The Effects of Robot-Canine Facial Morphology Manipulation on Trait Perception

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By

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1. Abstract

Previous research has examined the effects of morphology on the way people perceive the traits of others. There also exists debate in the literature about whether morphological features influence the way people perceive trainability of dog breeds. The current study combined both of these aspects and investigated their applicability to human perceptions of the traits of robot canines. Participants were required to rate 54 morphologically manipulated images of robot canines on traits of strength, speed, agility, intelligence, aggressiveness, loyalty and trainability. The set of images consisted of every possible combination of two face colours, three ear shapes, three face shapes, and three eye colours. Eye colour, face shape, face colour and ear shape were all found to have significant influence on trait perceptions. Implications in regard to the field of robotics and the selection of working dogs are discussed.

2. Introduction

This study considers a variety of research that has explored the way in which peoples' perceptions are influenced by physical features. The following literature overview addresses the influence of these features of humans, non-human objects and canines, and their relation to the field of robotics.

2.1 Human Morphometrics

The study of the shape of living organisms has extensive history. By the middle of the twentieth century, the study of morphological shape had benefited from advances in both the quantitative description of shape, and statistical analyses describing variations in these shapes (Adams, Rohlf & Slice, 2004). This has resulted in the development of the modern field of morphometrics - the study of the covariation of shape with other variables (Bookstein, 1997). Studies that have considered human aspects of morphometrics have generally sought to investigate how both perceived and objective measures of various traits and qualities change as biological shapes change.

One area of morphometrics of particular interest to researchers is that of the facial morphometrics of humans, and the way that face shape affects how people perceive one another. Researchers of human morphometrics have examined the effects of facial shape in regard to perceived attractiveness, strength, and various other attributes. Humans are generally content to make personality judgments using facial features alone, without any behavioural cues (Penton-Voak, Pound, Little & Perrett, 2006) and these judgements are made quickly, without deliberation or reflection (Todorov et al, 2005; Hassin & Trope, 2000).

One such example of the effects of morphometry comes from Windhager, Schaefer & Fink (2011).They studied the relationship between male facial structure, hand grip strength, and women's perceptions of male dominance, masculinity and attractiveness. Specific morphological features were associated with varying perceptions of these traits. Dominance and masculinity were attributed to roundness of face, width of eyebrows and prominence of jaw; attractiveness and height were associated with length/width of jaw, and width/volume of lips.

Similarly, Carre, McCormick and Mondloch (2009) conducted a study investigating the relationship between the width-to-height ratio of male human faces and aggressive behaviour. They note that facial width-to-height ratio is independent of body size, and may result from sexual selection rather than occurring randomly. Along with comparing behavioural measures of aggression with facial width-to-height ratio, the authors also had participants estimate the men's levels of aggression based solely on facial photographs. Two studies were conducted; in the first, the faces were shown for 2000ms; in the second, only for 39ms. In both studies, the observer's estimates were highly correlated with the actual aggression of the men suggesting that facial width to height ratio not only influences people's perception of aggression, but also correlates with objective measures of the trait. The lack of difference in perceiver judgments between the two exposure times of the photographs also provides evidence that judgements of a face happen quickly, and are not significantly affected by exposure duration.

Facial width has also been investigated in the context of trust (Stirrat & Perrett, 2010). Participants in this study were asked to make decisions regarding collaboration for mutual financial gain, or exploitation for greater personal gain. Males were deemed less trustworthy with wide rather than narrow faces. Interestingly, this perception proved to be accurate, such that men with greater facial width were more likely to exploit the trust of others in the game. This phenomenon was also controllable; computer manipulation of the original stimuli resulted in differing perceptions, depending on how the images were manipulated.

The impact of facial features on decisions that people make in day-to-day life has also been explored. Ballew & Todorov (2007) sought to test whether competency judgements from faces would predict election victory at better than chance rates. Participants were shown photos of both winner and runner up for 89 senate elections, and asked to judge which of the two was more competent. If participants recognised either of the faces for any given election, their judgements for that election were not analysed, to avoid any bias from previous knowledge of the contenders. They found that participants were more likely to choose the winner as being more competent. This suggests that the effects that faces have on day to day decision making may actually be more pronounced than most would assume, in ways that those making the decisions would be unlikely to recognise. The studies described above highlight the way in which faces impact upon decisions that people make in their everyday lives, and how particular aspects of faces relate to particular judgements and perceptions. Although this summary is by no means all-encompassing, it exemplifies the significant influence human faces have on perceptions and decision making.

It is worthy to note that the effects of facial morphometry on perception have also been shown to extend to inanimate objects. Windhager et al (2012) conducted a study with participants from Austria and Ethiopia, in which they were shown car-front geometry with shapes that were similar to face-shape geometry. Differing nationalities were used as a means of avoiding confounds such as car-model familiarity, as the day-to-day exposure to cars in Ethiopia would likely differ greatly to that in Austria. Participants were asked to rate the front-on views of the cars on various psychological traits. Shapes that corresponded to maturity, maleness and dominance were highly similar in both countries, despite the different types of vehicle that each population would likely be familiar with. Because this phenomenon generalizes beyond human faces, the system used to recognise features of faces may be used in the recognition of other objects, as long as those objects are similar to human faces in composition.

2.2 Canine Morphometrics

In regard to this study, the way in which morphology's influence extends to non-human faces is particularly relevant. Morphology's effect on people's perceptions of dogs is by no means as well researched as it is in humans, but there is still research that has considered it as a central topic. Helton (2010) describes the way in which humans perceive differing breeds of dog to have differing levels of trainability. Evidence from various studies (Coren, 1994; Ley et al., 2009; Rooney & Bradshaw, 2004; Serpell & Hsu, 2005) shows that the ranking of breeds in terms of trainability is consistent, with the same breeds repeatedly being ranked high or low on this trait. Although there is a consistent perception by experts that there are differences in trainability between breeds, there are multiple studies that provide evidence to the contrary. Helton (2010) compared agility competition statistics for breeds that were perceived to differ in trainability, and found no significant difference in terms of precision between breeds perceived to be elite and other breeds. Furthermore, trainers reported no significant difference in the amount of time required in training to achieve mastery between "elite" breeds and other breeds deemed less trainable. Pongracz et al. (2005) also failed to find any differences between breeds in the learning of a detour task (in which dogs have to navigate an obstacle) from human demonstrators. Although there is debate whether trainability differences genuinely exist between different dog breeds, one point is clear: whether or not these differences actually exist, they are undoubtedly *perceived* to exist.

The question then becomes, if these differences are only perceived to exist, rather than being objectively measurable, what creates and shapes these perceptions? Helton (2009) explored the possibility that this perceived difference might exist due in part to differences in morphology between different dog breeds. As noted by Helton, various differences in the physical characteristics of dog breeds are obvious and are based on cephalic index (ratio between skull width and length). Dogs are classified along a spectrum of dolichocephalic (long skulls), mesocephalic (moderate skulls) and brachycephalic (broad skulls).

Helton (2009) conducted a study in which the cephalic properties of various breeds of dog were compared to their perceived trainability (from Cohen, 1994). The aim was to test the hypothesis that perceived levels of trainability would differ between cephalic morphologies; namely, that breeds perceived to be highly trainable would have a more mesocephalic morphology. In support of their hypothesis, it was found that the breeds perceived to be highly trainable present as more uniformly mesocephalic; that is, they are closer to the mean cephalic shape of all dogs sampled. Helton (2009) posits that this might be due to specific tasks that dogs at each end of the cephalic scale are known to specialise in. The selection of dogs in the middle of the scale as the most trainable might be due to a perception that they are suitable for a wider range of tasks, rather than specific tasks.

2.3 Robotics

As the world of technology changes, it is reasonable to predict that the effects of morphology will be relevant not only in humans and animals, but also in machines that share their characteristics. The use of robots in various applications is increasing, as useful designs come to fruition and the costs of the materials needed to build them decreases. As a way to ensure that interactions between robots and humans become more efficient, it makes sense that robots should have features that humans easily understand. Facial aspects are an important factor in this, due in part to the above descriptions of the way that humans quickly make judgments from faces. As noted by Dautenhahn & Werry (2000), the life like appearance of a robotic system does not matter as much as the degree to which the system can express personality, character and emotion. That is, it is not how closely the morphology of a robot matches a familiar form, but whether it can express qualities that a person can relate to. This point is important, as it conveys the idea that the most humanoid looking robot may not necessarily be the most adept at creating an effective human-to-robot interaction. Some studies discussing the importance of realism in robot faces such as Blow et al (2006) consider the problems with creating human-like faces for robots. Faces are complicated, hard to make, and are the most likely part of a robot to give it properties associated with the "uncanny valley"— an idea proposed by Mori (1981), which posits that although increased realism of a humanoid robot increases its acceptance, there is a point prior to perfect realism where the robot becomes disturbing, diminishing its acceptance significantly. Given this insight, it makes sense that robots should be created with the aim of expressing different properties depending on their use, rather than prioritising highly realistic humanoid features. For example, a robot used to teach children would need to be able to convey friendliness and intelligence without appearing scary. In contrast, a robot used in a military application may benefit from appearing intimidating and tough. Implementation of information gathered in both human and non-human studies of morphology would likely be useful in the design of robots, particularly in regard to the efficiency of their communication with humans. Knowledge of the ways that particular areas of morphology relate to the creation of particular perceptions offers insight into the way that robots should be designed for particular uses.

Although repeated interaction with robots may allow people to make assessments based on actual robot behaviour, initial acceptance or purchase decisions may be made solely on the *look* of the robot (first impressions). Indeed the history of technology is rife with examples of more functional products being beaten in the market by the elegance of design (for example, there were a number of pre-existing competitors to the iPod which actually had more functions, but the iPod conveyed initial positive impressions).

In addition to the various morphometric features manipulated in the current study, the colour of the robot canine's eyes and faces were also manipulated. While colour is not really a morphometric property, it may interact with morphometric features and influence people's impressions. For example, a robot with red eyes may look even more aggressive when combined with a facial profile indicating power or masculinity.

The role and function of colour in terms of perceptual organisation has been previously explored. One theory proposes that those in the animal kingdom with colour vision use it as an important tool to gain information about important environmental factors, such as species identification, sexual attraction, danger, and poison (Pinna & Reeves, 2013). Dresp-Langley & Langley (2009) note that colour signalling is used ubiquitously in the lives of humans, and affords us the ability to react appropriately in certain environments. The importance of colours in human life extends beyond the relatively simple functions that it provides in the greater animal kingdom. Humans have assigned various emotional aspects to colours; for example, the colour red is often attributed to danger; pink to love and affection, and green to life, vitality and health (Dresp-Langley & Langley, 2009). Birren (1978) & Sharp (1975) showed that red is associated with aggression, black with anxiety, and green with withdrawal. The impact that different colours have on emotions and decision making gives them relevance in any situation where a judgement of an object, organism or situation is formed.

This study seeks to tie together aspects of research from human and canine morphology literature and the field of robotics, to explore the extent to which the morphology of robot canines affects the way a robot is perceived. There is also particular interest in the way that morphology affects perceptions of the trainability of canines, due in part to the lack of agreement on this topic in literature. In the present study, variables of eye colour, face shape, ear shape and face colour will be investigated in regard to their effect upon perceptions of seven traits (strength, trainability, agility, intelligence, loyalty, speed and aggressiveness) when manipulated.

These variables were chosen for particular reasons. There are a number of features that could be manipulated in the creation of a robot; however, the variables described above have been shown to have influences upon human perception in contexts other than robotics.

Given the above, the following hypotheses are made regarding the outcomes of this study.

Hypothesis 1 – eye colour will have an impact upon perceptions of traits. The various associations that humans give to different colours (as mentioned above) are expected to impact upon the way that people rate the seven traits. Specific eye colours are consistently associated with particular qualities in popular culture; red eyes are more often given to dangerous characters and villains (a good example being the Cylon robot characters in the original Battlestar Galactica television show, with bright red lights resembling eyes and the intention of ridding the galaxy of life).

Hypothesis 2 – Ear shape will have an impact upon perceptions of traits. Although there has been little research into the way that shapes of ears impact how people perceive the owner of the ears, properties associated with particular types of ears in popular culture hint at a link. The cropping of ears is commonplace in fighting dogs in countries where the practice remains legal; the result of this process leaves the dog with distinct upright pointy ears, a look which is unsurprisingly associated with fighting and fierceness. These general associations of particular ear types for particular temperaments of dog are evident in the way dogs are shown in popular culture, especially film and television.

Hypothesis 3 – Face shape will have an impact upon perceptions of traits. In particular, the work of Helton (discussed above) posits that the varying perceptions regarding the trainability of dogs might be due to their varying cephalic indexes (ratio of width to length of skull). Based on this work, it is expected that the dogs that are regarded as the most trainable will have neither a particularly narrow or particularly broad facial structure. The literature on human morphology (also discussed above) provides evidence that humans make various trait judgments based on particular facial features; as this has been shown to extend to non-human objects, it is expected that it will extend to robotic canines.

Hypothesis 4 – Face colour will have an impact on the perception of traits. As discussed above, colour is a vital tool that members of the animal kingdom rely on to gain information about their environment. Studies have provided evidence that humans readily associate particular emotions and qualities with particular colours, and it is thus expected that face colour will have an influence upon the trait perceptions measured in this experiment.

3. Method

3.1 Participants

Fifty nine participants (29 male, 30 female) completed the experiment. Participants were recruited through University of Canterbury research forums, and internet social networking. The age of participants ranged from 19 to 38 (M = 23.39, SD = 3.94).

3.2 Materials and Procedure

The experiment was distributed using the online survey software Qualtrics, meaning that the experiment could be completed wherever an internet connection was available. Participants were notified that it would take approximately thirty minutes to complete the experiment. The experiment consisted of two sets of questions. Initially, participants were asked to answer a series of demographic questions. The second set of questions consisted of 54 images of robot canines (included in Appendix A). Participants were asked to rate these images on strength, speed, agility, trainability, aggressiveness, intelligence and loyalty. A seven-point Likert scale was used in the rating of traits, ranging from a score of 1 (strongly disagree) to a score of 7 (strongly agree).

The 54 images were created from one original image, and used combinations of four different variables; three ear sets, three face dimensions, three eye colours, and two face colours. The ear set consisted of upright ears, bent ears, and floppy ears. Face dimensions consisted of the original image, 15% shorter/15% broader than the original image, and 15% longer/15% slimmer than the original image. Eye colours used were brown, red and blue, and face colours used were black and white. If the colour of a face was white, the lines detailing the features were black; if the face was black, the lines detailing the features were white. Each image was displayed on a grey background, and for each participant, the 54 images appeared in a random order. Every image was displayed once and never more than once.

Participants were not able to progress from an image until they had answered all seven questions for each image. Figure 1 shows an example image and question set; the entire set of images used is included in Appendix 1.

The scaling of the base image to the broader/shorter and longer/narrow images was achieved using the scaling tool in the image manipulation program GIMP; this provided an accurate way of exactly scaling an image 15% in a particular direction. The base image was initially created using only half a face, enabling it to be mirrored and thus perfectly symmetrical. Upon completion of the experiment, participants were offered the opportunity to enter a prize-draw for an iPad. To ensure personal email addresses could not be linked to particular participant’s responses, they were redirected to a separate Qualtrics survey if they wished to enter.

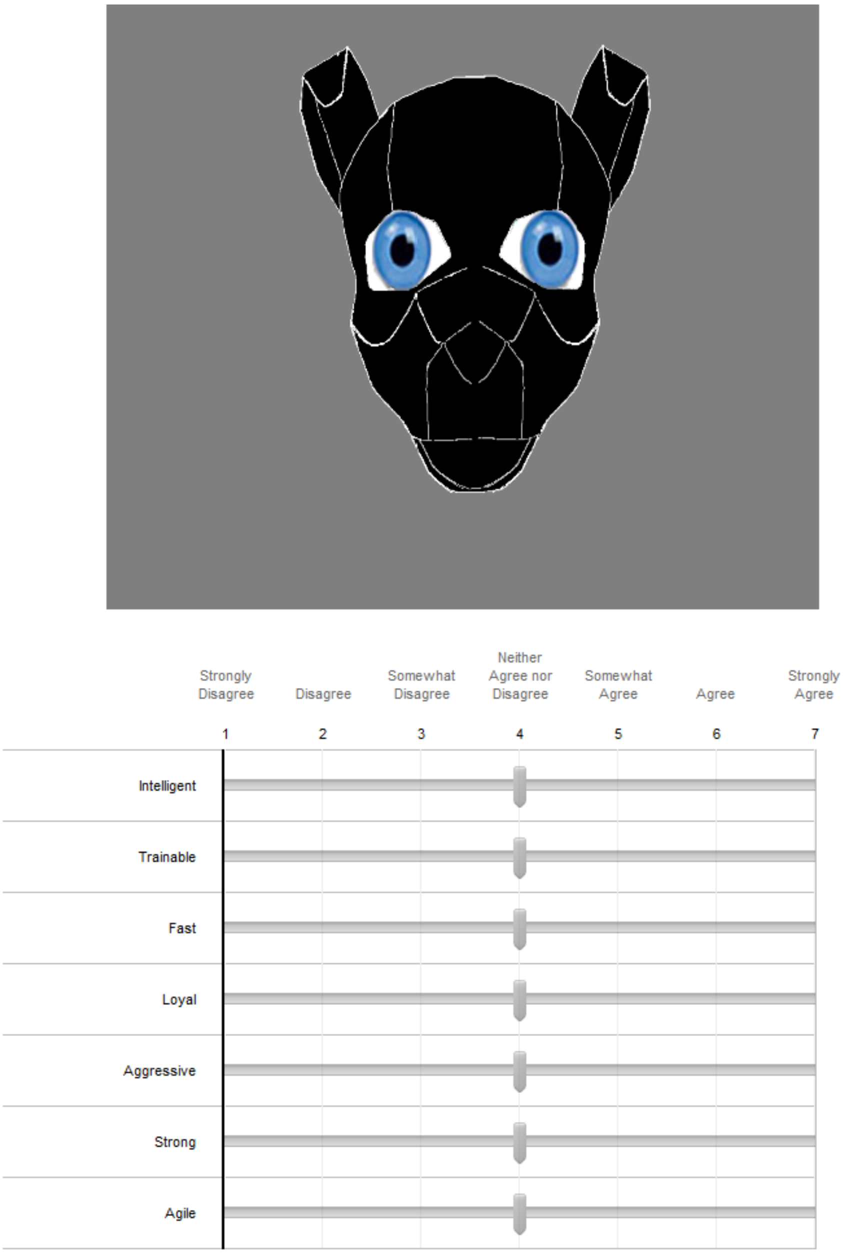

Figure 1. Sample question, for face with bent ears, standard face shape, blue eyes and black face colour.

4. Results

4.1 Statistical Analysis

Ratings of each trait were analysed with a 2 (Face Colour: black or white) by 3 (Eye Colour: brown, blue, or red) by 3 (Head Shape: narrow, medium, or broad) by 3 (Ear Shape: upright, bent, or floppy) repeated measures ANOVA. In the case of a significant effect, pairwise comparisons with Bonferroni corrections were conducted to determine significant differences between variables.

4.2 Intelligence

Significant main effects were found for eye colour (F (2, 53) = 4.83, p =.012, η_p^2 = .154.), ear shape, (F (2, 53) = 18.41, p =.000, η_p^2 = .410), face shape (F (2, 53) = 14.49, p =.000, η_p^2 = .353), and face colour (F (1, 54) = 7.57, p =.008, η_p^2 = .123). Blue eyes were rated significantly more intelligent than brown eyes (p = .015), all other eye comparisons did not show significant differences. Bent ears were rated significantly more intelligent than floppy ears (p = .000), as were upright ears (p = .000). There was no significant difference between bent ears and upright ears. Narrow faces were rated significantly more intelligent than broad faces (p = .000), as were standard faces (p = .000). There was no significant difference between narrow and standard faces. Black faces were rated significantly more intelligent than white faces (p = .008).

There was a significant ear by face shape interaction, F (4, 51) = 3.39, p =.015, η_p^2 = .210 (see Fig. 2 for the interaction). All other results were non-significant, p > .05.

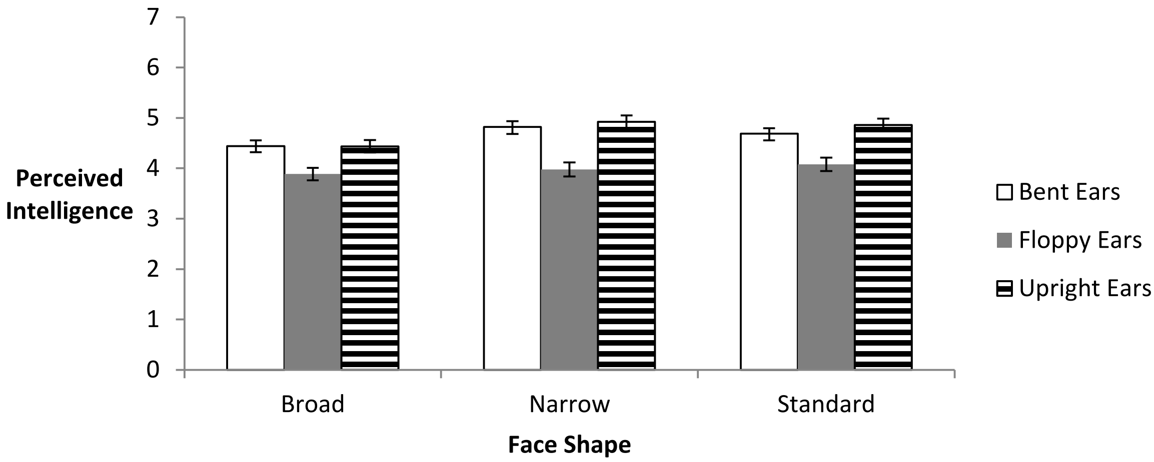

Figure 2. Ear shape by face shape interaction for perceived intelligence.

4.3 Trainability

Significant main effects were found for eye colour (F (2, 53) = 22.29, p =.000, η_p^2 = .457.), and ear shape (F (2, 53) = 14.00, p =.000, η_p^2 = .346). Blue eyes were rated significantly more trainable than red eyes (p = .000), as were brown eyes (p = .000). There was no significant difference between blue eyes and brown eyes. Bent ears were rated significantly more trainable than floppy ears (p = .000), as were upright ears (p = .000). There was no significant difference between bent ears and upright ears. A significant ear shape by face shape interaction was found, F (4, 51) = 4.267, p =.005, η_p^2 = .251 (see Fig. 3 for the interaction). All other results were non-significant, p > .05.

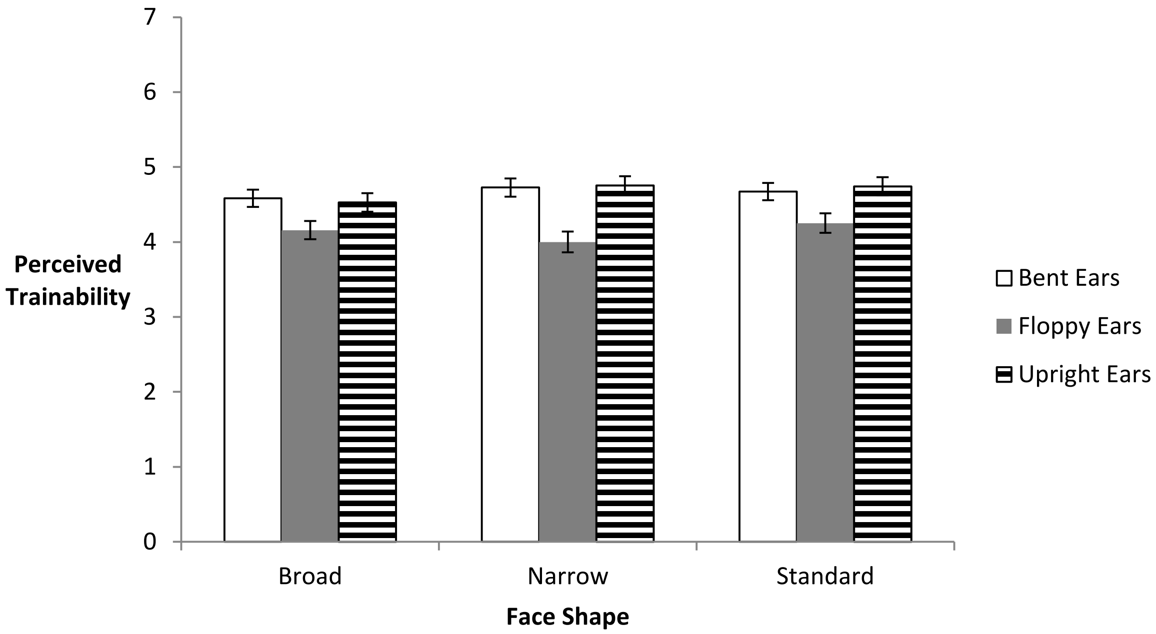

Figure 3. Ear shape by face shape interaction for perceived trainability.

4.4 Speed

Significant main effects were found for ear shape (F (2, 54) = 41.32, p =.000, η_p^2 = .605.), face shape, (F (2, 54) = 18.96, p =.000, η_p^2 = .413.), and face colour (F (2, 54) = 55.000, p =.000, η_p^2 = .235.). Upright ears were rated significantly faster than both bent ears (p = .000) and floppy ears (p = .000). Bent ears were rated significantly faster than floppy ears (p = .000). Narrow faces were rated significantly faster than both broad faces (p = .000) and standard faces (p = .004). Standard faces were rated significantly faster than broad faces (p = .000). Black faces were rated significantly faster than white faces (p = .000). A significant ear by face shape interaction was found, F (4, 52) = 3.79, p =.009, η_p^2 = .226 (see Fig. 4 for the interaction). All other results were non-significant, p > .05

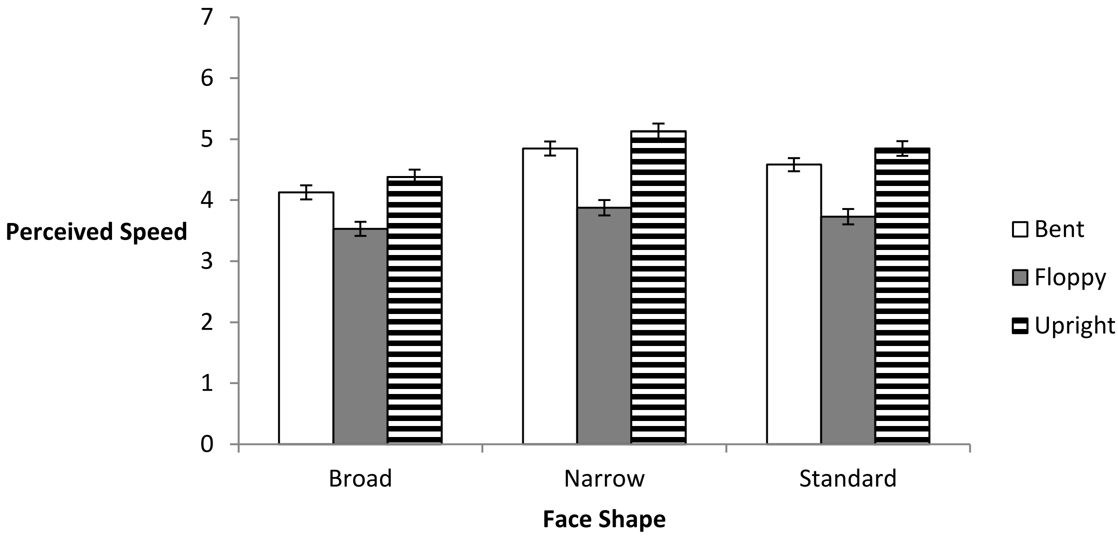

Figure 4. Ear shape by face shape interaction for perceived speed.

4.5 Loyalty

Significant main effects were found for eye colour (F (2, 53) = 22.11, p =.000, η_p^2 = .455), ear shape (F (2, 53) = 12.21, p =.000, η_p^2 = .315), and face shape (F (2, 53) = 3.17, p =.050, η_p^2 = .107. Blue eyes were rated significantly more loyal than red eyes (p = .000), as were brown eyes (p = .000). There was no significant difference between blue eyes and brown eyes. Bent ears were rated significantly more loyal than floppy ears (p = .000), as were upright ears (p = .017). There was no significant difference between bent ears and upright ears. Despite a significant main effect of eye colour, Bonferonni-corrected pairwise comparisons did not show a significant difference between face shapes. A significant ear shape by face shape interaction was found, F (4, 51) = 5.46, p =.001, η_p^2 = .300 (see Fig. 5 for the interaction). A significant eye colour by ear shape by face colour interaction was also found, F (4, 51) = 2.63, p =.045, η_p^2 = .171 (see Fig. 6 for the interaction). All other results were non-significant, p > .05

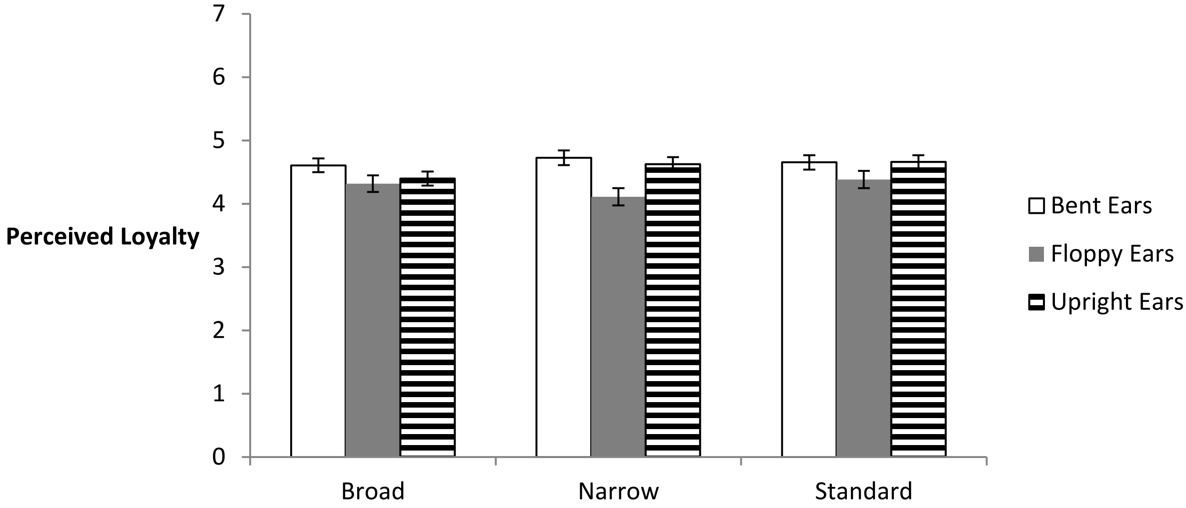

Figure 5. Ear shape by face shape interaction for perceived loyalty.

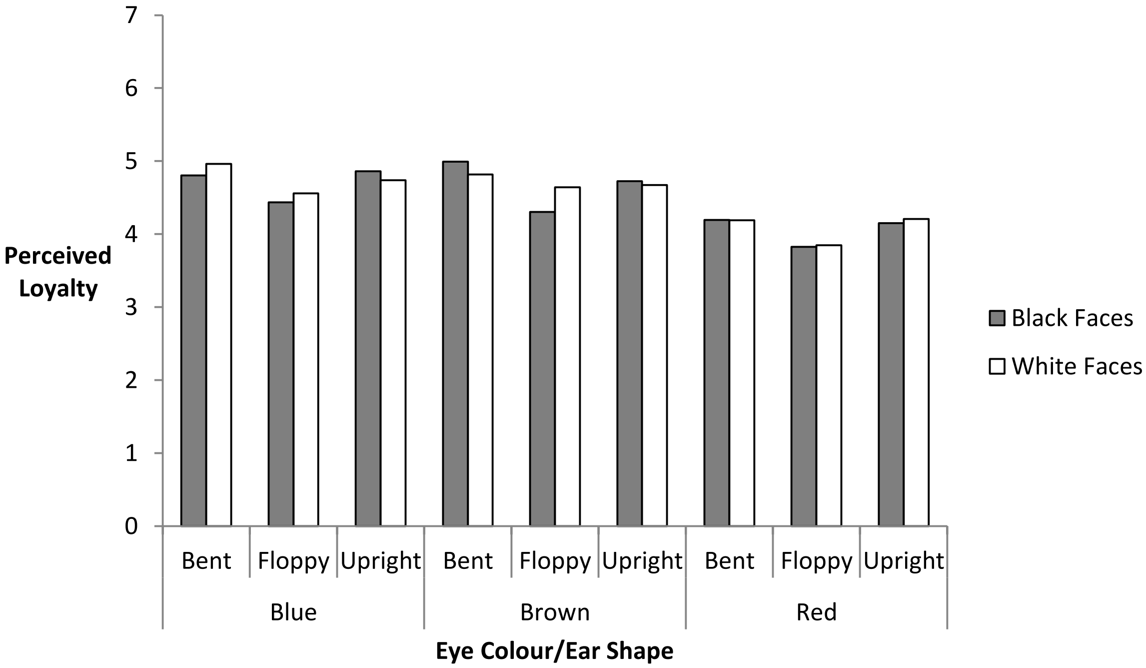

Figure 6. Eye colour by ear shape by face shape interaction for perceived loyalty.

4.6 Aggressiveness

Significant main effects were found for eye colour (*F* (2, 54) = 21.37, *p* =.000, η_p^2 = .442.), ear shape (*F* (2, 54) = 9.97, *p* =.000, η_p^2 = .270) and face colour (*F* (1, 55) = 21.36, *p* =.000, η_p^2 = .280). Red eyes were rated as significantly more aggressive than both blue eyes (*p* = .000) and brown eyes (*p* = .000). There was no significant difference between blue and brown eyes. Upright ears were rated as significantly more aggressive than both bent ears (*p* = .000) and floppy ears (*p* = .029). There was no significant difference between bent and floppy ears. Black faces were rated as significantly more aggressive than white faces (*p* = .000). A significant eye colour by ear shape interaction was found, *F* (4, 52) = 4.42, *p* =.004, η_p^2 = .254 (see Fig. 7 for the interaction). All other results were non-significant, *p* > .05.

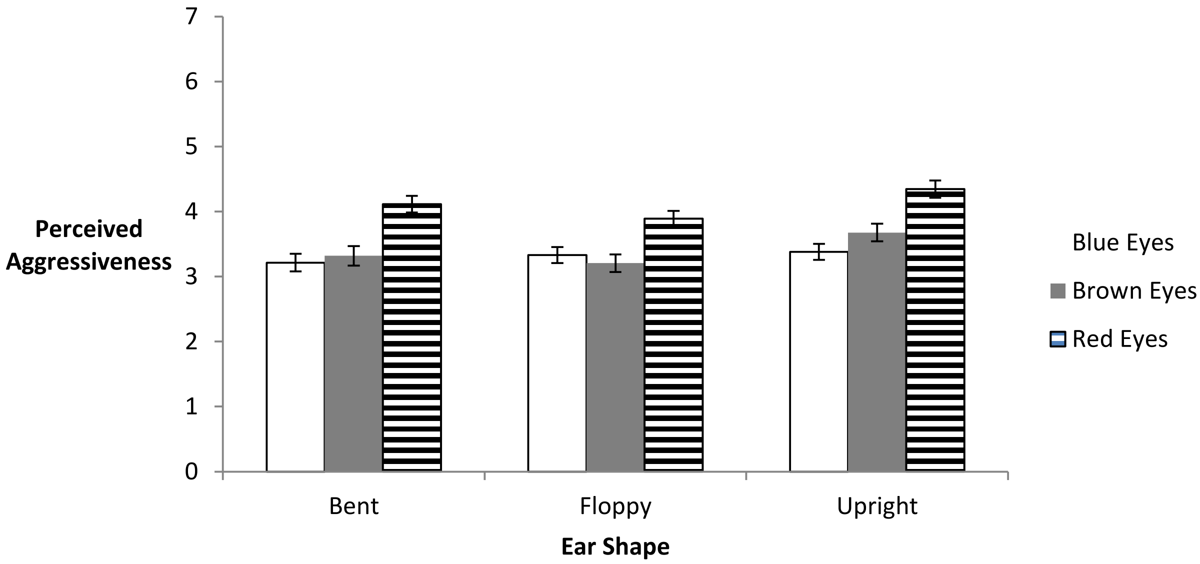

Figure 7. Ear shape by eye colour interaction for perceived aggressiveness.

4.7 Strength

Significant main effects were found for eye colour (F (2, 54) = 6.05, p =.004, η_p^2 = .183.), ear shape (F (2, 54) = 9.12, p =.000, η_p^2 = .252.) and face colour (F (1, 55) = 30.16, p =.000, η_p^2 = .354.). Red eyes were rated as being significantly stronger than both blue eyes (p = .005) and brown eyes (p = .006). There was no significant difference between blue and brown eyes. Bent ears were rated significantly stronger than floppy ears (p = .003), as were upright ears (p = .000). There was no significant difference between bent and upright ears. Black faces were rated as being significantly stronger than white faces (p = .000). A significant ear shape by face colour interaction was found, F (2, 54) = 5.01, p =.010, η_p^2 = .157 (see Fig. 8 for the interaction). All other results were non-significant, p > .05.

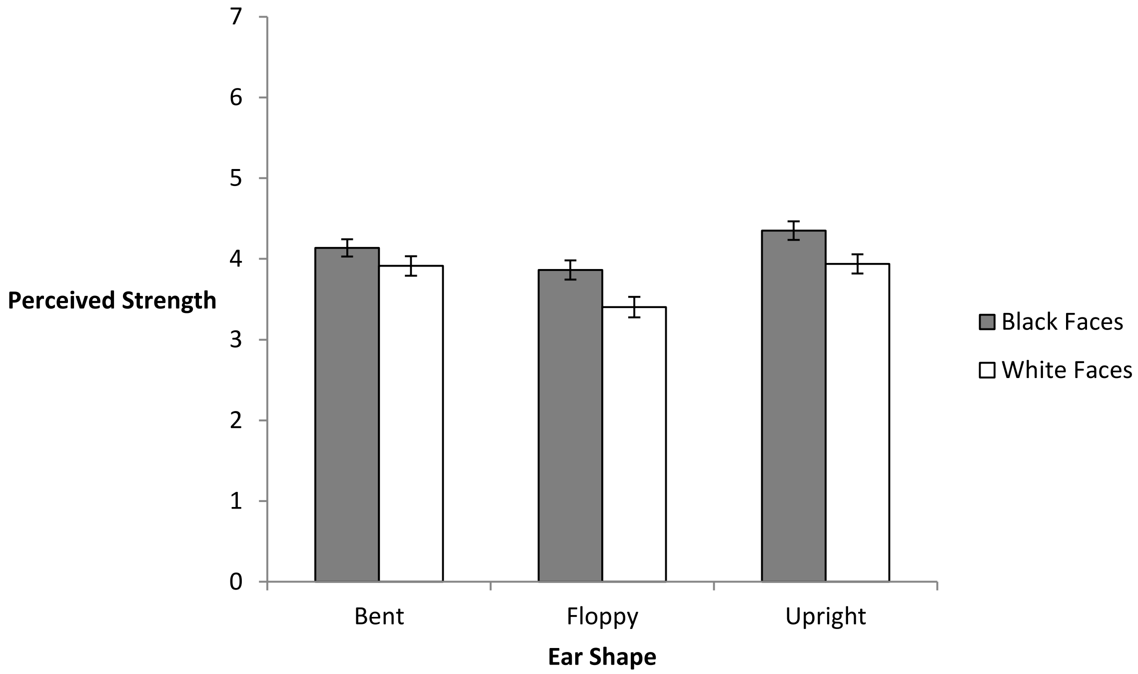

Figure 8. Ear shape by face colour interaction for perceived strength.

4.8 Agility

Significant main effects were found for ear shape (F (2, 54) = 37.63, p =.000, η_p^2 = .582.), face shape (F (2, 54) = 18.92, p =.000, η_p^2 = .412.), and face colour (F (1, 55) = 7.74, p =.007, η_p^2 = .123.). Upright ears were rated significantly more agile than both bent ears (p = .000) and floppy ears (p = .000). Bent ears were rated significantly more agile than floppy ears, (p = .000). Narrow faces were rated significantly more agile than both broad faces (p = .000) and standard faces (p = .001). Standard faces were rated significantly more agile than broad faces (p = .000). Black faces were rated significantly more agile than white faces (p = .007). All other results were non-significant, p > .05.

The means and standard deviations for each face characteristic and trait can be found in Appendix B.

5. Discussion

The purpose of this study was to investigate the effects of canine robot morphology on the way in which particular traits are perceived. Eye colour, face shape, ear shape and face colour all had a significant influence on the way that people judged the faces of robotic canines. For perceptions of intelligence, blue eyes were rated more intelligent than brown eyes. Both bent and upright ears were rated as more intelligent than floppy ears, and narrow faces were rated as more intelligent than both broad and standard faces. Black faces were rated as more intelligent than white faces. For perceptions of trainability, blue and brown eyes were rated as more trainable than red eyes, and both upright and bent ears were rated as more trainable than floppy ears. For perceptions of speed, upright ears were rated as faster than both bent and floppy ears, and bent ears faster than floppy ears. Narrow faces were rated as faster than both broad and standard faces, and standard faces as faster than broad faces. Black faces were rated as faster than white faces. For perceptions of loyalty, blue and brown eyes were rated as more loyal than red eyes, and both bent and upright ears were rated as more loyal than floppy ears. For perceptions of aggressiveness, red eyes were rated as more aggressive than both blue and brown eyes, and upright ears were rated as more aggressive than both bent and floppy ears. Black faces were rated as more aggressive than white faces. For perceptions of strength, red eyes were rated as being stronger than both blue and brown eyes, and both bent and upright ears were rated as significantly stronger than floppy ears. Black faces were rated as significantly stronger than white faces. For perceptions of agility, upright ears were rated as more agile than both bent and floppy ears, and bent ears were rated more agile than floppy ears. Narrow faces were rated more agile than both broad and standard faces, and standard faces were rated more agile than broad faces. Black faces were rated more agile than white faces.

5.1 Eye Colour

Eye colour's influence on perceptions of intelligence, trainability, eye colour, aggressiveness and strength is likely to be of use in the design of robots for particular purposes. With this information, it makes it possible to design either a robot that has a set eye colour based on its purpose, or a set of eye colours that change when appropriate. Based on the evidence from this study, selection of a robot's eye colour can be made with information about the robot's purposes when interacting with humans; for example, a robot that would operate in a caring role would likely convey unwanted aggression if it were given red eyes.

Eye colour only had an influence on one out of the three physical traits (strength), yet had an influence on all four of the psychological traits. Based on previous findings as to how humans attach particular emotions to colours, it seems logical that this would translate more easily to psychological characteristics than simple physical abilities. The effect of red eyes on increased perceptions of strength may be due in part to the numerous associations that the colour red has in everyday life. It is easy to see how the property of strength could be linked to a colour that is associated with aggression, anger and blood. The influence of eye colour on trainability might not be particularly relevant in regard to the issue of differing perceptions of trainability between real breeds of dogs, since generally eye colour isn't specific to particular breeds. Also of note is that although the current study demonstrates effects of red eyes, this isn't generalizable to real-life dogs, as it is not a naturally occurring eye colour.

5.2 Face Shape

As with eye colour, the evidence for the influence of face shape on trait perceptions could be of use in the design and implementation of robots. Face shape's influence on the perception of the physical traits of speed and agility isn't particularly surprising, given the common associations that slender forms have with these traits. For both speed and agility, perceptions were the highest with the most slender face, and the lowest with the broadest face.

Interestingly, face shape was not found to have a significant influence upon perceptions of trainability. Following Helton's (2009) evidence of cephalic index predicting differing perceptions of trainability it was predicted that more standard faces, rather than broad or narrow, would be perceived as more trainable. The direction of the findings, while not statistically significant, was in line with these expectations. The results may not have reached significance for several reasons. The robot canines used in this study are obviously not real dogs, are only 2-dimensional images (people may find trainability in this context hard to rate), or may not have varied enough in width/height for any relationship to be evident (the difference used here was more subtle than found amongst natural breeds of dogs). Other, more salient factors (like eye colour) may have appeared more relevant. Nonetheless, this could be further investigated by conducting a similar study that concentrated solely on cephalic index, and whether extensive manipulation of this variable could reproduce results similar to Helton (2009).

5.3 Ear Shape

Along with eye colour and face shape, ear shape's influence in this study provides information that may be relevant in a variety of contexts. Unlike some of the variables manipulated, the effects of robot canine ear shape may not be as generalizable to other forms. Canine ears have a relatively large variation in shape between breeds, yet this is not seen in humans, and not often in other animals. Even considering this, the knowledge that ear shape has an influence upon perceptions of traits might still be of use. Robots such as Darpa's Big Dog that are modelled partially from canine features (Playter, Buehler & Raibert, 2006) would benefit from consideration of the types of ear shape that could be beneficial for particular uses. A canine-like robot in a military setting might, for instance, be fitted with upright ears if it was needed to look intimidating, or bent/floppy ears if it were to be used in a rescue/reconnaissance role where intimidation would be less desirable. Despite the ear shapes used in this study being more constrained to canine-like forms than variables like colour and face shape, the fact that robots in canine forms are already available to the consumer (for instance, Sony's "Aibo" robot dog) confirm ear shape's relevance.

Ear shape's significant influence on perceptions of trainability is of interest, as it offers another possible explanation for the perceived differences in trainability between differing breeds of dog. This might be in part due to the fact that floppy ears are more likely to be associated with puppies, as even dogs that eventually have upright ears are born floppy eared. Helton (2010) discusses the way in which particular dogs might be overlooked for working roles, based on little evidence other than tradition. Ear shape could be a contributing factor to this oversight— intelligence, trainability and loyalty are all traits that should be considered when selecting dogs for a working environment, and the current study has shown that ear shape influences perceptions of all three.

5.4 Face Colour

Similarly to eye colour, face shape and ear shape, this study provides evidence that black and white faces create differing perceptions in regard to particular traits of robots. The impact of colour on the perception of robots could be further investigated in a number of ways. It would be interesting to see whether similar effects emerged in a study examining the impact of colour of the entirety of a robot, rather than just the face. Additionally, it would be of interest to gauge the impact of a larger variety of colours, rather than just black and white. In terms of physical traits, this study found that canine robots with black faces were rated as more proficient than white faces in all of the physical traits (speed, strength and agility) measured.

The only variables that face colour did not affect were those of perceived loyalty and perceived trainability. Based on the findings of this study, face colour is worthy of consideration in the design of robot.

5.5 Real World Implications

The findings from this study offer use in many applied settings. As the use of robots becomes more commonplace in environments where they are required to interact with humans, more emphasis will be placed on the efficiency of these interactions. In any situation where a particular purpose for human-robot interaction is required, these results are relevant. For example, if a robot aimed at teaching children is perceived as aggressive and unintelligent, this will likely be of severe detriment to the goal of providing quality education.

The results from this study provide insight into the usefulness of certain robot designs for particular settings. If designing a robot as a substitute for a guard dog, it would be desirable to ascribe it features corresponding to ratings of strength, aggression and speed. Based on qualities manipulated in this study, this would consist of a robot with a narrow face, red eyes, upright ears and a black face. Similarly, it is easy enough to construct the most/least ideal faces for a particular trait; a trainable-looking robot dog would have blue or brown eyes, and bent or upright ears, while a non-trainable robot dog would have red eyes and floppy ears. If a robot was required to look unintelligent, it would have brown eyes, floppy ears and a broad white face - a robot that was required to look weak, would have the added option of changing blue eyes for brown.

Secondly, the results from this study have implications in the way that dogs are selected for working roles. Even though these results are not perfectly aligned with previous research on the subject, the trend of perceptions being influenced by morphological features is worth investigating further. Working dogs occupy roles in a number of diverse fields, and in many cases, there are set breeds of dog that are considered as the most appropriate for particular fields. Helton (2010) gives the example of the breeds typically used in land mine detection; Labrador Retrievers, Belgian Shepherds, and German Shepherds. Helton notes that smaller dogs (such as Beagles or Jack Russell Terriers) may be more useful for this task due to their decreased weight and thus decreased likelihood of detonating a land mine, yet these breeds are overlooked in favour of the more traditional breeds. It may be that there are particular morphological features that, through tradition and other influencing means, are responsible for the selection of particular breeds for particular roles. Given that trainability differences have not been demonstrated between breeds for tasks like this, acknowledgment of any biases in the selection process could prove beneficial to the industry. It might emerge that breeds that had not been considered previously are useful for particular roles, offering a larger pool of breeds to choose from, and breeds that might be more physically suited to niche conditions.

5.6 Limitations & Future Research

Traditionally, research would be carried out in a rigorously controlled environment, but in this study participants were free to complete the survey anywhere. Recent research has shown, however, that this type of unsupervised experiment might not necessarily hinder the acquisition of high-quality data. Buhrmester, Kwang and Gosling (2011) reviewed the system of Amazon’s Mechanical Turk (MTurk), a system which shares characteristics with the Qualtrics system used in the current study. The MTurk obtained data that were at least as reliable as those obtained by traditional methods, evidence that supports the legitimacy of experiments conducted in an online environment. Another limitation is the colours that were used; the sets used for both eye colour and face colour were limited, and a better understanding of the effects of colour would be attained by using a far greater spectrum. Also worth noting is that solid, block colours were used throughout the study; given the large scope of composition materials for robots, it would make sense for future studies to investigate shades, patterns and textures as well as colour. The interactions found in this study are worthy also of future research, to investigate more closely the ways in which the variables of these study affect one another.

Although this research has provided evidence of the ways in which perceptions are shaped by robot morphology, it barely scratches the surface in terms of research possibilities. The range of possible shapes for use in the design of robots is near endless. It would be of interest to investigate whether the effects seen in this study (and in human morphology studies) extend to robots modelled on the structures of different animals, the stereotypical popular culture robot form, and abstract shapes. Furthermore, exploring the possible ways in which facial morphology interacts with changes to other parts of a robot would expand upon the restriction of this study to faces alone. It would be expected that a robot with a “slow” face might not be perceived as such if it were given six legs, rather than four; the extent to which multiple variables might interact is unknown. The use of the red eye colour in this study might contribute to the phenomenon of the “uncanny valley” if used in more human-like robots, as it doesn’t occur naturally. Whether or not this uncanny-ness occurs if unnatural features are paired with unnatural morphology, rather than recognisable morphology, would have implications in the design of both natural and non-natural looking robots. Future research would also benefit from investigating whether or not the perceptions displayed in this study change with age, gender or experience with robots/canines. It could be assumed that people who have had extensive experience with either robots or dogs might have given different answers to those with relatively little experience. Human morphometrics has described how particular facial aspects have differing influences depending on gender (albeit, mostly on attractiveness); it would be interesting to investigate any significant differences between gender responses in the traits that were rated in this study.

The current study has provided clear evidence of the effects that morphology has on the way humans perceive traits of robots canines. To the best of our knowledge, this is the first such study to examine the effects of features such as ear shape and eye colour in dogs/robots on perceptions of traits. This can inform both on-going research within canine morphometrics and selection for training purposes, and research in robotic development. As robots become a more commonplace feature in the home, school and workplace, future research will likely be able to shed more light on the nuances of human-robot interaction, and aid the field of robot design accordingly.

6. References

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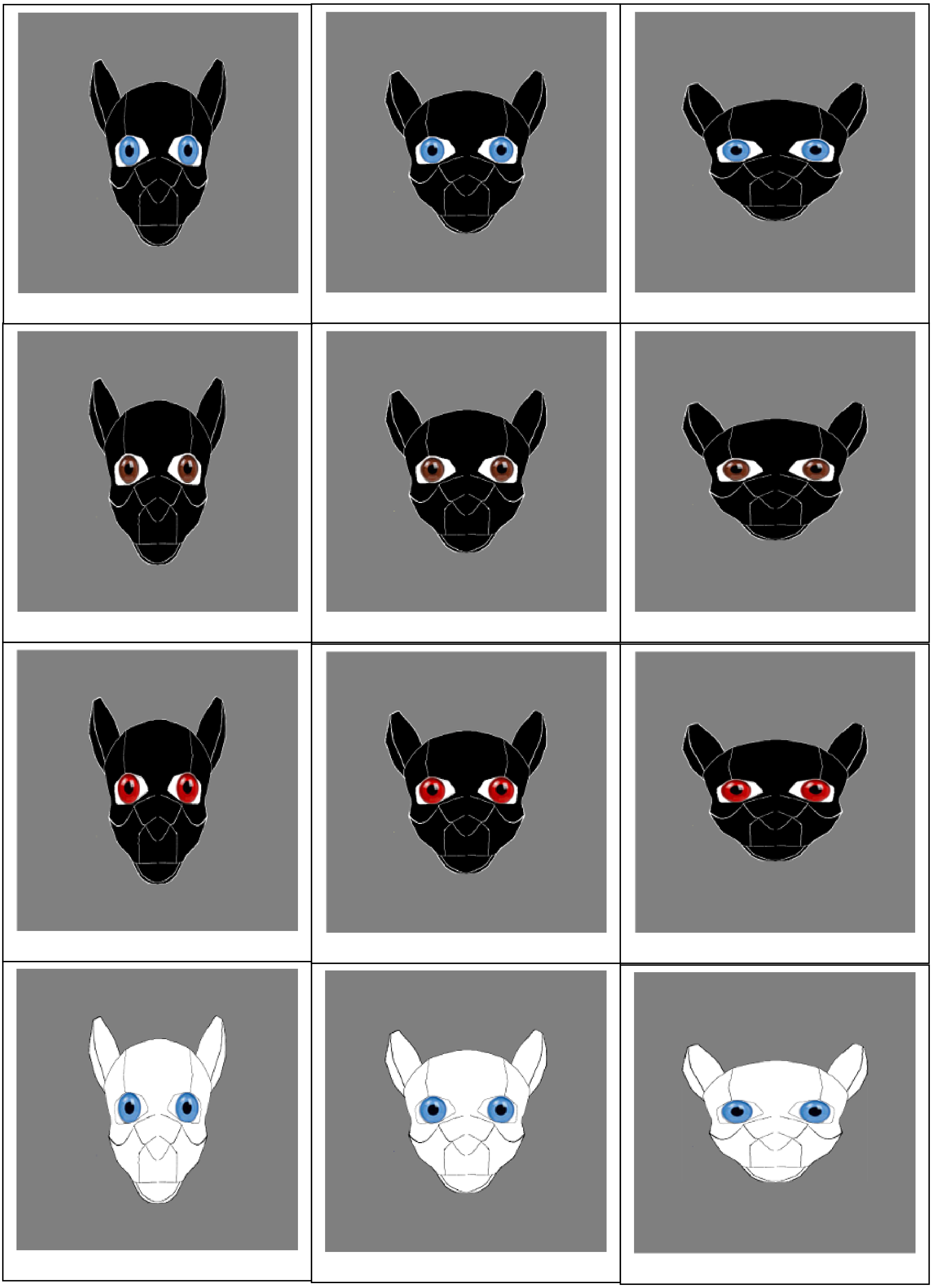
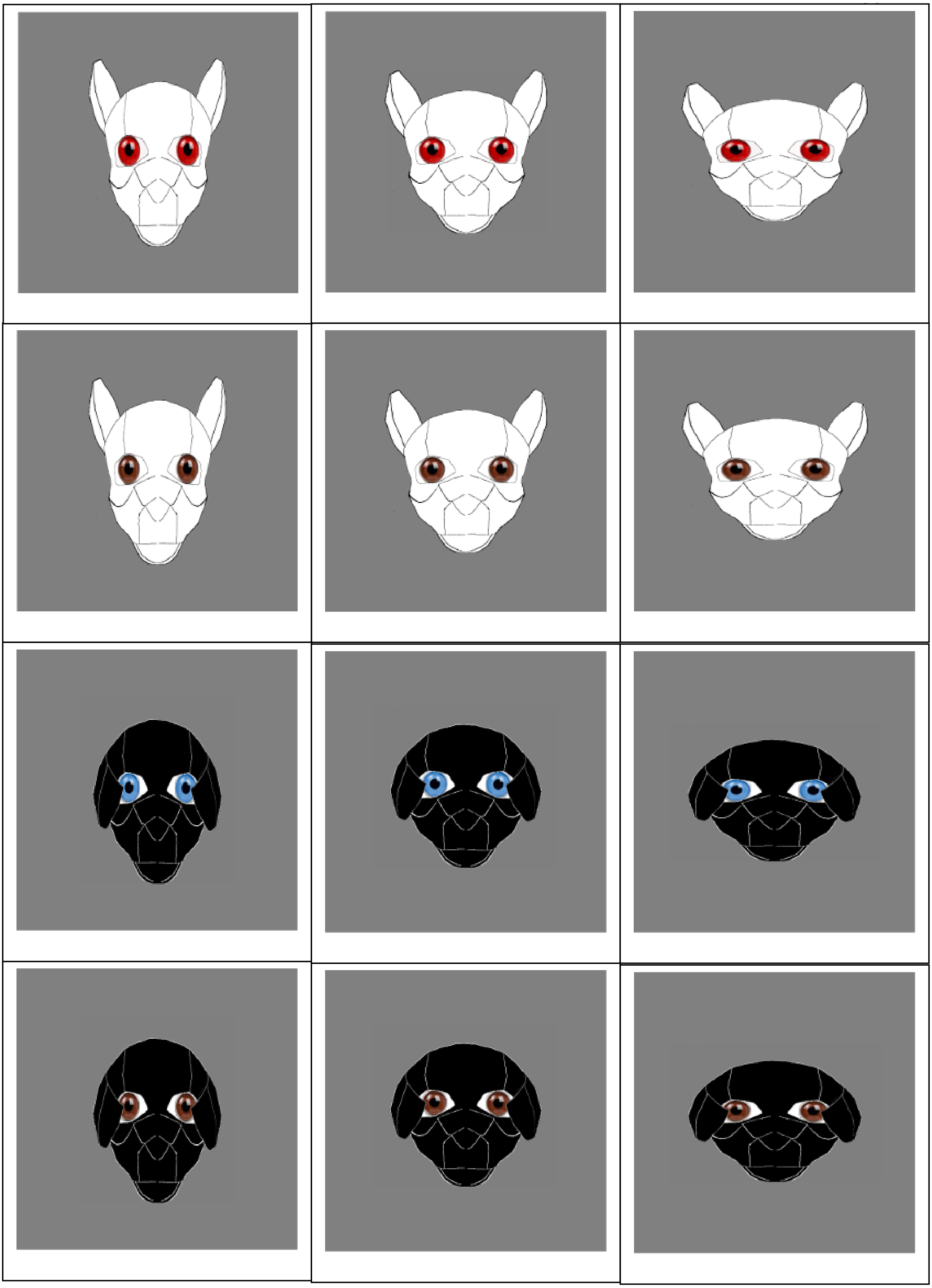
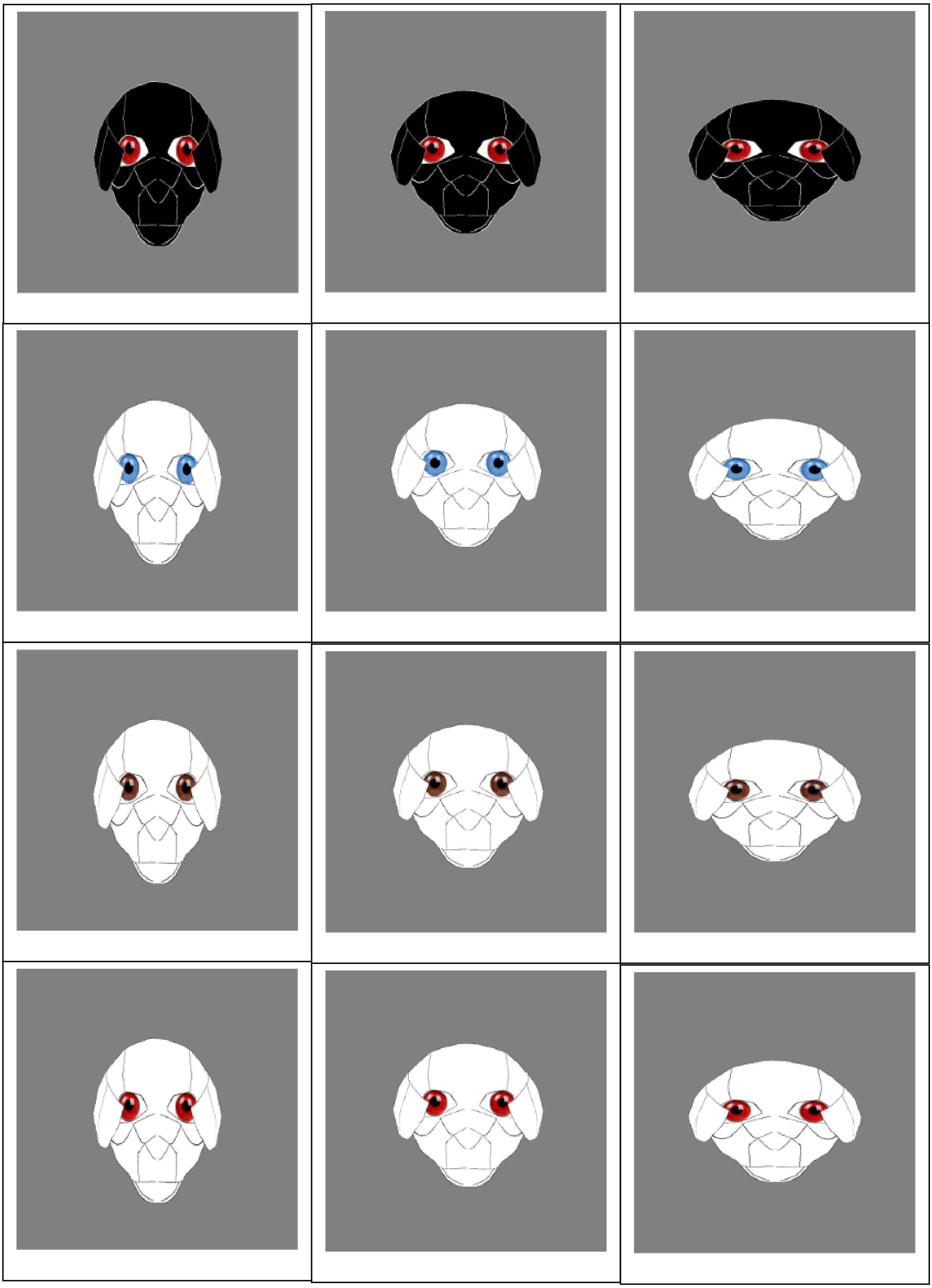
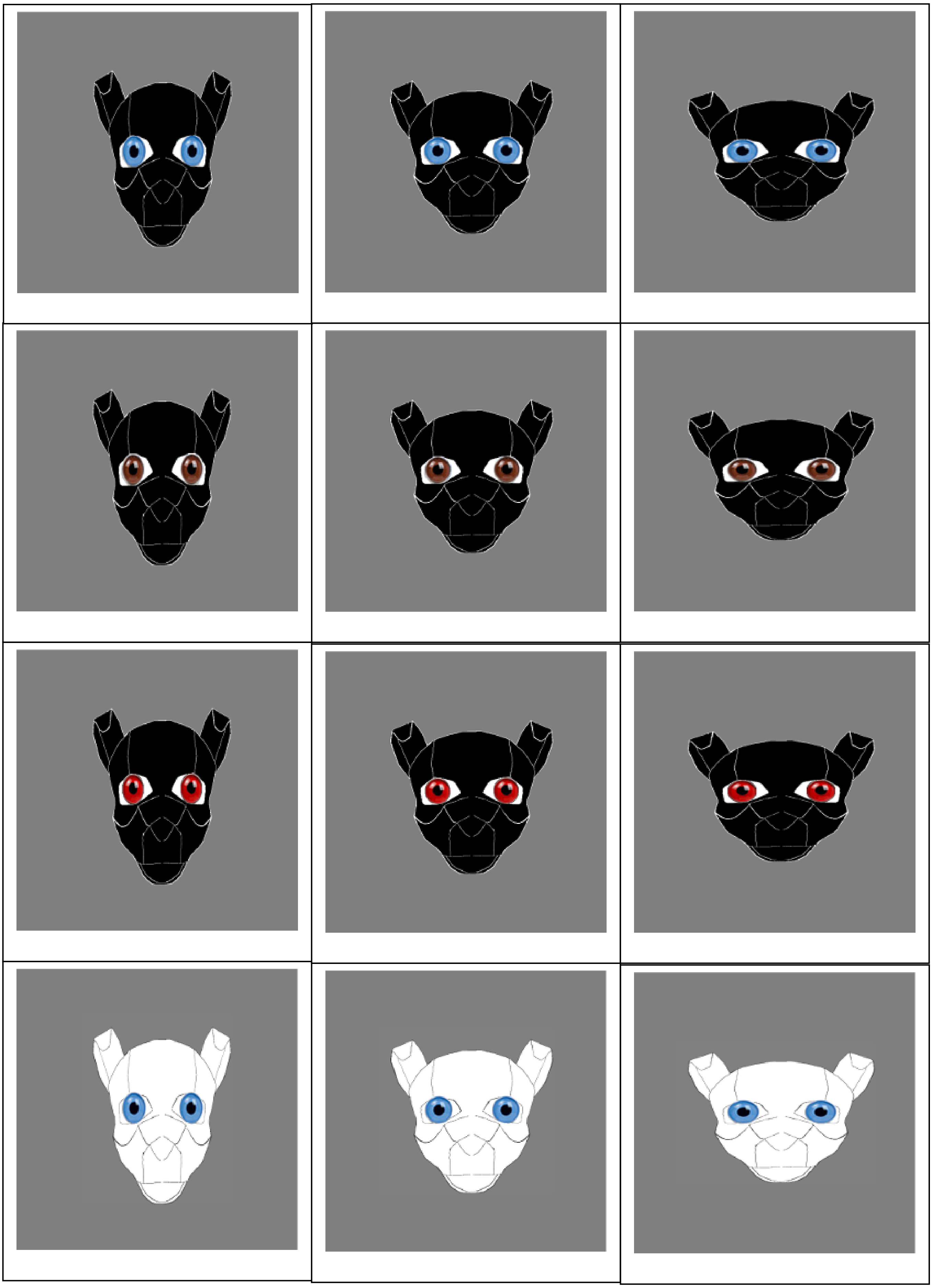
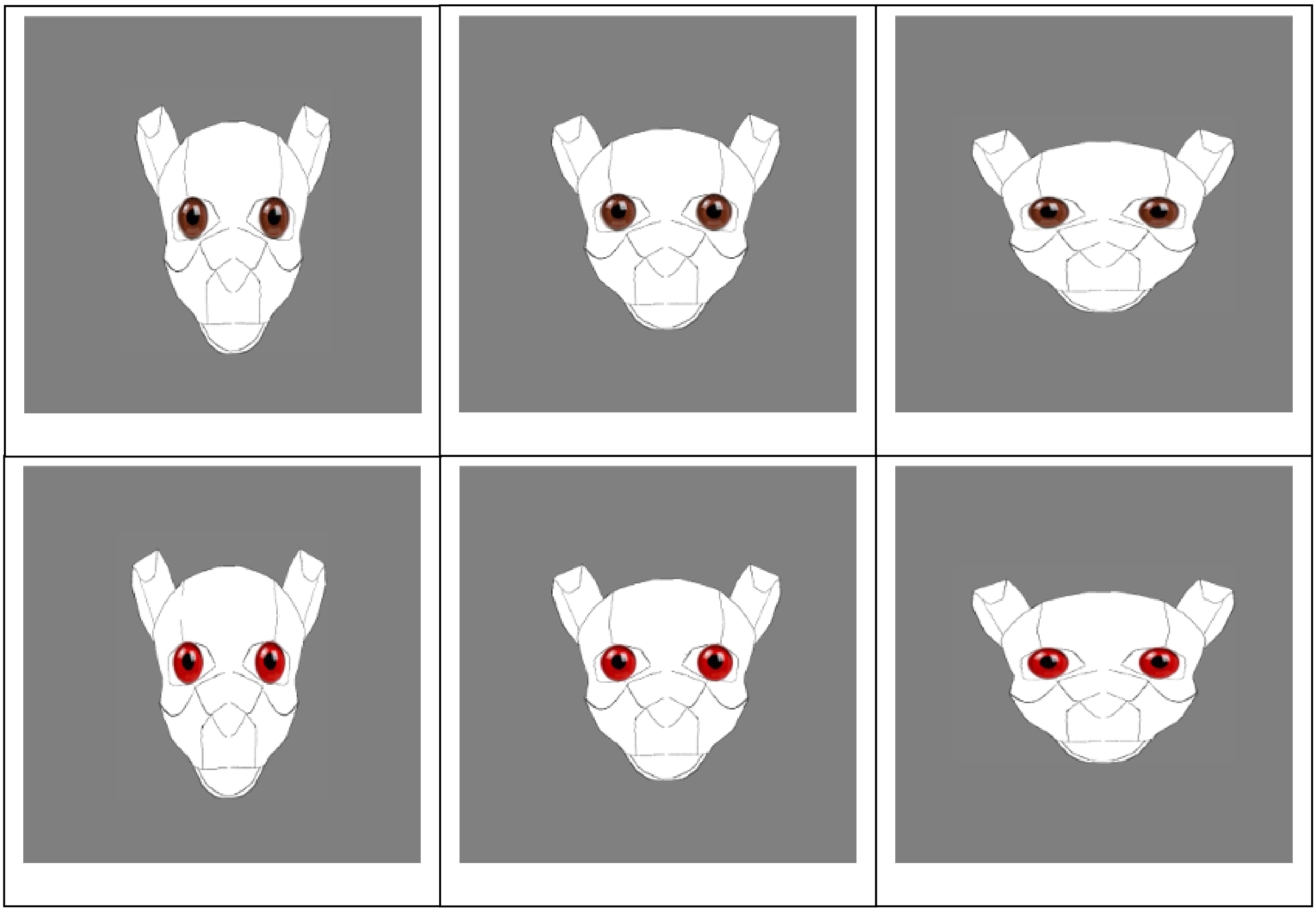
Appendix A











Appendix B

Table 1: Means and Standard Errors for judgments of each trait based on physical feature manipulations.

	Intelligence		**Trainability**		**Speed**		**Loyalty**		**Aggressiveness**		**Strength**		**Agility**	
	M	*S-E*	*M*	*S-E*	*M*	*S-E*	*M*	*S-E*	*M*	*S-E*	*M*	*S-E*	*M*	*S-E*
Eye Colour														
Blue	4.564	0.104	4.699	0.112	4.356	0.097	4.727	0.109	3.309	0.116	3.839	0.103	4.371	0.099
Brown	4.428	0.104	4.594	0.105	4.278	0.096	4.693	0.106	3.4	0.108	3.879	0.105	4.294	0.097
Red	4.378	0.104	4.179	0.112	4.383	0.094	4.069	0.117	4.116	0.123	4.081	0.099	4.357	0.092
Ear Shape														
Bent	4.649	0.102	4.661	0.105	4.52	0.097	4.661	0.103	3.549	0.106	4.024	0.105	4.48	0.099
Floppy	3.981	0.122	4.136	0.124	3.712	0.111	4.269	0.125	3.475	0.132	3.633	0.116	3.817	0.1
Upright	4.739	0.115	4.675	0.114	4.785	0.107	4.56	0.102	3.801	0.103	4.143	0.113	4.724	0.113
Face Shape														
Broad	4.255	0.102	4.422	0.105	4.012	0.106	4.439	0.103	3.56	0.096	3.883	0.105	4.066	0.101
Narrow	4.574	0.106	4.494	0.111	4.619	0.103	4.486	0.107	3.668	0.107	3.985	0.104	4.59	0.104
Standard	4.541	0.101	4.556	0.107	4.386	0.095	4.564	0.102	3.597	0.11	3.932	0.1	4.365	0.096
Face Colour														
Black	4.528	0.102	4.518	0.103	4.458	0.097	4.477	0.102	3.771	0.105	4.116	0.098	4.421	0.097
White	4.385	0.099	4.463	0.106	4.22	0.092	4.515	0.105	3.445	0.104	3.751	0.105	4.261	0.097

A boxed set of variables denotes a significant main effect for that set.