercises.

In conclusion, dogs seem to acquire more quickly and spontaneously global/configural information and when an effect of training is present, this effect is specific and strictly context-related.

Deepen which features capture dog's attention and in which ways attention can be affected have important implications in improving dog-human interactions and communication. Research on this topic could lead to step closer towards the understanding of dogs cognitive abilities, and more practically, to give inputs to caregivers and professional practitioners about how to enhance the quality of training or communication and to choose different strategies to gain the performances desired according to contexts.

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2. E. Pitteri, P. Mongillo, P. Carnier, L. Marinelli, L. Huber (2014). Part-based and configural processing of owner's face in dogs. *Plos One*, vol. 9; e108176.

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3. E. Pitteri, P. Mongillo, S. Adamelli, S. Bonichini, L. Marinelli (2014). The quality of life of pet dogs owned by elderlies depends on the living context, not on the owner's age. *Journal of Veterinary Behavior*, vol. 9; p. 72-77.
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