Embodied Cognition and Representation in Domesticated Dogs

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Abstract

Embodied cognition is a relatively recent approach in the philosophy of mind. Similarly, the volume of research into dog cognition has increased in the last decade and is set to keep on growing as we learn more about the animals with which we have associated for so long. This thesis argues that the principles of embodied cognition can be productively applied to the study of dogs. Adoption of these principles can improve experimental design and inform the conclusions that we draw from empirical data regarding dogs' cognitive capacities and behaviour. This dissertation advocates for ethologically appropriate studies, designed for dogs rather than humans, a greater emphasis on the dynamic interplay between the dog, environment and humans, and fresh interpretations of the behaviour and cognitive skills that dogs demonstrate. Moreover, the models of embodied representation expounded in this thesis aid our understanding of dog behaviour and cognition and can enhance our approach to dog training. The thesis closes with a case for embodied representations as facilitators of rational actions in the domesticated dog.

Preface and Acknowledgements

Dogs have always enchanted me with their adaptability, trainability and the love and companionship they offer. I am grateful that I have had the opportunity to combine my love for dogs with my interest in embodied cognition. My main hope for this thesis is that it may provide a useful theoretical background and practical application to the way we train, study and understand these remarkable creatures.

Thanks to my supervisors: Dr. Justine Kingsbury who inspired, coached and supported me with a consistency and kindness that kept me going; Dr. David Lumsden who introduced me to the philosophy of mind twelve years ago and ignited an interest in the field that stuck; Dr. Nicola Starkey whose practical suggestions regarding the review of empirical studies was invaluable; and Professor Kim Sterelny who guided this project in its fledgling state.

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Contents

Introduction

Dogs accompany humans through our diverse walks of life. In the United States there are roughly 73 million pet dogs, 6 million in Canada and 43 million pet dogs in Eastern Europe (Coren, 2012). Sometimes dogs occupy a place in the family unit similar to that of a human child. Children often grow up with dogs and may relate to them as a kind of sibling: a constant, loved and cherished playmate, and someone with whom they can learn how to be gentle and considerate. Adults choose to live with dogs for a variety of reasons: to protect the home, for company, for work, to enable them, in the case of dogs trained for those with disabilities, to carry out their lives. Dogs are also part of the workplace. They work on farms, at airports, in police units, as part of search and rescue teams; the list goes on. Our association with the domesticated dog is prolific and remarkable.

This thesis reviews what we know about dog cognition from recent studies and considers it in the light of the principles of embodied cognition. I use the domesticated dog as a case study; because of their unique place in human society and long-standing history of association with humans they make a fascinating species for the application of embodied cognition.

Dogs have been associated with human beings longer than any other animal. In fact, dogs developed close associations with people roughly 3 thousand - 5 thousand years before any other animal (Kubinyi, Viryáni and Miklósi, 2007). In the past, the dog's entrance into human society was thought to be through its role as a pet. Since then it has been hypothesised that dogs' usefulness in hunting sparked the beginning of dog domestication (Clutton-Brock, 1984). However, there really is no conclusive evidence to suggest whether domestication sprang from keeping dogs as pets or from using them for hunting. There are so many different ways in which different cultures use their dogs that it is very hard to identify one of them as the primary role of the dog in early dog-human societies. For example, early dogs could have been a handy clean-up crew for our human ancestors. They would perhaps have eaten discarded or rotten meat and if times were lean they would also have been a food source for humans. However the dog came to be associated with humans, there is no doubt that this association has made the dog what it is today.

The genetic origins of domesticated dogs is still under investigation. Some consider it possible that dogs descended from wolves plus a variety of other canid species such as jackals, dingoes and coyotes (see Conen, 1995, for example). Conen (1995) argues that this accounts for the genetic similarities found between dogs and other species of the canid family. But most agree that the domestic dog is descended from the wolf. Studies of DNA, behaviour, vocalisations and molecular biology all point exclusively to the wolf as the domestic dog's most likely ancestor (Serpell, 1995). However, there is still a lot of disagreement over which sub-species of wolf the dog descended from, or whether different types of dog (e.g. hunting, sledding, guarding) descended from different sub-species of wolf.

Evidence suggests that during the late Pleistocene era (100 thousand – 1.8 million years ago), humans and wolves co-existed in a wide variety of different places. There would have been plenty of opportunity for the emergence of dogs as domesticated animals in separate regions and for continued genetic mixing to occur between dogs and wolves (Lorenz, 1965 and Vilá, Savolainen, Maldonado, Amorim, Rice, Homeycutt, Crandall, Lundeburg and Wayne 1999). The descent of dogs from a variety of different wolf species in diverse locations would also account for the fact that dogs come in different shapes, sizes and colours (Savolainen, Zhang, Luo, Lundeberg, Leitner, 2002). However, it is very difficult to find evidence for this hypothesis based on DNA studies. None of the wolf lineages which have previously been thought to provide domesticated dog ancestry are conclusive. It is likely instead that wolves and dogs diverged between 11 thousand and 16 thousand years ago in a process involving extensive interbreeding (Freeman, Gronau, Schweizer, Ortega-Del Vecchyo, Han, Silva, Galverni, Fan, Marx, Lorente-Galdos, Beale, Ramirez *et al*., 2014).

Where the domestic dog originated and over what time period is uncertain. Savolainen and his colleagues (2002) examined mitochondrial DNA sequence variations among 654 dogs. They claimed that their subjects represented all major dog populations worldwide and concluded on the basis of their research that the first domestic dogs existed between 15 thousand and 40 thousand years ago in East Asia. Prior to this study, it was thought by most that the dog was first domesticated around 15 thousand years ago. However, Vilá, et al. (1997) suggested that it may have been as early as 50 thousand -100 thousand years ago. This time window coincides with the beginning of colonisation in South Asia by Homo Sapiens: Some of the oldest sites at which the bones of wolves have been found in association with those of our own ancestors are in South Asia.

The beginnings of domestication of the wolf may even have been much earlier than Vilá et al. (1997) suggest. For example, some 300 thousand years ago, at the site of Zhoukoudian in North China the bones of wolves have been found nearby early hominid bones (Lindsay, 2008). Also, in the Cave of Lazaret near Nice in the South of France, the bones of wolves have been found near to hominid remains dated at 150 thousand years ago (de Lumley, 1969 as cited in Clutton-Brock, 1995). Earliest of all, however, in the Boxgrove site in Kent, England where wolf and early hominid remains were dated at 400 thousand years ago (Clutton-Brock, 1995). However, it is possible that some of the earliest wolves' bones were kept as hunting trophies; wolves have been hunted for a long time. Therefore early evidence of wolf and human bones at the same location cannot be relied upon as evidence of the start of domestication.

In summary, the earliest domesticated dogs did not look much like the average modern dog. The approximate time at which the dog began looking like domesticated dogs of today, based upon mitochondrial testing (Savolainen et al., 2002) and the dating of remains is between 15 thousand and 20 thousand years ago (Miklósi, 2008, p.114). Early evidence of wolf remains at ancient human burial sites, such as those mentioned above, while interesting do not conclusively suggest that humans began domesticating wolves much earlier than 15 thousand to 20 thousand years ago. However, we can suppose that there began to be an overlap between the hunting or scavenging grounds of wolves and human occupation sites right back when the wolf remains were being left alongside those of humans. Perhaps, while wolves scavenged on human waste or came to hunt in the same areas as early humans, the odd wolf pup became habituated to humans and tamed whereas the less submissive or more mature wolves were killed for food, driven away or simply tolerated.

As the domestic dog evolved, specific character traits were selected for that promoted association with humans. Also, there were physical changes. The snout became shorter than a wolf's and the teeth became more compact. Other physical changes that we see in various breeds of dog such as longer fur about the eyes and flopped down ears also occurred. Notably, many of these physical changes resulted in diminished perceptual sensitivity. Perhaps as their reliance on humans for food and protection increased, perceptual acuity became less influential over the dog's reproductive success than traits that humans find endearing or useful. Breeds such as the Bearded Collie whose eyes are covered by a fringe of thick fur are a good example of diminished perceptual ability and the droopy ears commonly seen in many different breeds of dog are less sensitive to sound than the upright ears of the wolf.

Once the early dogs had entered human society, humans were at a dramatic advantage for hunting. The dog, they discovered, could be trained to track or hold the prey at bay while the hunter aimed and threw his weapon. Furthermore, dogs are faster runners than humans and could chase down prey to drive back toward human hunters. In the history of our relationship with the domesticated dog, humans have selectively bred dogs with social skills that suit the needs of people. For example, a tractable disposition, trainability, perceptual sensitivity to social cues, and a tendency toward co-operation are all traits that would have enhanced the success of dog-human relationships. Furthermore, different traits are highly sought after depending on the use to which the particular human society wanted to put their dogs.

As humans began to use dogs for different types of work, different traits began to appear. For instance, dogs that were selectively bred by humans for hunting or herding developed a stronger tendency toward cooperation with humans and other dogs (McConnell and Bayliss, 1985).In addition, a heightened herding instinct is selected for in dogs being bred to move stock around. Well-developed social cognitive skills would be most useful in dogs put to relatively new roles such as guide dogs for the blind (Naderi et al., 2001). Naderi et al. performed one of the first tests on the types of interaction between a blind person and his/her guide dog. They found that one of the most significant abilities a dog must have if it is to be a successful guide dog is the ability to switch between the roles of leader and follower depending on the situation. This ability builds on the innate co-operative ability of the domestic dog and interestingly, it mirrors cooperation between humans in complex cooperative activity (Naderi et al., 2001). Enculturation, the process by which a dog (or human) can pick up on the rules of a society or group by observation and learning, may also be responsible for the development of certain cognitive abilities in the domestic dog (Cooper, Ashton, Bishop, West, Mills, Young, 2003). Coppinger and Coppinger (2002) suggest that the process of domestication may have selected for certain skills such as the ability to read human cues, which living in a human environment helps to foster.

Experiments are being conducted now in an effort to understand more about the cognitive skills of the domesticated dog. One of the most fascinating things, in my opinion, about dog cognition is the possibility that due to their long-standing and close association with humans, the way that humans think, communicate and behave around dogs is likely to have influenced the communication, behaviour and cognitive skills of the domestic dog. This thesis examines what we currently know about dogs in the light of a paradigm in cognitive science called embodied cognition. The embodied cognition viewpoint encourages a much stronger emphasis on the role of the body and the environment in cognitive processing. Its application to dogs is fruitful because it can shed new light on how we view certain aspects of dog cognition and reveal gaps in our currently knowledge worthy of further research.

Structural Outline

This project begins with a critical review of studies regarding the cognitive skills of the domesticated dog. The research I review is largely the work of scientists engaged in experimental psychology and I discuss conclusions which can be drawn from their studies. The initial critical literature review bears fruit in the form of a new way of considering conclusions drawn from experimental research into dog cognition.

Following the opening literature review, I outline the theoretical pillars of embodied cognition and argue that embodied cognition provides an excellent basis for studying dog cognition. Taking each pillar of embodied cognition in turn, I explain how it can be productively applied to dog cognition and give examples to demonstrate.

Various theories of representation have arisen from embodied cognition. Two theories of representation from this paradigm are next outlined and applied to dogs. The two theories are Clark and Grush's (1999) emulation theory of representation and Rowlands' (2006) theory of representation in action. Discussing these theories is worthwhile because they can shed light on mechanisms behind dog behaviour and help us to further understand and train the dogs we are associated with. Training considerations occupy the penultimate chapter of this project along with reasons for the future application of embodied cognition to the broader study of animal cognition and behaviour.

The final chapter argues that embodied cognition can help make sense of the notion of rationality in domesticated dogs. After explaining an account of rationality from embodied cognition, I argue that it can be usefully applied to domesticated dogs to understand how they might be thought of as rational creatures.

In short, dogs are part of most human cultures. They enable us to live, work and serve others in a plethora of ways. Therefore, they deserve our understanding, and our continued efforts to further our understanding of them. I put forward the discussions and arguments to follow, in the hope that our understanding of the behaviour and cognition of dogs may be considered in a different light and advanced. In this thesis, I show how the cognitive science paradigm of embodied cognition is a productive and valuable lens through which dog cognition can be studied.

Chapter Summaries

Chapter One: Cognitive skills of the domesticated dog

The opening chapter provides a literature review on a substantial portion of the recent research into dog cognition. Taking types of cognitive skills in turn, the critical review summarises the main findings of recent research and reflects on alternative conclusions and explanations with regards to the empirical data. Dogs demonstrate a remarkable ability to dogs are able to use human cues as an aid to problem solving and are also extremely sensitive to human attentional states. Dogs' range of problem solving is diverse; he can, for example, learn by imitation and deduction. However, there are two significant confounding variables which threaten empirical research into dog cognition: the herculean task of controlling for confounding variables and the dog's tendency to use human social cues, especially those from a familiar human, sometimes over and above other conflicting environmental cues. Furthermore, some studies and areas of study may not be ethologically appropriate. The opening discussion highlights the thought that when we design experiments for dogs we have to keep the distinctive characteristics of dogs in mind. For several reasons that will be explained, I argue that using experiments designed for humans is problematic because insufficient attention may be given to differing sensory and other capacities of dogs to humans in designing experiments for dogs. The two most significant areas of research which may not be ethologically appropriate are research into counting and studies about object permanence. Instead, I suggest, a productive way forward for research into dog cognition would be to examine which cognitive skills are manifest in the dog's daily life and usual interactions with his environment.

Lastly, I will argue in this opening chapter that by adopting a new approach to non-human animal cognition, fresh light may be shed upon the conclusions we draw about dogs' cognitive capacities. For example, the opening literature review finds evidence of what has been taken as a diminished capacity for problem solving in domesticated dogs, compared with wolves. That is, wolves tend to engage more independently in problem solving tasks, whereas a dog will look to the human present for additional cues. By viewing conclusions such as these through the embodied cognition framework, I suggest that rather than demonstrating a weaker problem solving ability, dogs may be off-loading their cognitive work onto an aspect of their environment (the human present). The second chapter outlines the main strands of embodied cognition to demonstrate how embodied cognition as a new approach might be productively applied to research into non-human animal cognition using dogs as a case study.

Chapter Two: Embodied cognition and Chapter Three: Embodied dog cognition

The second chapter introduces embodied cognition and teases out the seven main theoretical pillars of the approach which can be used to guide research into non-human animal cognition. The seven main pillars are:

1. Cognition is situated
2. Cognition is time pressured
3. Cognitive work is off-loaded onto the environment
4. The environment provides the agent with affordances
5. Cognition is for action
6. Cognition has evolved
7. Cognition is body-based

The second chapter does not constitute a defence of embodied cognition because its main aim is to pave the way for my attempt to show how this new approach may be productively applied to experimental conclusions regarding domesticated dogs and provide reflections on existing research. Instead the motivations and principles of embodied cognition are described, along with the most significant contemporary theories. The work of the third chapter is to then apply embodied cognition and demonstrate the formulation of principles to guide further research into dog cognition. At the end of the third chapter, I introduce the role that representations may play in descriptions of dog behaviour and cognition and suggest that two theories of embodied representations from theembodied cognition paradigm can help in the explanation of dog cognition and behaviour.

Chapter Four: Embodied representations

The fourth chapter introduces two important theories of representation to come out of the embodied cognition literature. These are Clark and Grush's emulation theory of representation and Rowlands' theory of representation in action. I introduce these theories to demonstrate a new way of thinking about representation. This chapter constitutes an explanation of these theories, but does not argue that embodied representations are the only type of representations that may be at work in non-human animal cognitive processing. The main point here is that they make a good starting point for thinking about representations in dogs.

There are many different sorts of representations posited in studies of non-human animal cognitive processing, but some models are unclear and others are taken from human-centred theories and applied to non-humans. This, I argue, is problematic because, according to many prevalent theories, human representations are inner mental states. Much non-human animal cognition, however, is not like this. The picture that embodied cognition paints for us highlights the situated, action-based nature of animal cognition, and representations are no different. Thus, accepting the embodied cognition approach entails a new look at how we approach representation in non-human animals such as dogs. The two theories of representation under discussion provide this fresh approach and the fifth chapter brings the theories of representation to life by showing how and when they can enhance our understanding of dogs' cognitive processing in situations they might face.

Chapter Five: Embodied representation use in dogs and Chapter Six: Studying dogs using embodied cognition and embodied representations

Through a series of scenarios the fifth chapter begins to show how theories of embodied representation might enhance our understanding of dog behaviour and cognition. The main goal of this chapter is to show that these theories have explanatory value and how this approach to representations might be productive. I return to some of the main findings of the literature review on dog cognition and suggest ways in which the data might be interpreted given a new understanding of representation in dogs. The main areas in which I argue that embodied representations are at work in dog cognition include learning by imitation, anticipatory planning in novel situations and the use of human cues such as pointing and attentional states. The overarching aim of these two chapters is to show how a clearer view of what animal use of representations might entail sheds light on the way in which we might view their behavior in certain circumstances.

Chapter Seven: Embodied cognition and dog rationality

The seventh chapter provides an argument for a new approach to how we conceive of rationality in dogs. I claim that embodied representations underpin our conception of what makes an animal's action rational including times when information about the environment is hard to come by, or when the situation is challenging and novel. From a philosophical standpoint, rationality in domesticated dogs is important because it has ethical implications. For example, Kant once argued that animals had only instrumental value because they lacked the requisite rationality for intrinsic value. He wrote:

> Every rational being exists as an end in himself and not merely as a means to be arbitrarily used by this or that will
>
> ... Beings whose existence depends not on our will but on nature have, nevertheless, if they are not rational beings, only a relative value as means and are

> therefore called things. On the other hand, rational beings are called persons inasmuch as their nature already marks them out as ends in themselves (Kant, 1785, p.428).

This argument and variations of it have consequences for the way that non-human animals such as dogs are treated. A future area of research is the philosophical investigation into the ethical implications of a robust account of rationality with its roots in embodied cognition, such as the one I provide in this final chapter.

Chapter One: Cognitive skills of the domesticated dog

The opening chapter begins with a discussion of the perceptual abilities of the domesticated dog. I begin with a discussion of canine perception to elucidate the ways in which the dog sees the world. The dog's worldview is so vastly different to our own because his methods of sensing the world are so divergent to ours. This is an important point to bear in mind, as I shall argue, when we work with, study and train our dogs. From here, it moves to a comprehensive review of studies into dog cognition. The following discussion is structured to move from perception, and cognitive processes which are heavily dependent upon humans, to more abstract forms of cognitive processing.

1.1. Perception

Physical characteristics of a dog's perceptual system affect the nature and character of his cognitive processes (Anderson, 2005a, p. 14).[1] The following discussion provides an overview of the sensory apparatus and abilities of the domesticated dog. What a dog attends to in any given situation is probably not what we attend to. There are vast perceptual differences, motivational differences and learning differences; all of which affect what the dog will use and focus on when interacting normally with his environment, or when completing experimental tasks set for him. This section of the chapter aims to outline the perceptual capacities of the domesticated dog. Then, with the dog's perceptual framework in mind, I move to a review of the recent literature concerning dog cognition.

1.1.1 Vision

Canine retinas contain predominantly rods, and very few cones; only 3% of all photoreceptors are cones (Peichl 1992). Because of this, their ability to perceive colour is poorer than ours. Studies have suggested that the domesticated dog is capable of perceiving two hues: blue and yellow. Colours that fall between these two hues such as greenish-yellow or yellowish-red would probably be perceived as white or light grey. This means that dogs are not good at distinguishing between green and yellow, yellow and orange, or orange and red (Miller and Murphy, 1995) and their vision is largely dichromatic.

The optic chiasm has a crossover of about 75% in the dog, which means that the average dog has good binocular vision (Aguirre 1978; Odom, Bromberg and Dawson, 1983). Furthermore, experimental data suggest that dogs have an enhanced visual sensitivity for motion. They can discriminate moving objects at a distance of 800-900 metres but the range falls to 500 metres if the objects are stationary (Miklósi, 2008). In addition, it seems that dogs notice shorter durations between light flashes than we can. They have a shorter flicker fusion threshold – effectively their visual system 'updates' more frequently than ours, so the refresh rate of the frames on a TV would be too slow for dogs and they would see a series of static images rather than a continuous moving image. The refresh rate is 50-60 Hz for human watching, but the optimal value for dogs would be 70-80Hz or more (Coile, Pollitz, and Smith, 1989).

Dogs' eyes also function better in dim light compared to human eyes which strain in dim light. In short, dogs' eyes are better suited to detecting motion and for distinguishing between light and dark shades rather than perceiving colour and stationary details at long distances (Lindsay, 2001). In many studies into dog cognition, visual cues are controlled for extremely well. This is a direct result of the experiments being designed with a human-centric bias. When we conduct experiments which involve the dog searching for something, problem solving or categorising on the basis of visual information, we should indeed control for visual cues, although the emphasis should be on controlling for olfactory cues, and we ought to bear in mind the visual perceptual differences between humans and dogs.

1.1.2 Taste

Gustatory perception is little understood in the dog; more is known about canine auditory and olfactory perception. Studies have indicated that dogs and humans share a pattern of taste receptors on the tongue. This suggests that salty, sugary, and sour tastes are localised toward the front two-thirds of the tongue, while bitter tastes are located toward the rear third of the tongue. However, even though specific tastes are stronger in these specific areas, these same tastes are detected over the entire surface of the tongue (Lindsay, 2001).

Despite the dog's tongue being similar to our own, it is still debatable whether dogs can taste salt: past experiments have provided evidence that they cannot (Boudreau, 1989 as cited in Lindsay, 2001). As Boudreau notes, it is unlikely that most carnivores can taste salt because their diet will provide them with their salt requirements without them having to seek it out. Herbivores on the other hand probably do taste salt since they will have to be able to detect sources of salt to supplement their diet. In summary, the domesticated dog's taste perception is probably much like ours except for the possibility that he cannot detect salt.

1.1.3 Hearing

As for the dog's auditory perception, dogs can hear sounds between

67 and 45 thousand Hz, well above the range of wavelengths that humans can detect (64 – 23 thousand Hz). Thus, dogs can hear sounds at high frequencies that are imperceptible to us, frequencies that are ultrasonic in human terms. Coren (2004) writes that the ability to hear such a wide range of frequencies may be an adaptation to hunting small animals that emit high pitched

squeaks and cause high-frequency sounds when moving through leaves and grass. This is important to remember when we are setting up experiments such as invisible displacement tasks. We must make sure that they can't use auditory cues that are inaudible to us and ensure that dogs' success on such tasks is not due to the simple fact that they heard where the item was moved to.

1.1.4 Smell

Nietzsche's famous remark 'all my genius is in my nostrils' (Nietzsche,2009, p. 333) applies best to dogs. A much greater portion of the dog's brain is devoted to the sense of smell than in humans. Almost an eighth of the dog's brain is devoted to olfaction while in comparison the human olfactory lobes are much smaller (Syrotuck, 1972, p. 11).

Scent in puppyhood is the most important factor for survival in the dog. When a litter is whelped, the newborn pups have their eyes closed. Their first contact with their mother is via smell, the pup is guided to his mother's nipple by scent. One might think that a pup is guided to the nipple by following the heat source, yet when hungry he will disregard his litter mates and head straight for the 'milk bar' even though his littermates generate the same warmth as his mother. In addition, the pup quickly learns the varying scent of the bitch in certain situations (Pearsall and Verbruggen, 1982).

Dogs also suffer from 'nose fatigue'. It is important to note that canine nose fatigue, when a dog's nose becomes gradually less able to perceive a scent after prolonged exposure, may not be caused by an internal process, as it is in humans, but by a set of external causes. Dry, warm air on a dusty field will exceed the ability of a dog's nose to humidify the air. The nasal membranes become dry and odorous molecules no longer find the watery layer in which they must dissolve in order for the dog to detect them. To counter this effect, dogs may lick their noses but even this maynot be enough. The best remedy is a long drink of cool water. This should be taken into account during tracking experiments and other olfaction- based activities we ask of our dogs.

After a period of training, it was found that the dog can sense a concentration of the chemical n-amyl acetate that is 1.0×10^3 to 10.0×10^5 fold lower than humans can sense (Walker, Walker and Cavnar, 2006). Probably the largest difference in the olfactory capacities between dogs and humans is the square area of olfactory sensory cells inside the nose; humans have about 1.5 cubic inches whereas the average German Shepherd has about 6 cubic inches. Thus, a much greater surface is exposed to scented air in the dog's nose (Pearsall and Verbruggen, 1982, p. 7). Furthermore, it is estimated that a human has five million olfactory sensory cells, while a typical German Shepherd has 220 million (Syrotuck,1972). Some breeds of dog have more olfactory sensory cells than others. For example, Dachshunds typically have 125 million olfactory sensory cells and Fox Terriers have somewhere around 147 million (Syrotuck, 1972). The cell count appears to increase with the size of the dog but more research is needed to be sure; it is also unclear whether fewer sensory cells mean a poorer sense of smell.

Dogs also have more than one sensory system devoted to smell. They sense most odours using receptors in the olfactory cavity, but also have a vomeronasal organ which opens into the nasal cavity (Syrotuck,1972). The vomeronasal organ has its own layer of receptor cells and is specialised for the detection of species-specific chemical signals (i.e. sex pheromones). Though the precise role of the vomeronasal organ is not clear, it is thought that information from the vomeronasal cavity passes straight through to the limbic system and influences maternal care, aggression, and the secretion of sex hormones (Salazar, Cifuentes and Sanchez-Quinteiro, 2013).

Smell plays an enormous role in the dog's perception of his environment and of all the dog's senses it is the most finely tuned and used. Much communication between dogs occurs via smell. The urine of a dog contains information concerning the sex, age, overall state of health, diet and recent sexual behaviour of a dog (Csányi, 2000). Humans also secrete a scent trail. The use of perfumes, soaps, deodorants, shampoos and so on are now in widespread use. Add to this the secretion of skin oils from sebaceous glands and the by-products of this chemical breakdown of cells and secretions, plus additional scents we pick up as we move through our day combine to form human scent which can be transferred onto objects that we touch only once and detected by dogs.

Therefore, when designing experiments with the domesticated dog, the importance of controlling for confounding olfactory cues cannot be overstated. All these smells and more will be passed from object to object with one touch leaving a clear trail as scent molecules fall with the movement of a hand, foot or shake of the head. For example, when testing for object permanence in dogs we must be careful that olfactory cues are properly controlled for due to the threat of accidental olfactory cues providing confounding variables. The dog can probably detect via following a scent trail where the 'invisible' object has gone.[1] This, in the light of the above information, seems a daunting task, but some researchers have attempted it. For example, Gagnon and Doré (1992) tried to control for olfactory cues in an object displacement task. They write:

> Olfactory cues were masked with a solution of rose water diluted in tap water (1:10) that was sprayed on the objects, the screens, and the carpet. This substance was chosen because it was highly odoriferous, edible, and nontoxic. Two fans, placed at each end

[1] In object permanence studies 'invisible' tends to be synonymous with 'imperceptible'. This holds true for humans most of the time, but is not the case with dogs.

of the semicircle formed by the screens, served to spread the rose water odor uniformly (Gagnon and Doré, 1992, p. 65).

However, this does not seem adequate. The dog's sense of smell is at least ten thousand times better than our own. In the domestic dog, the surface area of the olfactory epithelium is up to 50 times larger than humans and as we have seen there are up to 50 times the number of olfactory receptors (Kalderbach, 1998). (This varies, though, depending on the breed of dog.) Moreover, because of the sheer quantity of scents the dog is able to detect, one hypothesis is that they must be able to 'layer' the scents or keep them all separate and be able to focus their attention on individual scents selectively, in much the same way as we can visually concentrate on one object rather than all the others in our immediate environment.

So while rose water may mask many scents for humans, it is unlikely to do so for dogs. Therefore, the fact that the dogs in Gagnon and Doré's (1992) study still succeeded in invisible displacement tasks in the odour masking condition does not, contrary to their conclusion, show that dogsare solving invisible displacement tasks from an understanding of object permanence. An alternative explanation is that despite all the rose water they can still smell where the target item has been moved to.

In the early 1900s, von Uexkull remarked that each species has its own perceptual world, or Umwelt (Drickamer, 1996). It can be difficult to step outside our own perceptual world and try to understand that of the domesticated dog given that his primary sense is one of our weakest. In vertebrates, the cerebral hemispheres developed from the roof of the olfactory lobe (Saslow, 2002). Olfaction was the predominant sense of animals coming out onto land and was exploited for distance information.

In addition, the mammalian limbic system was largely driven by olfactory input. Evidence of this is felt in humans when we so easily recall an emotion from the past by its association to a particular scent. However, in primates, particularly humans, the emphasis on olfaction has diminished and our olfactory structures are not as strong as those of our ancestors.

Dogs use their sense of smell for prey detection, social functions via detection of pheromones, scent mark investigation to determine, for example, sexual status and receptivity, kinship recognition, and recognition of other relevant aspects of their environment. Olfactory stimuli provide information during both the day and night (hence the usefulness of police dogs for night time work) and unintentional olfactory messages may be transmitted to the dog we are working with. There are chemicals released in human sweat when we are scared and adrenaline is pumping and when a dog is tracking a human he is often following a trail based on adrenaline in his target's sweat. Similarly, when we are controlling for social cues inadvertently provided by an experimenter during experiments (such as involuntary changes in facial expression sometimes controlled for by blocking visual access to the human’s face during experiments) we must remember that social cues for the dog are just as much, if not more, olfaction-based than visual. In the invisible displacement task above, social cues were controlled for by placing a screen between the dog and experimenter. However, this does not control for any olfactory cues that the experimenter may release during the experiment. As a simple example, if the experimenter experiences a jolt of adrenaline when the dog moves toward the hiding place of the target item during visible and invisible displacement tasks, it is possible the dog can smell this and learn to use this scent as a cue to ‘solving’ object permanence tasks.

1.1.5 Touch

The sense of touch is facilitated by somatosensory receptors located within a dog’s skin. There are five categories of these receptors: The nociceptors, associated with pain, proprioceptors, sensitive to body movement and position, thermoreceptors, sensitive to hot and cold, chemoreceptors, sensitive to chemical stimulation and mechanoreceptors, sensitive to pressure due to physical changes of the body. Particularly important for a dog’s sense of touch are his whiskers. The dog’s whiskers, known as vibrissae, are unique follicle receptors. They provide the dog with protection for his muzzle in navigating around objects and particularly protect him from injury to his eyes or collision with objects. These vibrissae are also capable of detecting vibrations caused by moving objects and simple changes in air currents (Lindsay, 2000). Again, we need to be careful to control for cues that the dog may inadvertently receive during experiments. For example, if the dog can sense simple changes in air currents or vibrations associated with movements that he is not supposed to be able to perceive, this will confound the results.

1.1.6 Perception: Conclusion

In many experiments with dogs, much is made of controlling for environmental and social cues by restricting the dogs' visual access to experimenters, aspects of their environment and so on. But we should bear in mind that controlling for other perceptual cues are just as important. When dealing with dogs in experimental psychology we need to fully understand the acuity of dogs' senses of smell, touch and hearing. As is clear by now, these senses play a much greater role in canine perception than they do in human perception. Dogs have adapted to discern visual cues with amazing skill, but any well designed experiment into the dog's cognitive capacities will need to take their other remarkable senses into account and control for the confounding variables that may arise from dogs' heightened sense of smell, touch and hearing. In addition, well-designed dog experiments should attend to the differences in visual perception between dogs and human.

My aim throughout the following discussion, which will occupy the remainder of this chapter, is to give an overview and discussion of what has been studied in relation to dog cognition, conclusions that have been drawn and the basis of these conclusions. For a clearer structure, the studies are divided into sections based on the type of cognitive capacity they address, although of course it is unlikely that in reality these cognitive capacities are completely discrete. I have ordered following discussion to move from more interactive forms of communication and cognitive processing between the dog and his environment to studies of more abstract cognitive processing

1.2 Cognitive Skills

1.2.1 Communication

Dogs can adapt to the internal rules of whatever social organisation they are in. For example, a family dog with training can abide by rules put in place by its human family and generally seem happy to be part of the social group. Pet dogs can bond with family members and interact with them to mutual benefit and enjoyment. In short, the cohabitation of humans and dogs seems natural and with sensible training the enculturation of the dog into a human family is usually a smooth process. Of course, there are dogs that for one reason or another do not fit in to human society with the ease I have described and different cultures have diverse attitudes toward dogs and how they are treated. In many cultures, dogs are not accepted into the family home, but in the UK around a quarter of all families include one or more pet dogs and in North America, even in the cities, around one fifth of all households have a dog (Conen, 1994). There are data to suggest a close similarity between how humans interact with their dogs and how they interact with young infants (Mitchell, 2001). From the dog's side, the attachment behaviour of dogs is analogous to that of human toddlers and canine subjects were able to discriminate and respond differently to their caregiver than to other humans (Topál, Miklósi, Dóka, Csányi, 1998). Dogs also respond differently to separation from the person they are most closely attached to than to separation from other members of the family; thus reinforcing the conclusion that not only do most dog owners regard their dogs as members of the family, dogs also become selectively attached to members of their family.

The foundation of our relationship with dogs, whatever the dog's role, whether he is a companion, a farm dog, a hunter's aid or a guide dog, is communication. In this context, communication is the responding to and giving of social cues in a variety of situations. The ability to learn to communicate with humans was the most advantageous trait for the early domestic dog to possess (Hare, Brown, Williamson, and Tomasello, 2002). Probably dogs acquired the ability to read human communicative clues as a response to their living in contact with humans during the course of their evolution. This is thought to be supported by the finding that dogs show better comprehension skills in some versions of a two-way choice task than chimpanzees (Miklósi, 2008). The two-way choice task involves the subject using a human's pointing cue to decide which of the two presented vessels contains the food reward. Clearly, though, there are many experimental differences between the testing of dogs and the testing of chimpanzees that would make comparative statements of this nature difficult. Whether or not we can conclude on the basis of Miklósi's study that the dog's communicative abilities are a result of dogs and humans' historical relationship, there seems to be little doubt that the evolution of the domesticated dog's ability to communicate with us has influenced and been influenced by human beings over the years.

In ethological research, communication is often defined as 'an animal's behavioural act that alters the probable conduct of another animal in a manner that, on the average, is advantageous for the communicating animal's survival and reproduction' (Csányi, 2000, p. 161). When asked, most dog owners will happily provide anecdotal evidence of their dog's astounding ability to communicate. Dogs readily learn how to let their owners know when they need to go outside, for example. Furthermore, the remarkable communicative and interactive abilities are exemplified when we consider the number and diversity of communicative interactions the guide dog of a blind person is trained to perform on a daily basis. Here is a list of some examples:

Obstacle Avoidance

Navigate around stationary obstacles e.g. lamp posts, parking meters or pillars.

Navigate around hazards e.g. open manholes and deep potholes. Navigate around low hanging obstacles e.g. awnings or tree branches to avoid a collision.

Avoid moving objects e.g. bicycles, people, strollers, shopping carts, wheelchairs.

Leash guide around obstacles indoors or outdoors for a short distance.Intelligent disobedience as in refusing a command to go forward into the road if there is oncoming traffic or intersecting traffic in the team's path.

The dog is also trained to halt, abruptly, rather than collide with a vehicle that intersects the team's path when it enters the intersection during the team's crossing.

Signal changes in elevation

Halt or sit to indicate every curb.

Halt to indicate descending stairs at the top of a flight of stairs. Halt to indicate steps up into a building or patio area.

Halt to warn of edge of subway or train platform.

Halt to warn of approach to edge of cliff, ditch or other outdoor drop- offs.

Halt when confronted by a barrier such as at construction site.

Intelligent disobedience - refuse a command to go forward if there is drop-off.

Find objects on command

Find an exit from a room; indicate door knob. Find the elevator bank.

Find specific entrances and/or exits.

Find an empty seat, bench, or unoccupied area. Find a customary seat in a particular classroom.

Follow a designated person such as a waiter to restaurant table, clerk to elevator, etc.

Locate a specified destination such as store in mall, hotel room or home from a distance, once all other decision points such as intersecting streets, hallways, etc. have been passed.

The list above is a list of trained communicative behaviours. The dog is intensively trained through positive and negative reinforcement to respond in precise ways in certain situations. There are several interesting things to note from the list of examples of communication and responses between a guide dog and his human that are accomplished as a result of the dog's training. Firstly, all the communication between the human and dog revolves around actions. Some of the signals from the dog inhibit actions such as '*Stop*'; some promote actions such as '*Cross the road*'. And prominent in the list above is that dogs have learned to associate words primarily with actions and this is the way communication works between humans and dogs; our signals to dogs are action-based. They are signals for the dog to perform a specific action, whether it is retrieving a dropped item or herding sheep into the next paddock. This seems to make sense from an evolutionary perspective. The most useful dogs to have around would probably have been the ones that quickly learnt associations between words and useful actions. I will return to this point and discuss it in more detail later on.

One of the very first experiments on dog cognition was a test of the dog's ability to discriminate human spoken words. Buytendijk and Fischel (1936) trained a dog to respond to a verbal command and then gradually changed the word by systematically changing the phonemes within it. They report that the beginning of words is more significant for dogs, on the grounds that the dog was more likely to fulfil the command if the change occurred at the end of the word than at the beginning. Certain physical properties of complex sounds can have a more direct influence on a dog's behaviour.

Studies have also shown that dogs can be trained faster to perform a passive action to a long note with a descending fundamental frequency. In contrast, an active response was trained more easily when using a sequence of shorter notes with a rising frequency (McConnell, 1990). These findings indicate that the tone, frequency and sound of words are discriminated by a dog, perhaps more so than the phonemic sound of the word itself. The reliance on tone and sounds of a word makes sense given that dogs' barks are varied in tone, frequency and length according to their communication function. That the higher, faster barks resonate with an active, more emphatic communication is a way in which barking represents what is being communicated. Effective human-dog communication will employ this. For effective communication our verbal commands to dogs should accord in tone, length and frequency with what is being requested. This is analogous to the human use of hand gestures when speaking to another human. When excited or agitated a human will usually gesture emphatically, using whole arm movements and open hands. A dejected human conveying something negative will gesture with arms closer to the body, if at all, and the hands will not move as much (Navarro, 2008). Even without understanding what the speaker is saying a great deal can be conveyed through gesture. And it is the same with our communication with dogs; by varying the tone, pitch, length and frequency of our commands we can convey much information to our canine listener.

The ideas I have just presented work well with an embodied cognition approach, the theory that our cognitive capacities are inherently connected to our physical bodies and the environment. The same approach can also apply to communication. An embodied cognition approach to communication entails emphasising the body and action-based nature of communication, between dogs and for dog-human communicative exchanges. I argue throughout that harnessing the notion of embodied cognition will be very useful in our interpretation and application of experimental data on dog cognition. So far I have discussed verbal communication of actions through sounds which embody the action requested. Now let's look at some interesting studies into dogs' comprehension of human names for objects.

Kaminski, Call and Fischer (2004) were interested in the dog's ability to learn the relationship between a word and an object. Kaminski and her team discovered a pet Border Collie named Rico who demonstrated a remarkable ability to match words with objects. With his owners, Rico had supposedly learnt the labels for over 200 hundred items. Most of which were toys and balls. He could correctly retrieve these items on request with astonishing accuracy. Rico learnt the names of these items by his owners bringing him a novel toy or ball, repeating its name two or three times and then letting Rico play with it. After this initial procedure, the name of the item became part of Rico's vocabulary and he could fetch iton request. As an initial study, Kaminski et al. designed an experiment to test whether or not Rico's ability could be due to the 'Clever Hans' effect. In the early 20th Century, an Orlov trotter horse became famous for his ability to do arithmetic. For example, in response to a question such as ‘what is 4+4?’ he would paw at the ground with his hoof a number of times to indicate his answer. So the answer he would give to ‘what is 4+4?’ would be eight hoof beats on the ground. His ability to solve maths problems was later found to be due to his ability to read unintentional signals emitted by his handler via subtle facial and bodily cues (Davis, 2002).

To rule out the “Clever Hans” effect, Kaminski and her colleagues placed the owner out of Rico’s sight and asked him to fetch randomly selected toys. Throughout their study, Rico’s owners remained out of his sight and he correctly retrieved 37 out of 40 items.

Kaminski and her colleagues then designed a further test to try and determine whether Rico could ‘fast map’. Fast mapping is the process that occurs in children when they quickly form hypotheses about the meaning of a new word after a single exposure. The experimenters placed a novel item with seven familiar items in a room adjacent to the one Rico was in. In the first trials, Rico was asked to bring a familiar item. In second or third trials he was asked to fetch the novel item, labelled with a novel name. The results showed that Rico was apparently able to link the novel word with the novel item. This, Kaminski et al. suggest, is because either he knows that the familiar items already had names or because they were not novel. Four weeks later, Kaminski and her team assessed

Rico's ability to fetch the novel item using the previously unfamiliar name. Rico correctly retrieved the target item in 3 out of 6 sessions. This level of success is comparable, they noted, to that of a three-year old infant.

Kaminski and her colleagues concluded that Rico reliably associates names with objects. And his 'experience with acquiring the names of objects allowed him to establish the rule that things can have names. Consequently, he was able to deduce the referent of a new word on the basis of the principle of exclusion when presented with a novel item along with a set of familiar items' (Kaminski et al., 2004, p.1683). This study highlights the fact that while most of our communication with dogs may revolve around action-based cues, dogs' ability to associate human words with objects may be significant.

We should still be guarded, however, about concluding that Rico is truly associating the word with the object alone. Rather, the words 'squeaky toy' may to the dog signal 'fetch the squeaky toy,' which is an action associated with a particular object, not the object itself. Our human use of language is referent based. Humans have many words for many objects and we recognise that a word such as 'ball' or 'stick' stand for certain objects. When we talk about dogs' understanding of words, however, it simply may not be possible to say with certainty that, for the dog, the word denotes the object rather than the action associated with it.

Doubt over whether Rico really understood that a word stood for a referent was also raised by Bloom (2004). In response to this, Pilley and Reid (2012) designed an experiment to investigate the issue. In 2009, Pilley and Reid acquired an eight week old Border Collie called Chaser.

Figure 1. The three objects were placed on a yellow mat in front of Chaser. The experimenter sat behind the screen out of sight during the experiment (Pilley and Reid, 2012, p.189).

After three years' training the researchers concluded that they had successfully taught Chaser to identify over 1000 toys by name (Pilley and Reid, 2012). Chaser then participated in a study to see whether she understood that a word stood for a referent and not an action. Researchers had previously taught Chaser actions such as 'nose', 'take' and 'paw'. The action 'nose' was Chaser pushing an object along with her nose; 'take' involved her picking an object up with her mouth and 'paw' was the pawing action directed at an object by a front paw. Chaser was presented with three toys on a cloth and the experimenter remained out of sight. The toys in this study were already familiar to Chaser and she could fetch them on command reliably. The experimenter (from behind a screen) would call a command such as ‘nose lamb’ to which Chaser would invariably nose at the soft toy resembling a lamb. The trials were recorded and independent judges of whether her responses matched the command were employed. Their decisions indicated that Chaser correctly responded 100%. In the light of these results, Pilley and Reid wrote:

> Thus, Chaser produced a unique response oriented to each object depending upon the meaning of the associated command. She responded as though the commands and the proper-noun names were independent entities or morphemes. Thus, in effect, Chaser treatedphrases like “fetch sock” as though the “sock” was a sock and not “fetch sock” - indicating that her nouns referred to objects. Thus, Bloom's (2004) concern that Rico may not have understood the difference between “sock” and “fetch the sock” is ruled out in this study. These results clearly support the conclusion that Chaser understood ***reference*** – that the verbal noun of an object ***referred*** to a particular object with distinct physical features independent of actions directed toward that object (Pilley and Reid, 2012, p. 190, their emphases).

However, despite the authors’ conclusion, it is still uncertain whether Chaser was separating the required action specified by the verbs ‘paw’ ‘nose’ or ‘take’ from the names of the toys in front of her. It may be that she was taking the command ‘nose lamb’ to still refer to a specific action, inseparable from the toy itself; a more complex request for action than ‘lamb’ by itself might provoke (Grassman, Kaminski and Tomasello, 2012). The heart of the issue here is whether it makes sense to ask this question of an animal’s use of verbal commands. As I will argue later on, our default hypothesis should be rather that animals use words as signals for action and more work needs to be done to show that the ability of an animal to perform different actions with the same object on command is indicative of its ability to understand the proper referent for the noun being used. Defendents of Pilley and Reid’s suggestion that Chaser does understand the referent of the word ‘Sock’ by her ability to perform a range of actions with that sock might argue that she can, for example, isolate the command ‘Fetch Sock’ to mean something like ‘perform the action FETCH with *this particular item*. Thus isolating the object of the action from the action itself. However, as already mentioned, the same moment or command can be perceived a multitude of ways depending on the creature’s perspective. Later on in this thesis I introduce the notion that features of a dog’s environment are perceived as opportunities for action, or affordances. There are many reasons to adopt this framework as a way of beginning to understand how animals might perceive their world. If we stand inside this framework and think of the sock as an affordance, an object of significance to Chaser only in relation to the actions she associates with it, it becomes less clear that her ability to perform a diverse range of actions with the sock is evidence of her understanding that the sock is an object isolated from the things she might do with it.The earlier-mentioned Rico participated in an interesting study more recently in which he and five other dogs were investigated for their ability to understand the correct item to fetch after looking at a photograph, a miniature or a life-sized replica of the object they were to fetch. Three of the dogs, Rico included, were trained to fetch many different items by verbal cue and the other two were inexperienced in the task. Kaminski et al. (2009) found that all the dogs were able to successfully use both the life-sized and the miniature replicas of the items as an information source regarding which item to fetch. The dogs' success in these trials was immediate in the case of the experienced dogs and occurred after just a few trials in the inexperienced dogs. Dogs were less successful with using photos as information about the required object leading Kaminski and her colleagues to hypothesise that dogs' lack of success in using the photos reflects their inexperience with them. This is certainly possible and further investigation would be interesting in this area. An alternative explanation is that dogs have trouble perceiving the photo clearly enough. The interesting point to note from Kaminski et al.'s 2009 study is that dogs are able to use a variety of human cues to facilitate their responses to the environment. Their use of human cues is not limited to verbal cues or gestures. Rather they seem adept at using many different types of human signals. In what follows I will discuss dogs' remarkable ability to use human pointing gestures and some comparisons between the performance of dogs and wolves in these tasks.

1.2.2 Barking and verbal cues from humans

Research into acoustic communication in dogs has grown in the last few years (Faragó, Pongrácz, Miklósi, Huber, Virányi and Range, 2010; Feddersen-Petersen 2000; Molnár, Pongrácz, Faragó, Dóka, Miklósi, 2009; Pongrácz, Molnár, Miklósi, 2010; Taylor, Reby and McComb, 2010) and barks and growls are an important part of canine communication.

Wolves also bark, but only rarely. The wolf's bark is usually a warning or protest with little acoustic variation (Fedderson-Petterson, 2000). In contrast, studies on dogs have shown that they have a much wider range of barks than wolves. Human participants were able to categorise at a significant level above chance recorded bark sequences from a number of different situations (i.e. a dog's bark sounds different when tethered to a tree, when he attacks a stranger through a fence or plays with his owner). The analysis of the barks seems to suggest that dogs use different barks in different situations. The dogs let out a lower frequency bark with a shorter interval between barks in aggressive situations. In play situations the barks had more harmonics, were higher in frequency and had longer intervals between barks (Pongrácz, Molnár, Miklósi and Csányi, 2005b). An interesting study would be to look at whether play barks resembled puppy barks. Anecdotally, my own and friends' dogs do emit similar barks in play as they did as pups suggesting that in play situations, puppy-like vocalisations may be used.

In a more recent study, Molnár, Pongrácz, Dóka and Miklósi (2008) used a machine learning approach to categorising dogs' barks. They had a computer loaded with a program which would classify dogs' barks in accordance with their different acoustic features and the context in which they were emitted. The barks were from different individuals in different contexts. Initially, the program would have the bark inputted along with the context of the bark. Then they tested the computer with unknown barks and found that the computer was able successfully to categorise the dogs' barks on the basis of their acoustics. That is, the program could recognise the sort of bark and output which context it was likely to have occurred in. This suggests that barks are a way of communicating a dog's situation and emotional states, and they are situation-specific. Communication occurs through variations in pitch, tone or frequency of the barks emitted. We can improve our verbal cues by placing emphasis upon the acoustic nature such as the frequency and tone of each cue, for example a command for a high speed action such as a ‘Find’ command would ideally be radically different in sound to a positioning command such as ‘Stay’. Ensuring distinctive variation in the acoustic nature of our verbal cues will aid the dogs’ discrimination of them. The theory behind matching the tone of our verbal cues to the required action is that cognition can be embedded in our bodily actions and vocal sounds. We instinctively learn much about the mental state of a person whom we are with on the basis of the way they hold themselves, gesture, move and sound. In fact, these cues are often more reliable than the words a person is saying, for it is much harder to lie with body language than it is with words (Navarro, 2008). The same theory applies to our communication across species. When our verbal and bodily cues match the action being requested we are more likely to be understood by our non-human recipient.

Information about the physical nature of the sender of auditory communication is also embedded into dogs’ barks and growls. Vocal signals are affected by the physical body of the sender and are a reliable indicator of a dog’s body size. In fact, we know this intuitively and most people can distinguish between a large dog and a small dog reliably based on the sound of their growls and barks alone. Moreover, people with experience with dogs will be able to distinguish between types of growls and barks. For example, our little Terrier's growl when a child is accidentally about to hurt him is much gentler (the tone is not as deep or intense) and shorter in duration than the deep and long growl he'll give to his pack mates if he is guarding a good stick. Children growing up with dogs learn these different sorts of growls and barks quite naturally. Our son will rush to the window when our three dogs start the bark they reserve for the return of a family member or close friend. But he'll ignore the barking kerfuffle that they create when someone unknown comes to the gate. Some of human infants' understanding of canine vocal communication is probably taught by adults. In many cases this is learned implicitly. In an interesting study, Faragó, Pongrácz, Range, Virányi, and Miklósi (2010b) designed an experiment to determine whether body size was in fact encoded somehow into the growl in dog-dog communication. They presented images of dogs to their canine participants and paired the presentation of an image to the sound of a growling dog. When the size of the growling dog in the image matched the size of the growling dog in the acoustic stimulus the dogs looked sooner and longer at the image. This, Faragó et al. suggested, is indicative of the conclusion that dogs' growls transmit information about the sender's size. They then go on to hypothesise that dogs might be able to generate a mental representation of the sender of an acoustic signal such as a bark or growl, with respect to the sender's size. While the question of what the mental representation might be is left open, it seems reasonable to suggest that information about a dog's physical status, his size, strength and

Figure 2. The method of recording the growls in the three different contexts (a) Food guarding, (b) playing tug of war and (c) threatening stranger approaching (Faragó et al. 2010b, p.919

possibly gender, is embedded into his acoustic communication. Acoustic communication such as barking and growling therefore may serve multiple functions - as a signal for action and as an information source about the sender. Taylor et al., (2010) found similar results in their study suggesting that dogs will respond differently to growls from large dogs as opposed to growls from little dogs. Many different factors contribute to dogs' reactions to growls though, including individual dogs' past experience such as the level and quality of training and socialisation they received and innate tendencies toward agonistic or passive behaviours. This ought to be remembered when experiments are being designed since many things will affect a dog's reaction to another dog's growl not just what is encoded into the growl. Certain vocalisations are also context-specific (Yin and McCowen, 2004; Faragó et al., 2010b) and in 2010 a study was published with evidence suggesting that dogs rely on context-dependent acoustic cues. Faragó et al. (2010b) analysed the responses to growls in a food-guarding situation. In preparation, they recorded growls from dogs in threedifferent contexts: during play, guarding a bone from another dog, and reacting to a threatening stranger. Faragó et al. then analysed the acoustic structure of the growls and performed playback tests in an experimental food-guarding situation. In their analysis they found that play growls differed acoustically from the other two (agonistic) types of growls. Play growls were higher in frequency and agonistic growls were lower infrequency. In their study, playback of food-guarding growls deterred other dogs from approaching and taking away a seemingly unattended bone more effectively than growls recorded in the threatening stranger situation which suggests that the growls and barks of dogs are context-specific.

This study is ground-breaking because it is the first one to investigate the context-dependent nature of dogs' growls; although anecdotal evidence from dog owners suggests that our experience with dogs teaches us that they do have different barks and growls for different situations, little research has been done in this area until Faragó et al.'s (2010b) study.

In conclusion, barking and growling are important aspects of dog communication. Research into vocal signals from dogs is increasing and new research has indicated that dogs' barks and growls can vary according to their frequency, tone and rhythm (Pongraz et al. 2010; Faragó et al 2010a and 2010b). Moreover, barking and growling are context-dependent methods of communication: acoustic signals that are specific to certain situations.

1.3. Learning and problem solving

Experiments into learning and problem solving in dogs are multifarious. I have loosely divided up the studies in this section for easier reading from studies on those processes which require more dog-environment interaction, to the experiments into more abstract cognition.

1.3.1 Problem solving: comparing dogs and wolves

In the past, researchers have suggested that domestication has served to dampen the domestic dog's cognitive abilities. Frank and Frank (1982, 1985) observed that tamed wolves tend to solve problems by trial and error learning and do so more effectively than domestic dogs. Therefore, they wrote, while domestication has selected for tractability and trainability, it has left domesticated dogs with weaker cognitive skills than their undomesticated counterparts. But perhaps in reality the cognitive functioning of the domestic dog is not inferior to that of wolves, just different. Problem solving ability merely appears to be diminished because the domestic dog's reaction to problem solving tasks is redirected by the dog's dependency on her human experimenter, handler or owner. Using twenty eight dog and owner pairs, Topál, Miklósi and Csányi (1997) divided the pairs into two groups: one group was classified as 'Companion Relationship' and the other as 'Working Relationship'.

Those dogs in the ‘Companion Relationship’ group had a somewhat close relationship to their owners and were part of the family home. Some in this category had undergone obedience training, others had not. Dogs in the ‘Working Relationship’ category were not incorporated into the family structure and not as well socialised with humans as the dogs in the companion relationship category. Each dog was faced with the same problem: that of working out how to access food in a dish placed on the opposite side of the fence to the dog. The solution to this problem was to pull the dish by the handle from under the fence in order to consume the food.The dependent variables were: 1) the number of times each dog looked at the owner; 2) following of the owner; 3) latency of manipulations; 4) the number of manipulations they gave the dish handle and 5) the number of food items eaten. The independent variable was the relationship between the dog and owner. Topál and colleagues reported that dogs in the ‘Companion Relationship’ group took longer to begin to solve the task. They waited longer before manipulating the dish handle compared to the dogs in the ‘Working Relationship’ category. In addition, dogs in the ‘Companion Relationship’ category looked at and followed their owner more frequently and performed fewer manipulations of the food dish before encouragement than the dogs in the ‘Working Relationship’ category. In short, in the unfamiliar problem solving task the companion dogs tended to exhibit more reliance on their owners in the solution of the problem. Incidentally, the breed of the dog and whether or not the dog had undergone obedience training did not appear to modify the effect of the human-dog bond in this experiment. On the basis of this experiment, Topál et al. concluded that:

> This study could provide a new way of interpreting the dog's problem solving ability. Manipulation test performance is thought to be one of the manifestations of cognitive capacities. Our results show that the decrement in the cognitive test performances of dogs demonstrated previously in comparison with wolves (Frank and Frank, 1982; 1985; Frank et al. 1989), may be due to the dog's sensitivity to its relationship with humans (tendency to behave socially dependently) and not due to some cognitive disability (Topál et al. 1997, p. 222).

The study of Topál and his team certainly seems to suggest that the effect of close socialisation between humans and dogs has led to a reliance on human cues in dog problem solving. I agree with their conclusion that the reliance upon human cues can be seen not as a diminished problem solving capacity, but rather a different strategy for solving problems. It would be interesting to repeat their study with a control group of dogs from both categories with their owners absent in light of considerations that the familiarity between the dog and the person giving the cues is likely to affect the dogs' responding to cues in the experimental setting.

A more recent study by Topál, Gergely, Erdöhegyi, Csibra, and Miklósi (2009) has also suggested that human cues were responsible for dogs' failure in object permanence studies. They found that if an experimenter showed the location of a reward underneath cup A and then hid it under cup B, in full sight of the dogs, the dogs would continue to search under cup A for the reward. Curiously, human infants do the same thing. They will continue to look under cup A even though they have seen the object moved to cup B. Tomasello and Kaminski (2009) remark that it seems as though by the time the adult hides it in location B, the infant already has

learned a general principle about this object's normal location. This result, also known as the 'A not B error' (Kis et al., 2012) was not found in human-raised wolves. The wolves will follow what they have seen and the human's actions or presence does not affect performance (Topál et al.,2009). We will look in more detail at this finding below during the following discussion of object permanence.

1.3.2 Dogs' use of human gaze direction and pointing gestures

It has been suggested that, in contrast with dogs, wolves are less skilled in communicative interaction with humans. As Kubinyi, Virányi and Miklósi (2007) report, this is true even with wolves that have been intensively socialised. There are various reasons for the differences in the understanding of human communicative behaviour of wolves as opposed to domestic dogs (Byrne, 2003). Domestic dogs seem to be able to follow pointing actions made by someone's hand. They can also follow a person's gaze (Soproni, Miklósi, Topál, Csányi, 2002; Miklósi, Polgárdi, Topál and Csányi, 2000). This has led to several suggestions that dogs, in virtue of their having this ability to follow a person's gaze or pointing gesture, are capable of entertaining certain mental states such as beliefs about what the person is looking at (Baron-Cohen,1994; Byrne, 2003). Byrne writes: "In humans, pointing and gaze-following have been causally linked to reference, one of the fundamentals of language; moreover, pointing and gaze following are generally seen as part of a suite of abilities that together confer a 'theory of mind'" (Byrne, 2003, p. R347). Dogs, Byrne goes on to suggest, are able to follow pointing by the head and eyes or pointing by the hand. They can follow pointing by the hand even if the hand that is pointing must cross the person's body to the target item. Dogs can also follow hand pointing if the hand remains stationary and the human moves in the opposite direction to way she is pointing. However, Byrne does then point out that nothing in the behaviour of domestic dogs can give us conclusive evidence that they are capable of having a theory of mind: Their behaviour doesn't conclusively tell us that they understand the mental states of the pointers. Indeed, it is extraordinarily difficult to prove that any non-human animal has a theory of mind.

According to Byrne, the most likely account that we can give at this stage for why dogs might have acquired such a remarkable skill as being able to follow a person's gaze or point, is what he calls a 'special-purpose adaptation. It is a skill that has perhaps developed from the need to interpret the movement of prey based on the gaze or signal of fellow human or canine hunters.

In a separate study, Miklósi, Kubinyi, Topál, Gácsi, Virányi and Csányi (2003), report that even though domesticated wolves can follow hand pointing to an extent, they never acquired the same level of competence as domestic dogs. However, more recently, Virányi, Gácsi, Kubinyi, Topál, Belenyi and Ujifalussy (2008) did find that after extensive training, wolves could come to use human pointing gestures. Their ability increased in parallel with their willingness to look at the human pointer.

The difference between the wolves' ability to follow gaze and hand- pointing and dogs' ability may come from the simple fact that dogs look at humans' faces but wolves don't very readily (Miklósi et al. 2003). Clearly, animals that don't look much at humans' faces have little chance of learning the contingencies between human gaze-direction and events in the world. Dogs' natural tendency to attend to humans' cues is affected by their species' history of socialisation with humans and by the individual's experiences. Dogs will attend most readily to humans with whom they have a relationship (Horn, Range and Huber, 2013).

Moreover, the tendency to attend to people's social cues such as pointing can vary according to the breed of the dog (Passalacquaa, Marshall-Pescini, Barnard, Lakatos, Valsecchi, Prato Previdea, 2011). Passalacquaa et al. confronted dogs with an unsolvable task and found that hunting and herding dogs such as the Australian Terriers, Border Collies, Golden Retrievers and Labrador Retrievers looked toward the human more often and for longer than primitive breeds of dog such as the Akita Inu, Alaskan Malamutes and the Siberian Husky. Dogs who looked the least at the human were American Staffordshires, Boxers, German Shepherds, Bull Terriers and Rottweilers. In all breeds the tendency to look at humans for social cues increased with the age of the dogs. This led the authors to conclude that:

> Although the domestication process has shaped the emergence of human-directed gazing behaviour (Miklósi et al., 2003), the subsequent selection for cooperative working traits may have had a strong influence on its occurrence. The fact that this behaviour increased with the age of the subjects suggests that an appropriate human environment might be necessary for the development and learning of this behaviour (Passalacquaa et al., p.1049).

Miklósi and his team tested the tendency of dogs to look at people's fa'ces by making unsolvable a task that dogs previously succeeded in resulting in a food reward. The reactions of the dogs were immediate: they looked at their owners' faces and back at their task. This, Miklósi et al., explain by saying that the dogs' reactions were those of an animal that had no understanding of their owners' mental states but could learn information quickly by looking at their owners' faces. They concluded that what domestication has done for the dog is to select for the tendency to look at the human face in times of uncertainty. This may have led the way for dogs' and humans' long association since it enables the domestic dog to read 'the behavioural intentions and likely needs of another species' (Byrne, 2003, p. R348). We should note that the sense in which a dog may read the behavioural intentions of another agent need not involve the attribution of internal mental states. Anticipatory planning, as I shall argue later, can occur at the sub-personal level using cognitive mechanisms that do not depend upon the attribution of internal mental states.

Another possibility is that for wolves, direct eye contact may be seen as a threat or challenge. Thus, wolves are less willing to look at humans'

faces and have a lower tolerance for humans looking them directly in the eye (Topál, Miklósi, Dóka and Csányi, 1998; Gácsi, Topál, Miklósi, Dóka and Csányi, 2001). This is the case even after months of training and hundreds of trials for point-following; socialised wolves have only been found able to follow human pointing at the level of naive dogs (Viryáni et al. 2008). This further supports the conclusion that dogs are much better at following human pointing cues than socialised wolves, leading to the hypothesis that domestication of the dog has led to sensitivity to human communicative gestures.

An interesting study by Udell, Dorèy and Wynne (2008) examined the possibility that the differences found between wolves and dogs in following human pointing gestures is due, in part, to the testing conditions. In all studies on following human pointing, they noticed that wolves have been tested outside (Hare et al., 2002, Miklósi et al., 2003, Viryáni et al., 2008, as cited in Udell et al., 2008). In at least one case, the wolves were tested from outside their fenced enclosure, meaning that in this test there was a barrier between the experimenters and the wolves. In contrast, the domesticated dogs in most studies are tested inside, with no barriers between the experimenters and the domesticated dogs. Udell et al. conducted two experiments aimed at determining whether domestication is responsible for the failure of wolves and the success of dogs in human pointing tasks or whether the difference is down to reasons other than genetic predispositions. In their first experiment they tested eight human- reared wolves and eight pet dogs in similar settings. Both groups were outside and isolated from pack mates. Another eight pet dogs were tested in their homes, and eight dogs from the local shelter were tested indoors.

The first experiment required the dogs to respond to a human pointing cue. The human experimenter stood between two empty paint cans and pointed to one of them. The dog or wolf was 2.5 metres away from the human and the cans were each half a metre from the human on either side of him or her. When the dog or wolf indicated the correct choice, the experimenter clicked and dropped a piece of food on the chosen container. For an incorrect choice, no food was presented and the experimenter remained neutral. They found that the wolves tested outdoors and the pet dogs tested indoors performed at above chance levels in following the pointing cue. The performance of these two groups was similar but more individual wolves (six of the eight) followed the point in eight or more of the ten trials. This is in contrast to only three of the eight dog subjects doing the same. Both groups of pet dogs tested outdoors did not perform at levels above chance in responding correctly to the human pointing cue. None of the shelter dogs followed the human pointing cue and overall the shelter dogs were significantly less successful at following the pointing cue than the wolves.

In summary, the shelter dogs did not respond to the pointing cue to a significant level when they were tested outside and their performance was worse than that of the wolves. Therefore the experimental setting is a potential confounding variable in the study of cognitive skills in dogs and wolves. Thus, when considering the differences found between dogs and wolves we ought to look carefully at the settings under which these results have been generated.

In their second experiment, Udell et al. looked at whether the presence of a fence barrier between dogs and the human experimenter made a difference to the dog's performance in responding correctly to human pointing cues. There were two groups of seven dogs, all of which were pet dogs living in human homes. Dogs in one group were tested with a fence between them and the experimenter; dogs in the other group had no fence. Once again, the human experimenter had empty paint cans on either side and stood a short distance from the dog. But this time, the experimenter tapped on one of the paint cans rather than just pointing at it as in the first experiment. In the fence condition, the human experimenter was always on the same side as the cans, behind a fence, but the dog could get his snout within 10cms of the paint cans. If the dog indicated the correct choice, the human experimenter placed food on top of the can and the dog ate the food. (In the fence condition the food was sometimes too hard to get for the dog, so the experimenter promptly pushed the can with the food on through the fence so the dog could consume it). They found that dogs tested from outside a fenced enclosure performed at significantly lower levels than those dogs tested from inside the enclosure. Thus, the presence of the fence barrier, the authors conclude, has a significant impact on dogs' ability to respond correctly to human pointing cues.

Overall, Udell et al. found that wolves with proper socialisation, contact with humans and, most notably, appropriate experimental conditions were able to succeed at following a human pointing cue, sometimes performing better than the domesticated dogs. Udell et al. write that ‘unlike the wolves studied by Miklósi et al. (2003) and Viryáni et al. (2008), which were only mildly successful after hundreds of trials, the wolves in our study succeeded in using a momentary distal point with no prior exposure to the task and were presented with only a minimal number of trials during testing, suggesting that their performance is truly comparable to that of domestic dogs’ (Udell et al. 2008, p. 1771).

In summary, Udell et al.’s studies are indicative of the possibility that the divergence between problem solving abilities of dogs and wolves may, in part, be due to the differences in experimental settings and socialisation. This issue needs further investigation of course, but the findings outlined above are an important consideration when comparing wolves’ and dogs’ cognitive capacities.

Scheider, Kaminski, Call and Tomasello (2013) questioned dogs’ interpretations of human pointing commands. In their recent study they found that dogs react to commands in the form of pointing gestures from children differently than pointing gesture commands from adults. The children’s pointing gesture commands seem to carry less authority than adults, Scheider et al., conclude.

The authors favour this suggestion, but acknowledge that it is possible that the fact that a dog is usually trained by a particular adult may affect the dogs' reactions to children since commands from a particular adult (or adults in general) may be those that have been reinforced in the dog's experience. Contrastingly, Scheider et al. (2013) found that dogs did not react differently to children's and adults' pointing cues in a differently constructed study where the pointing gestures indicated a solution to a problem rather than a command. Dogs in their study could use both children's and adults' pointing cues to successfully find the food reward. The dogs did not differentiate between children's and adults' pointing cues in situations where the pointing gesture indicated the location of the food. In these situations, the dogs would choose the cup containing the food, based, according to the authors, on the information from the human pointing gesture regardless of whether the human was an adult or a child.This, Scheider et al. write, indicates that dogs do not interpret pointing as a command. This conclusion is based on the theory that if it were interpreted as a command, the same bias toward listening to the commands/cues of adults better than the commands of children would have been found.

Moreover, the familiarity of the person giving cues in an experimental setting has the potential to confound the experiment's results. Dogs, more than any other animal in general, have the ability to form close bonds with individual humans that they see on a regular basis. As a result, their responding to a human with whom they are bonded is bound to be different from their responses to a stranger. In a recent study, Cook, Carter and Jacob (2013), set out to investigate the effect of familiarity on dogs' responses in an experimental situation. They compared dogs' use of information from a stranger to dogs' use of information from their owner. They gave the dogs two possible choices, one of which was indicated to by their owner, the other of which was indicated by a stranger. The aim was determine the degree to which dogs' responses were affected by the familiarity of the person providing the cue to the food location. Only one of the containers presented to the dogs contained a food reward. Cook et al. hypothesised that dogs would show a bias toward following the cues of the owner rather than the stranger's cues. Cook et al.'s results suggest that the familiarity of a person providing social cues influences dogs' behaviour. The dogs in their study chose to follow cues from a familiar person more frequently than cues from a stranger. This was the case even when the owner's cues repeatedly provided information that did not lead to the food reward. Some dogs displayed a side bias, consistently choosing containers on a particular side. Interestingly, the dogs with a side bias would only choose the non- preferred side when the owner was standing near it:

> … revealing an apparent combined use of one social and one non- social strategy to solve the task …These results also demonstrate that dogs are not simply automatically deferring to

> a familiar human. Instead, they are actively engaging in attempts to solve the task, and one of their preferred strategies is to attend to the behaviour and/or location of a familiar human (Cook, 2013, p. 14).

In conclusion, we must be careful before we conclude that domestication is a predictor of sensitivity to human cues, as the shelter dogs' performance suggests. Even though the domesticated shelter dogs interacted readily with the experimenters and were picked on the basis that they would approach a human and accept food, their use of human pointing cues as an aid to problem solving was remarkably poor. Similarly, the presence of a fence between the experimenter and wolf subjects has in the past severely hindered the wolves' performance in following human point cues. In fact, with comparable handling, appropriate experimental conditions and socialisation, wolves might be just as sensitive to human cues as domesticated dogs.

Thus, evolution of a dog's tendency to use human social cues cannot by itself account for dogs' sensitivity to human cues - the socialisation and contact between humans and individual dogs (and humans and individual wolves) play a large part also in the development of sensitivity to human cues. Moreover, in the dog's lifetime he will learn to follow human cues if doing so leads to reinforcement. Also the breeding (Passalacquaa et al., 2009) and age of the dog (Doréy, Udell and Wynne, 2010) contributes to how readily the dog will use social cues. It is the combination of these factors that gives certain domesticated dogs their remarkable ability to use human cues as an aid to problem solving although exactly how dogs interpret human cues is uncertain.

Furthermore, the effect of handler familiarity upon the dog influences the dog's behaviour. As Cook et al.'s (2013) study suggests it is likely that the domesticated dog will respond more readily to commands from people with whom they are familiar. This may also hold true for wolves although to my knowledge it has not been tested.

Hence, there are good reasons why we should not assume that domestication alone has furnished the dog with heightened abilities tounderstand human social cues as an aid to problem solving. There are many factors, outlined above, which influence the degree to which the dog is able or willing to use human cues. Plus, we ought to be careful what we conclude from experiments designed to test dogs' use of human cues as an aid to problem solving. Individual experience, the experimental setting and design, and familiarity with the person giving the cues in the experiment will all affect how the dog or wolf responds to a social cue from a human. Each of these factors may be confounding variables within an experiment and need to be considered carefully.

The ability to follow human gaze or hand pointing may be an example of what Hare et al. (2002) meant when they wrote, ‘some aspects of the socio-cognitive abilities of dogs have converged within the phylogenetic constraints of the species with those of humans’ (Hare et al., 2002, p.1636). This convergence Hare et al. attribute to enculturation. Ontogenetic enculturation is a process proposed by Michael Tomasello and his group to explain why many hand-reared great apes succeed in cognitive tasks where zoo-raised or lab-raised great apes fail. The idea is that skills such as effective communication cues and responses can be learned as an animal lives with humans. Certain skills such as gaze following might not manifest or develop as readily unless the dog has associated with humans for a period of time. The emphasis for Hare et al. (2002) is on an individual’s experience rather than innate ability alone, and, to repeat my earlier point, it is probable that the dog’s ability to communicate is a combined result of innate potential and the individual’s experience with humans.

This makes sense; humans develop certain cognitive capacities because we are a part of a culture. These capacities are handed onto us by those who have reared us given that we have the innate potential to learn them. On this view, dogs and the hand-raised great apes acquire certain communication skills because they have a natural potential to do so and because they were raised in a human society. In addition, dogs have been selectively bred to respond to human cues.

There are, however, differences in the way in which dogs and wolves develop within a human society; dogs and wolves have different critical development periods. For example, dogs can begin socialisation with humans at 16 weeks old and integrate into human society perfectly well, whereas wolves must be socialised before they are 10-14 days old if they are to bond successfully with humans. Udell et al. (2008) suggest that

> … environment and development affect a social animal's ability to react in situation appropriate ways to the social cues of other individuals … [and] … we propose that animals genetically capable of responding to social cues will still differ in their ability to use specific forms of cue depending on their individual histories and environments during critical developmental periods (Udell et al., 2008, p.1772).

There does seem to be a difference in the readiness with which dogs will use human cues in comparison to wolves. However, as Udell et al.'s study highlights, learning and communication can be affected by the environment and even be situation-specific (occur in one setting, but not in another). Moreover, dogs' interpretation of human pointing cues still warrants some investigation because it is unclear whether dogs interpret pointing gestures as a source of information.

With this in mind, studies on communication between dogs and humans, and even between dogs and their pack mates ought to bear in mind the strong influence that individual histories, environmental factors and testing conditions may have on the development and execution of certain cognitive skills. The situation specific nature of learning and cognition will be further explored in the following chapter. Recognition of the situatedness of cognition is an important element of the embodied cognition paradigm which I argue can help inform our study of canine cognition.

1.3.3 Learning by imitation

Another way in which dogs problem solve is by imitation. Recently, experiments have refuted Frank's (1989) paper in which he suggested that dogs could not learn by observation (Kubinyi, Miklósi, Topál and Csányi,

2003). It was demonstrated that dogs that watch a human or fellow dog solving detour or instrumental tasks are more successful at those tasks than dogs that have not seen the demonstrators perform that task (Pongrácz, Miklósi, Kubinyi, Gurobi, Topál and Csányi, 2001). In addition, evidence has been obtained that suggests dogs are able to use a human action as a cue for showing a functionally similar behaviour (Kubinyi et al., 2003; Topál, et al., 2006a). Philip, a four year old Tervueren, was able in an experimental setting to use different human demonstrated actions as models for his own behaviour (Topál, et al., 2006b). First, the experimenters trained him to repeat nine human demonstrated actions on command. When his performance was over chance in response to the demonstrated actions, they demonstrated a novel action sequence. The action sequence involved moving an object from one place to another. On the same command as in the training session, Philip copied the novel action sequence more often than expected by chance over a series of trials. On the basis of this study Topál and his colleagues suggest that Philip may have the ability to generalise his understanding of copying. The dog, they write 'could have recognized the action sequence, on the basis of observation alone, in terms of the initial state, the means and the goal. This suggests that dogs might acquire abilities by observations that enhance their success in complex socio-behavioural situations' (Topál et al, 2006b, p.355). A similar study by Pongrácz, Mikosi, Vida and Csányi (2005a) reported similar conclusions to these. This study went one step further, however, and tested whether some breeds of dog were better at learning by imitation than others. Their results indicate that breed differences did not affect learning by imitation, but they did find that herding dogs looked back at their owners more frequently than hunting dogs. They also found that the age of the dog had no effect on its ability to learn by imitation.

Further to this, dogs not only seem able to learn by imitation, but they appear to do so selectively (Range, Virányi and Huber, 2007). This is parallel to results found in studies done on children. Range et al.'s (2007) experiment found that dogs may be able to choose to imitate an action based on inferences about that action's efficiency. Of course, more work needs to be done to confirm Range and his colleagues' findings and whether other animals as well as dogs have this cognitive skill. Most interesting would be an experiment to determine whether or not wolves have the ability to learn by imitation and if they do, whether they can do so selectively. Moreover, it would be interesting to test affiliative imitation in dogs and compare whether dogs are more likely to learn by imitation from close pack mates than from other dogs. The age and/or status of the demonstrator dog may also influence whether dogs will readily learn by imitation. To my knowledge this has not been tested in dogs, but a study has been conducted with horses and found that a younger horse will learn by imitation from an older horse, but not vice versa (Krueger, Farmer, Heinze, 2013).

1.3.4. Dogs' sensitivity to human attentional states

Recognition of a person's attentional state could be useful to the dog for providing feedback on the likelihood of a desired outcome or interaction. For example, our Terrier is an avid stick fetcher. After running to get the stick, he will stand (holding the stick in his mouth) in front of me. Rarely does he go behind me where I cannot see him. It seems, therefore, that he has learnt something about me: to get me to throw the stick again I need to be able to see his request for a game; and this is achieved by him standing in front of me. If I happen to be distracted and ignore him, even though he's right in front of me holding a stick, our Terrier will perform vertical jumps which bring him almost up to the level of my face, sometimes letting out a woof at the pinnacle of his jump. His efforts are usually effective since it is almost impossible not to notice someone when they have leapt into mid air and woofed in your face. Gácsi, Miklósi, Varga, Topál and Csányi (2004) write:

> When communicating by visual signals the sender either has to wait (passively) until the receiver's visual attention is directed at him/her, or alternatively he/she should modify his/her own behavior (actively) to become the focus of the other's attention. This could be achieved by producing attention-receiving signals, which direct the other's attention to the signaller or, alternatively, the signaler moves into the actual visual field of the receiver. Although animals (including humans) probably use both strategies, especially the latter is taken as evidence for the recognition of attention (Gácsi et al., 2004, p. 144).

Our little Terrier begins by passively waiting for my attention to be directed at him, before moving on to other attention-getting signals including jumping into my visual field and producing an attention-getting bark. However, Gácsi et al. continue,

> There is a difference if one defines the recognition of attention at the behavioral or cognitive representational level. In the first case one assumes that the individual is sensitive to behavioral cues that are associated with seeing or "attending". Such observable cues could be the presence or absence of eyes, the direction of head or body or simply the presence or absence of the other individual. In the second case the recognition of attention goes beyond the observation and recognition of specific cues, and results in a mental representation about the mental state of the other (Gácsi et al., 2004, p. 144).

Call, Bräuer, Kaminski and Tomasello (2003) tested twelve pet dogs, over a series of trials. They placed a piece of food in a location clearly visible to the dog. They were forbidden to take the food. In some trials the human looked at the dog throughout. In other trials the human a) left the room, b) turned her back, c) engaged in a distracting activity or d) closed her eyes. When the human looked at the dog throughout the trial the dogs retrieved less food, approached it in an indirect way or sat more often than in the other conditions where the human paid less attention to the dog.

There were no significant differences amongst the four other conditions where the human was not paying so much attention to the dog. The dogs approached the food more readily. This is interesting because in the condition where the human closed her eyes, she was facing the dog. Thus it is possible that dogs use humans' eyes as a way of reading humans' attentional states.

But it is possible that the dogs have simply learnt to use the presence of a human looking at them with their eyes open as a discriminative stimulus that informs the dog when it is not safe to disobey orders. An alternative explanation that Call et al. (2003) consider is that dogs may have some knowledge about visual perception. Call et al. cite a study by Hare, Call and Tomasello (1998) which found that dogs would return balls they had retrieved to the front of the human thrower. So even when the human turned his or her back the dog would circle around the human and drop the ball in front where, Call et al. suggest, the dogs knew the human could see it. However, this suggestion again might simply be that the dogs have learnt that there is a higher chance of the ball being thrown again if they drop it in front of the human. They need not really know anything about

Figure 3. Arrangement of the tests

visual perception. Therefore, more work is necessary before we can conclude that dogs have knowledge of others' visual perception.

Gácsi, Miklósi, Varga, Topál and Csányi (2004) designed a study to establish whether or not dogs are able to perceive the attentional states of humans in different contexts and, based on their perception of the humans' attentional state, whether the dogs will alter their behaviour accordingly. If the dogs changed their behaviour according to humans' attentional states across different contexts, the authors suggest this would indicate that dogs have a representational understanding of attentional states and are not just responding to humans' behavioural cues such as the presence or absence of eyes or the direction a person's head is pointing.

In their first experiment, the game situation, the owners played fetch with their dog. During the game the humans were asked to face the dog or face away from the dog before the dog approached them. The human participants were either wearing a blindfold or had one on their foreheads when facing away from the approaching dog or facing him.

In the second experiment, the dog fetched an object for his owner sitting in a chair. The owners took up each the four postures described in experiment 1 in separate trials.

The third experiment involved the dog fetching an object for his owner sitting on the ground with the same conditions: the owner was to adopt the same postures in separate trials. From these three experiments, the researchers wanted to determine whether being able to see the owners' eyes was an important influence upon the behaviour of the dogs. If so, then the authors expected to find that the dogs' behaviour changed between the conditions where the owner was either facing the dog or facing away from the dog. If dogs approached the back-turned owner they cannot perceive whether the owner has a blindfold over her eyes or not. Therefore, if dogs use the visibility of humans' eyes to guide their behaviour, then a difference in their behaviour with regard to the visibility of the eyes would be seen only in the facing condition.

In experiment four they tested whether the visibility of a person's eyes changed the dogs' behaviour in a begging situation. The fifth experiment tested whether the orientation of the person's face changed the dogs' behaviour in a begging situation. Overall, Gácsi and her colleagues found that dogs were more hesitant when fetching an object for a person whose eyes were covered by the blindfold and delays in responding indicate that the dogs were influenced by the change in body orientation even in the object-fetching tasks.

In summary, the authors found that the dogs did show evidence of recognising different behavioural cues associated with human attention. However, their performance was variable and changed according to the context. In the first experiment, the game of fetch, the dogs did not behave differently whether the humans were blindfolded or not, or whether or not they were facing him. In contrast, the dogs were more hesitant to retrieve an object for the blindfolded owner, compared to the non-blindfolded owner. Moreover, there was a significant preference shown in the begging condition for the humans who had their heads oriented toward the dogs. In conclusion, the authors suggest that dogs may understand the role of the humans' face orientation in social interactions, but they pay less attention to whether such facing behaviour is accompanied by the visibility of the person's eyes.

Based on this study and the one by Call et al. (2003) described above, dogs may be able to base their behaviour upon the perceived attentional state of humans, but this ability may not be generalisable. For example, it was not seen in the play situation as much as in the begging scenario. So the authors appear to rule out the theory of a representational understanding of human attentional states in dogs. The results of their experiment were expected, however. More likely is the thought that dogs have learned to attend to different aspects of their environment in different situations. Attention recognition may occur in some situations, but not others. And in certain situations, such as in experiments two and three, the presence of the blindfold covering the owner's eyes was an influence on the behaviour of the dog. But, in other situations, it was the orientation of the owner's face which determined the begging

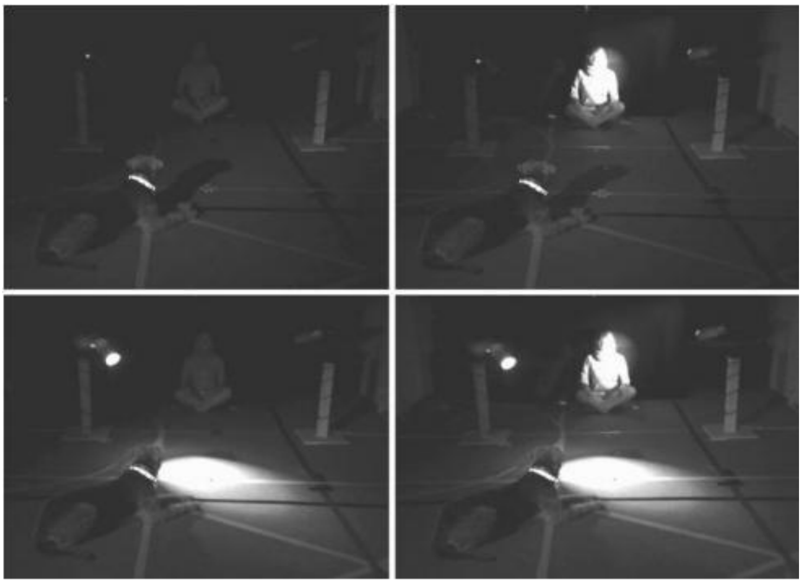

Figure 5. The layout of the different experimental conditions.

behaviour of the dog. Whether or not the dog is learning context specific rules is still speculation; the only conclusive statements to be made at the end of this section are that sensitivity to attentional states is likely to be, as with other cognitive skills, situation-specific.

An interesting recent study looked at whether dogs would be more likely to steal food in the presence of a human when the room was dark (Kaminksi, Pitch and Tomasello, 2013). Testing twenty eight dogs, they found that dogs were more likely to take the food when the food and the human were in darkness. Figure 7 above illustrates the four conditions of Kaminski et al.'s study. They found that dogs hesitated the longest intaking the food when the room was lit, whether or not the human was illuminated at the same time. The authors rule out the possibility that dogs have learned to use illumination of the food as a discriminative stimulus to guide whether or not they take the food. This is because dogs actually approached the illuminated food faster when there was no human present. Therefore, the authors conclude, their study presents evidence that dogs can take into account humans' visual perception of the food and use this to guide their behaviour. However, this is a tentative conclusion. More research is needed to clearly determine what dogs attend to when gauging a human's attentional state and whether or not there is more at work in the alteration of behaviour seen in the studies outlined above than could be explained by low-level associative processes and operant learning.

1.3.5. Deduction

Erdőhegyi, Topál, Virányi and Miklósi (2007) tested dogs' ability to perform deductive inferences. Their hypothesis was that if a dog was shown two possible hiding places and then shown which of the hiding places was empty, he would be able to deduce that the food reward was in the other hiding place. Importantly, the human participant called the dog's name to catch its attention, and alternated her gaze between the dog and the container that she manipulated to demonstrate that it was empty. But what happened was, in contrast to the finding of Scheider et al. (2013), that even when the dogs were shown that one of the containers was empty, they still chose the empty container much more than was expected by chance, leading the researchers to the conclusion that the dog could not infer the location of the food reward by exclusion. In light of these results, Erdőhegyi and his team thought that maybe the empty container was made more attractive by the human participant's manipulation of it. This would explain why the dog would choose the empty container despite the obvious absence of food in the empty container.

To test their conclusion, Erdőhegyi et al. designed a further test. The experiment was set up in the same way as before except the experimenter handled and tapped both boxes, not just the empty one. In this experiment, the dogs chose the container with the food reward inside more frequently than was expected by chance. Miklósi (2008) suggested that according to these results dogs do have the ability to perform simple inferences but their performance in such tests is easily overridden by social cues. This suggestion was controversial though and other researchers concluded that it is doubtful whether the dogs in this study were solving problems by virtue of inferential reasoning (Watson, Gergely, Topál, Gácsi, Sarkozi and Csányi et al. 2001; Collier-Baker et al., 2004 and Collier-Baker et al., 2006).

Reasoning by exclusion is the form of deductive inference that Erdőhegyi et al. (2007) were testing for in the study described above. Since their study, a more rigorous one has been designed and carried out by Aust, Range, Steurer and Huber (2008). The first step, they write, to testing for reasoning by exclusion is to determine whether the subject is able to choose an 'undefined' item (an item that does not already have an association to the dog - such as a novel object). This is essentially the same skill that Kaminski et al. (2004) were testing when they tested fast mapping in highly trained dogs like Rico in the experiment described above. But the choosing of the undefined, novel item may be due to

other factors; therefore, they remark, it is only 'if stability of the novel association in the presence of unfamiliar rather than familiar alternatives is maintained, [that] reasoning by exclusion can be inferred' (Aust et al., 2008, p.588). The participants were trained in a computer-controlled two- choice procedure which means they were presented two pictures on a computer screen and reinforced either negatively (no consequence was provided) or positively (a reward was obtained) for choosing one of the pictures. After the initial training, dogs were presented with a picture they had not seen before alongside a picture that they had prior experience with. They found

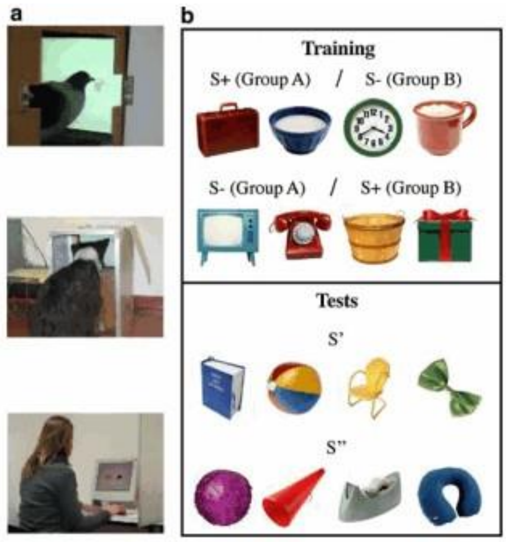

Figure 6. a. A pigeon, a dog, and a student working with their respective versions of the computer-controlled two-choice procedure. Pigeons and dogs were trained in Skinner-boxes to prevent distraction and social cueing. The human participants were visually separated from the experimenter by an opaque wall. b. The stimuli used to investigate reasoning by exclusion. Top panel: - Four training stimuli belonged to the positive class (S+) for half of the subjects of each group (Group A or Group B) respectively) and to the negative class (S-) for the other subjects. Bottom panel: Four test stimuli in the top row were shown together with S- in test 1 and together with the novel stimuli (S'', bottom row) in test 2 (Aust et al., 2008, p.589).

that half of the dogs and almost all the humans in the study chose the novel positive stimulus (a novel picture which they did not know was a positive stimulus) over the negative stimulus (the familiar picture) reliably. Their choice, Aust et al. argue, was based upon inferring positive class membership to the novel picture by excluding the negative stimulusand showed evidence of reasoning by exclusion (Aust et al. 2008, p. 587). The results of Aust et al.'s experiment also corroborate the results of Erdőhegyi et al. that social cues from handlers and a bias toward using social cues can inhibit dogs' use of reasoning by exclusion in experimental settings.

Aust et al.'s experiment neatly controlled for neophilia confounding the results of their study. To do so, they presented the novel positive stimulus from the first test described above along with a new 'novel' stimulus (a picture that the participant had not seen before Test 2. Most of the participants showed no bias toward choosing the picture they had not seen before over the picture which had been a positive stimulus in the previous test. In their discussion, Aust et al. conclude that their findings demonstrate that dogs can reason by exclusion. We should note, however, that this skill has been shown *in their experimental setting*. This is a different claim to the statement that dogs will use reasoning by exclusion adaptively in their interactions with their environment. What is of interest now is whether similar reasoning processes are observed in dogs interacting with their daily environment. This is an important step because it may be that in the experimental setting the dogs had learned to reason by exclusion, indeed they were taught to do this in the training trials, but whether dogs will exhibit reasoning by exclusion as they face ethologically appropriate tasks has yet to be shown.

In summary, when we are examining cognition in domestic dogs and other animals it would serve us well to take this further step and see if we can find the skills demonstrated by well-designed studies such as Aust et al.'s (2008) study in an animal's interactions with his natural environment. By doing this we can hopefully make solid hypotheses regarding the cognitive processes behind the dog's behavioural repertoire. When thinking about the use of deductive inference in dogs I struggle to find examples of when this skill may be used in their self-directed interactions with the world or in the actions required of them by humans. For example, for the behaviours (some of which are listed above) required from the highly trained guide dog as he guides a person to a location, it is not obvious that deductive reasoning is necessary, the guide dog is highly trained to respond in particular ways in specific situations. However, it would be useful to further examine the potential for dogs' use of deductive inference in the context in which it might be used. Moreover the studies described above emphasise that the effect of domestication coupled with dogs' experience with humans may have provided them with traits likely to prepare dogs to efficiently learn from humans in a wide range of situations (Kis, Topál, Gácsi, Range, Huber, Miklósi, and

Virányi, 2012). These traits may override other types of cognitive skill such as reasoning by exclusion and explain why dogs' performance in experimental settings can be offset by erroneous handler cues.

1.3.6 Understanding object permanence

Tracking and hunting prey places a heavy cognitive load on an animal's informational processing skills (Gibson, 1979). To pursue an object of prey, an animal must precisely discriminate and anticipate prey movements. Dogs, being cooperative hunters have the additional task of discriminating and anticipating the movements of other pack members. Furthermore, pursued prey can and does move out of sight. Tracking an animal requires the ability to locate hiding prey, and other behaviours such as hunting as a pack and mating demand interaction with other pack members that the dog may be unable to directly perceive.

Étienne (1995) defined three different groups of strategies that animals use to find hidden physical or social objects. The first level is observed in various predatory species such as spiders and insects. The behaviours that characterise this first level of finding hidden targets involve 'stereotyped movements or postures that increase the probability of contacting and catching prey that has disappeared. These behaviours occur over a short period of time and are only directed toward objects of immediate survival value' (Fiset et al., 2000, p.1). At the second level, instrumental learning has furnished the animal with the ability to find out of sight objects that they have had previous experience in searching for in that particular location. Rabbits and chicks reportedly demonstrate an ability to locate hidden objects using instrumentally acquired skills (Fiset et al., 2000). However, the skills acquired at level two are not easily generalised to novel situations and are quite rigid in their structure. Therefore, Fiset et al. conclude that there is a third skill acquired by some non-human animals in some situations. The third and highest level of skills related to locating hidden objects is 'spontaneous and active search behaviour' (Fiset et al., 2000, p.1). According to Étienne (1995), creatures engaging in this type of searching behaviour are demonstrating an understanding of object permanence. The cognitive structure that is said to enable an animal to cope with aspects of their environment that may not always be visible is object permanence.

The notion of object permanence was first developed by Piaget (1952). Piaget outlined several stages that human infants pass through which culminate in true object permanence. Since Piaget first developed his theory, researchers have used his framework to test for similar cognitive skills in animals. At stage one, an animal or human infant will not try to look for an object when it goes out of sight. Stage two is achieved once the animal or infant tries to pursue the object after it has moved out of sight. Stages three and four involve recovering a partially (three) and fully (four) hidden object from the place where they saw it disappear. The tasks that are involved in determining whether an animal or human infant is at stages three or four are often called visible displacement tasks. Stage five is reached when the animal or infant will retrieve an item that has first been hidden in several locations, then exposed, then hidden again in several other locations. Tasks to test for stage five are often called successive visible displacement tasks and at this level some degree of object permanence is thought to be manifest.

At stage six, the final stage, an animal or infant can master what is known as an invisible displacement task analogous to this one: a target object is hidden in a container, which is then moved behind a screen. The screen hides the container (and the object within it) from view. The target object is then transferred from the first container to the second (without the animal or infant seeing). The animal or infant is shown that the container is now empty and if he or she is able to infer where the item is now hidden they are said to understand object displacement (Piaget, 1952).

According to Gagnon and Doré, the skills that have been developing in a non-human animal or human infant as it progresses through the stages are: an understanding that an object continues to exist even when it is not visible (this capacity develops from stage four); the ability to infer the location of an object from the perceptual information available to the subject 'as well as from a mental reconstruction of movements that were not directly perceived but that were signalled' (Gagnon and Doré, 1993, p.

247). Whether or not the subject does indeed use a mental reconstruction of the object's movements in its inference is questionable, but certainly in the studies I shall review shortly on object permanence in dogs, the subjects do appear to make some kind of inference regarding the location of a no longer visible object.

There are differences between the stages that different species reach. For example, in some studies, cats and dogs have succeeded in visible displacement tasks but not in invisible displacement tasks (see Doré, 1986; Dumas and Doré, 1989; Fiset and Plourde, 2013). Cats, these studies conclude, can represent an invisible object but only when the object moves out of sight before their eyes. Cats and dogs, however, reach the visible displacement tasks (stage five) more quickly than monkeys with dogs arriving at stage 5 between 5-7 weeks. But it seems to take another few months before they are capable of object displacement (Reznikova, 2007, p. 136). The precise age at which dogs have been said to understand invisible object displacement is as yet undetermined. That they do develop it is suggested by previous experiments and it is possible that dogs develop an understanding of invisible object displacement based on higher cognitive processing requirements, such as those required by cooperative hunting (Gagnon and Doré 1994).

In the '80s, tests of object permanence in domestic dogs and wolves began. Frank and Frank (1986) tested 10 week old malamutes and wolves on object manipulation tests. They found that the wolves' behaviour displayed greater understanding of object displacement than the puppies of the same age. Thus, they suggested that cognitive differences may exist between wolves and dogs and these differences may be the result of the different species being faced with tasks of differing complexity. Despite the promising research on dogs and object displacement, Reznikova tells us that only great apes and parrots so far have been found to consistently pass corresponding tests to achieve stage 6 of the tests for object permanence (Reznikova 2007, p.136). However, until recently, researchers of dog cognition have been more confident than Reznikova suggests. This is largely due to the work of Gagnon and Doré on object permanence in domesticated dogs.

Gagnon and Doré (1994) tested sixty nine domestic puppies. Five groups of ten dogs were formed to examine object permanence in domestic dogs between the ages of four and six weeks. Three boxes were used and placed in the subject's most familiar environment, the litter nest (a pilot study showed that testing the puppies in an unfamiliar setting had a detrimental effect on the puppies' ability to respond to the task). Different sets of boxes were used depending on the height of the puppy. Two experimenters were involved, one to restrain the puppy in front of the boxes, another to manipulate the target item behind the boxes either in sight of the pup or out of sight of the pup, depending on whether the test was for visible displacement or invisible displacement. To keep the target object out of sight of the pup, it was moved behind a fourth box. Gagnon and Doré found that pups at 5 weeks began to search behind the boxes for a mobile object and could find it if the object was only partially hidden. By 7 weeks, pups could search for and find the object if it was totally hidden. However, they would only do this if search behaviour began before the object disappeared from view entirely. In these trials, the object was hidden in full view of the pups (visible displacement). However, none of the 8 week, 3 month or 9 month old pups succeeded at levels beyond chance in the invisible displacement problems. Trial and error learning seemed to best account for the success of some of them during these trials. Older dogs of 11 months of age did better at the invisible displacement problems. Gagnon and Doré conclude that dogs do develop an understanding of object permanence. Each stage of object permanence is acquired gradually until somewhere between 9 and 11 months dogs are able to succeed at invisible displacement tasks. They refer back to Gibson's remark that predators like the dog must be able to cope with a large amount of information processing in order to succeed at hunting and dealing with conspecifics. Although Gagnon and Doré are hesitant to attribute as necessary an understanding of invisible displacement to the development of complex social interactions, they do acknowledge that understanding invisible displacement might assist other, higher cognitive processing in dogs.

In Gagnon and Doré's 1992 study, they performed an experiment to test whether dogs were using scent cues to solve invisible displacement tasks by using rose water to disguise the scent of the target objects. In the scent controlled condition, the objects were sprayed with rose water and fans were set to blow the scent around the room. In the other condition, there was no attempt at odour masking. The dogs performed better in the visible displacement tasks than the invisible displacement tasks, in line with other results. And there was no significant difference in the results between the scent-controlled condition and the condition without control for scent cues. On the basis of this experiment, there was little control for odour cues in their later 1994 experiment. The odour controls in their 1994 study involved the placement of the target objects in the litter nests of the pups and the boxes in which the toys were hidden were rubbed with the toys before the trials began. However, it is possible that in their 1992 study, the odour cues were not successfully masked and the dogs were still using scent cues to track objects. Controlling for scent cues in experiments with dogs is an immense, maybe impossible, task.

In a different study Fiset, Beaulieu and Landry (2003) examined whether dogs' success in visible displacement tasks declined if there was a time interval between the hiding of the food reward and the dog being allowed to search for it. They hypothesised that dogs' performance would decline as the time interval got incrementally longer. In their first experiment, the time intervals increased by 10 seconds each time, and as expected the dogs' performance did decline as they got longer but remained above chance. In their second experiment, the increase in time intervals got bigger, this time increasing by 30 seconds after each trial. The dogs' performance still declined, but remained above chance until the interval lasted 240 seconds. During the time intervals an opaque screen was placed between the dog and the place where the object had been hidden. Throughout the time intervals the dogs tended to turn their heads from side to side. This behaviour, which was not predicted, lent weight to the idea that the dogs were not orienting their heads to the location of the hidden object as a non-mnemonic way of locating the hidden food. The most likely explanation of the dogs' success in the tasks set is, according to Fiset et al. (2003), that dogs encode and maintain an active representation of the hiding location in working memory during the retention intervals. When the dogs failed to find the hidden object, they were still searching in the correct general area, suggesting that they remembered roughly where the object went but could not locate its position specifically. According to Fiset et al., their results support the hypothesis:

> … that dogs do rely on a mental representation to memorise the spatial information of the target hiding location. This suggests that the strength of the memory trace of the hiding location decreased gradually in the dogs' working memory in the minute following the

> object’s disappearance behind the target location. However, how dogs maintain the spatial information about the hiding location in working memory for a relatively long period of time (240 s) is still unknown. One possibility is that dogs might use a form of rehearsal to keep the hiding location active in memory. However, our experiments did not provide any cues about this possibility and for the moment, this remains purely speculative (Fiset et al., 2003, p. 8).

Despite their outward success, there are some troubling issues with the experiments on object permanence with domesticated dogs. The most prominent of these is that there appears to be inadequate control for the effect of scent cues on the performance of dogs in these tasks. Moreover, dogs are extraordinarily perceptive of human social cues and we should determine, therefore, whether they might be responding to environmental or social cues rather than an understanding of object displacement. Social cues can even be as slight as the detection of adrenaline from an experimenter if the dog begins to respond correctly, or the perception of visual cues.

Collier-Baker, Davis and Suddendorf (2004) found that dogs failed invisible displacement tasks when tested under stricter conditions. Their experiment involved hiding the target item underneath a displacement device (the box behind which the object was moved in the invisible displacement trials). The displacement device was then moved between boxes visible to the dog. The target item was hidden in one of the boxes and the dog had to work out which one was the target box (where the item ended up being hidden). They compared the performance of dogs under the following conditions: when the head and body of the experimenter who performed the manipulations were hidden, and when the first and last box visited by the displacement device was not the target box, and the final position of the displacement device relative to the target box. They found that the performance of the dogs was similar to chance when the last box visited by the displacement device was not the target box. The movement of the displacement device was the environmental cue by which the dogs seemed to be searching. In addition, when the displacement device was non-adjacent to the target box after the object had been hidden, the dogs mainly failed the invisible displacement tasks. Interestingly, they found that whether or not the experimenter was visible did not seem to affect the dogs' performance on invisible displacement tasks. So in this study the dogs did not appear to be using information from the experimenter to solve the task. Instead their responses seemed most affected by the position of the displacement device and whether or not the last box visited was the target box. This gives us some insight into the environmental cues the dogs were trying to use to solve the invisible displacement task and obtain the target object and highlights the importance of allowing for the possibility that our initial thoughts about what dogs may attend to in such situations may not be accurate.

Even though Collier-Baker et al.'s study (2004) revealed no effect of experimenter presence on dogs' performance in the invisible displacement tasks, Fiset and LeBlanc (2007) looked more deeply at the issue of whether dogs might be responding to cues accidentally given by the experimenters. In one condition, visual perception of the experimenter who manipulated the object was blocked by a screen. In the other condition, the dogs could see the experimenter. They set the experiment up in the same way as Gagnon and Doré (1994); there were four boxes displayed on a platform in front of the dogs and the displacement device was always placed at either end of the row of boxes. They conducted visible displacement trials and invisible displacement trials. During the visible displacement trials, the dogs mostly watched the object the whole time in both conditions. In these trials the dogs mainly succeeded in the tasks. However, in the invisible displacement trials, the dogs looked at the experimenter manipulating the boxes for most of the trial (in the condition where the experimenter was visible). In this condition, the dogs succeeded in the tasks at a significant level. But when the experimenter was not visible the dogs' performance decreased.

This study suggests that domestic dogs do use the experimenter to increase their chance of success in invisible displacement problems. However, this effect was relatively subtle because it increased the performance of dogs solely in the invisible displacement trials in which the target location was one of the two boxes adjacent to the experimenter. In summary, Fiset and LeBlanc found that the dogs seemed to be using the experimenter as a landmark for guiding their search behaviour when the displacement device was moved behind one of the boxes next to the experimenter. Thus, they conclude: It appears that the dogs also hierarchically organized the visual cues available in an invisible displacement task: the dogs primarily searched as a function of the displacement device but when the experimenter was visible, they showed a tendency to use both sources of information. In conclusion, the present study supports the assumption that domestic dogs do not understand invisible displacement problems but rather search as a function of the final position of the displacement device and, to a lesser extent, the position of the experimenter (Fiset and LeBlanc, 2007, p. 223).

Therefore, in this study Fiset and Leblanc still found that the positioning of the displacement device played a large role in determining the responses that the dogs produced. The use of the experimenter's position also appeared relevant but only in connection with the position of the displacement device. Similar results may have been found in Collier- Baker's study had the experimenter been in closer proximity to the displacement device.

In 1994, Rutkowska hypothesised that studies that appeared to demonstrate a human infant's understanding of object permanence were merely a case of the infant's eyes continuing to track an object along the same path that the object was taking when it disappeared out of sight. In Rutkowska's study, infants were presented with an object moving on a course which involved its being out of sight for a moment. She noticed that as the object moved out of sight the infant's head and eye movements simply did not change. They continued at the same speed and direction so that when the object reappeared, the infant's gaze was at more or less the correct place.

In light of the findings outlined above, we must be really careful when attributing cognitive skills to non-human animals, and before we can be confident of domestic dogs' understanding of object permanence, further studies need to be conducted using strict controls for scent and social cues because these can have a confounding effect. One of the traits that domestication has furnished dogs with is the tendency to use human cues readily when problem solving. Kis et al. (2012) found that dogs have a strong tendency to commit the A not B error (recall from the above discussion on page 60). In their experiment, when the potential for the dog to use handler cues was removed from the trial, dogs' performance in finding an object that had just been moved to a new location substantially improved. On their results they write:

> We replicated the finding that dogs have a strong tendency to commit the A-not-B error after ostensive-communicative hiding and demonstrated the crucial effect of socio-communicative cues as the A- not-B error diminishes when location B is ostensively enhanced. These findings further support the hypothesis that the dogs' A-not-B error may reflect a special sensitivity to human communicative cues. Such object-hiding and search tasks provide a typical case for how susceptibility to human social signals could (mis)lead domestic dogs (Kis, et al, 2012, p. 737).

Humans' subtle cues have even been shown to affect dogs' performance in scent detection trials, so it is quite possible that in object permanence experiments unintentional experimenter cues are affecting the dogs' performance. Moreover, sometimes dogs' reliance on human cues is such that information provided by humans can override other environmental cues such as the scent of a desired object. For example, Szetei, Miklósi, Topál and Csányi (2003) found that half of the dogs in their study would choose an empty bowl of food on the basis of a human's cue rather than a bowl in which the dogs were able to see and smell food.

In a similar vein, Lit, Schweitzer and Oberbauer (2011) hypothesised that dogs will use human cues over environmental ones. Lit et al. suggested that handler beliefs may affect trained scent detection dogs' performance in virtue of the Clever Hans effect - the unintentional giving off of subtle behavioural and postural cues.

They found that handler beliefs did affect the dogs' performance. Lit et al., set up a study using trained explosive detection dogs and their human handlers. Their experiment involved placing decoy scents, paper markers (decoy signs indicating falsely to handlers the presence of a target scent) and target scents (marijuana and gun powder) in different locations around a church (a location which had never been used before for scent detection training or experiments). It was a double-blind experiment and each dog/handler team searched the church twice. Handlers were told that each condition might contain up to three target scents and target scent markers (the paper markers) would be present in two conditions. No information was provided about the decoy scent. The aim of the experiment was to see if despite decoy scents for the dogs and decoy markers for the handlers whether the dogs would alert correctly at the place where the target scent was laid.

Interestingly, many incorrect alerts from the dogs were given. In particular, more alerts were identified on the locations marked by the paper marker than on locations where the target scent had really been placed, or where there was a decoy scent (i.e. sausages and tennis balls).

The authors ruled out the possibility that handlers were mistakenly signaling their dogs' alerts since the handlers were all experienced in responding to a clear and discrete 'alert' behaviour from their dog. Moreover, when the handlers were debriefed at the end of the study all were visibly surprised at the results of the experiment in which they'd just been involved.

Therefore, it seems that in this study the dogs were affected by their handlers' perception of the paper markers and signaled an alert in response to the handlers' unintentional cues. The authors write that a likely explanation is that dogs respond not only to scent, but to additional cues issued by handlers. This is likely since in training alerts are obtained from the dog in response to overt cues, such as vocal cues and physical prompts from their handlers. The authors go on to suggest that:

> When considering alternative explanations for the incorrect responses, it is further possible that some alerts resulted from target scent contamination during initial set up of conditions. This is unlikely, given the emphasis of alerts toward marked sites, particularly when considering that the initial pattern of alerts was modified by human influence. The array of alert locations also does not support this explanation notably because no dogs alerted on or around the doors where the scent containers had briefly been placed. Moreover, detection dogs are trained to identify scent source rather than scattered residual scent. For example, dogs trained to alert on gunpowder are not expected to alert in an airport area simply because an armed officer passes through (Lit et al., 2011, p.393).

In summary, dogs are exceptionally susceptible to subtle cues from humans which can influence their behaviour in certain experimental conditions. Although it was not always the case in the studies outlined in this section, as Lit and her colleagues have shown in their experiment, the beliefs of handlers and experimenters does (at least) have the potential to significantly affect the behaviour of dogs. This, coupled with the finding that human cues can be used over and above environmental cues such as the presence of a scent (Szetei et al., 2003; Kupan et al., 2011), makes controlling for the Clever Hans effect vital to the reliability of experimental conclusions such as conclusions regarding whether or not dogs understand object permanence. Moreover, we need to consider the possibility that dogs may be more likely to be affected by unintentionally given cues from humans they are familiar with; it may be that the confounding effect of unintentional experimenter cues is less potent when the experimenter is a stranger to the dog. We ought also to consider the possibility that understanding object permanence is task and situation specific. The embodied cognition paradigm emphasises that cognitive skills such as understanding object permanence are likely to be task and situation specific because cognition is a dynamic interplay between the dog and the environment. When we add into consideration that dogs' domestication and experiences with people have fostered a tendency toward their using social cues from humans above other sources of information and their own problem solving tactics it is not surprising that the understanding of object permanence is tricky to demonstrate in an experimental setting. It would be more useful perhaps to examine dogs in their different walks of life and observe any instances during which an understanding of object permanence might explain their behaviour.

1.3.7 Understanding the connection between means and ends

Piaget observed that around 8 months of age, human infants moved beyond what he called 'circular reactions'. By this, he meant that the infants progressed from simply relying on operant conditioning in learning about the world to understanding cause and effect.[2] Since Piaget, researchers of animal cognition have been interested in whether animals are capable of this further level of understanding: understanding the connection between an action and its effect. One reason why this skill is so interesting is that knowledge of the connection between means and ends is argued to underpin the

Figure 7 The experimental set up. In this picture, the dog is attempting to access the food reward by pawing at the box (Osthaus et al., 2005).

[2] In classical conditioning, the behaviour from the animal is brought about by the conditioned stimulus, such as Pavlov's dogs' salivation response to a bell. In contrast, operant conditioning involves voluntary behaviour in that the animal's behaviour is not automatically caused by the stimulus. The probability that a response will be elicited by a stimulus is instead a function of prior reinforcement. That is, the consequences a particular behaviour has received in response to a stimulus affect the chance of the animal producing it in future presentations of the same stimulus

capacity to transform an intention into a plan (Osthaus Lea and Slater, 2005, p. 37). Osthaus, et al. (2005) tested whether or not dogs were capable of understanding the connection between means and end. They looked at whether dogs would learn that pulling on a piece of string dragged a piece of food previously out of reach into a position where they could consume it. They set up a low, flat box with a transparent top so the dog could both see and smell that there was a reward in the box but out of reach. Attached to the reward was a long piece of string that lay on the floor and poked out through the side of the box nearest to the dog. When confronted with this problem, Osthaus et al. found that the dogs two problem-solving strategies: Either they would paw close to applied the food regardless of. whether the string was at the site they were pawing. Or, if the string was in the site that was closest to the food, the dogs would still paw close to the food and paw at the string as well. If the latter of these strategies proved successful, its performance was rapidly perfected; eventually, the string was reliably pulled and the food reward obtained. Thus, Osthaus et al.'s study showed that dogs were able to learn to obtain the food by pulling at the string. However, they concluded, rather than doing so by learning the connection between the string and the food, dogs do so by through operant conditioning over several attempts. They do not develop a means- end understanding in relation to the task.

To explain this result, the researchers suggest that perhaps dogs have lost some of their ability to solve problems. That is, they fail to learn the means-end connection because in their cooperation with humans, the human provides cues to aid the dog's problem solving. An analogous experiment was conducted on string pulling using language-trained and non-language trained African grey parrots by Irene Pepperberg in 2004. Pepperberg found that two language trained parrots demonstrated no means-end understanding when confronted with the same task. The parrots simply asked their human trainers to give them the treat. In contrast, the parrots with no language training solved the problem easily.

Osthaus et al. (2005, p.46) conclude their discussion by saying 'it appears that the availability of human-aided solutions to problems can sometimes inhibit the expression of animals' cognitive abilities'. The results of this experiment are similar to those of other problem solving tasks that dogs are faced with. We saw above that dogs seemed to perform quite badly in problem solving tasks such as pulling a handle to drag a container bearing a food reward toward them. Their performance appeared to be quite poor especially in comparison with wolves faced with the same problem.

A more recent study, however, compared dogs' ability to solve string- pulling tasks to wolves' ability (Range, Moslinger and Virányi, 2012). They found was that neither wolves nor dogs demonstrated the ability to solve string-pulling tasks and so there is no evidence of an understanding of means-end connections. This leads to the possibility that domestication is not at fault for dogs' lack of understanding of a means-end connection, as the authors concluded. There was a difference between the dogs' and wolves' performance but it existed in the types of errors they made, not in an aptitude for understanding the means-end connection in the experiment.

Moreover, it may be misleading to couch the dogs' performance in these experiments in terms of a lack of understanding or a deficit in problem-solving ability. Rather, as has already been suggested, they might just be accustomed to using a different method of problem solving. Much as we would use a calculator to solve a hard sum, dogs likely simply refer to their human for the solution. This is still problem solving, just as our solving the sum by using a calculator is still problem solving. The dog is problem solving in Osthaus et al.'s study by off loading cognitive work onto an aspect of their environment. This is an important thought because it applies to all the other experiments in which dogs may use social cues as an aid to problem solving. Our co-evolution with the dog has adapted him to do just that, so separating his use of social cues from his ability to problem solve may be tricky. This is because for domestic dogs, problem solving in certain situations simply involves reliance on human cues. Often, in the presence of humans, dogs will paw at a door, or near an unobtainable yet desired item in what seems like a request that an object be retrieved, or manipulated on their behalf. Whether or not the dog is aware of what he is doing makes no difference to whether his activity counts as problem-solving. When a child rotates a block to work out whether it will fit into a slot, she does not necessarily need to be aware that she is rotating the block as a means to solve the problem she faces. The fact that she does it is enough for her action to count as problem solving by reducing some of the cognitive load by rotating the block.

But what does this tell us about the dog's understanding of the relationship of means to ends? We have seen in previous experiments that dogs tend to solve problems by 'looking up' the answer in referring to a human, and this could be what they were doing in the string pulling experiment. The authors acknowledged this possible explanation for the dogs' behaviour, but they overlooked the possibility they may still have an understanding of using certain means to achieve an end. Pepperberg's language trained parrots, if their non-language trained counterparts are anything to go by, were able to solve a means-ends task analogous to Osthaus et al.'s experiment, but they chose to refer to the humans for aid with the task instead. Perhaps the same thing happens with dogs. An interesting experiment would be to repeat Osthaus et al.'s study with human experimenters present in one trial and with human experimenters absent in another.

Furthermore, tasks such as learning to pull on a string to achieve a goal bear little relation to the problems that dogs face in their natural environments, especially where food is involved. An additional explanation for dogs' failure in the string pulling task could be due to what is known as the proximity bias. The proximity of food is thought to trigger an inherited predisposition to just go for the food directly, especially if the dog has beenfood deprived for the experiment. This instinctive reaction may overshadow any recognition of means-end connections, and in combination with the inability to inhibit this response, could lead to the proximity bias of dogs and their failure in string pulling tasks (Lea et al. 2006). Moreover, if we bear in mind that dogs' cognitive capacities are context and action specific, then we ought to realise that a means-end understanding will also be context and action specific. In a dog's natural environment (say the sheep farm of a working dog) a means-end understanding may be present.

Even if the dog is not aware of the connection between the means and end, the connection is there nevertheless. For example, even if he is not conscious of it, there must be a connection for the dog between his actions and what the flock of sheep will do. This is integral to the Collie's success in herding sheep. However, take the same dog and confront her with the string pulling task and she may simply not be able to generalise this knowledge to the task. The Border Collie's cognitive skills have been learned in direct relation with her performance (and evolved from her ancestors' performance) of certain tasks. Therefore, the sheep dog has evolved to herd sheep and demonstrate an understanding of means-end connections which is context dependent rather than an abstract skill.

But the question may come to mind, 'isn't the Collie just acting from instinct? Does she really have an understanding of the effects her actions will have on the sheep? This is a line that many people adopt but it implies that for cognitive skills, such as means-ends understanding, there must be *conscious* thought processes. This need not be the case. For example, when my niece was first learning to walk, her dad would sit with her standing across the room from me and I would sit a few metres away and beckon her with my arms open. Keira's goal was to reach me. Doing so involved leaving my brother and walking the short distance between us. It is uncertain whether Keira was explicitly conscious of the means-end connection: that 'to get to aunty, I have to walk the distance between me and her'. Whether or not she was actively aware of that fact does not negate the possibility of a cognitive link between her walking across the room and her goal of getting to me. My point is that in the cases of Keira learning to walk and the Border Collie rounding up the sheep, understanding may not be a conscious awareness of a representation of her present state, coupled with a representation of her desired future state plus the means by which the two are connected. Rather, a means-end connection may instead (in animals and infants) reside in voluntary, controlled actions that are performed in response to a situation. Perhaps a conscious understanding of means-ends connections is integral to human understanding of cause and effect, but it need not underpin understanding in non-human animals or infant humans.

1.3.8 Counting

West and Young (2002) suggested that domestic dogs may have the ability to count. Individually, 11 dogs were encouraged to watch three biscuits being placed behind an opaque screen. On one trial, the experimenter (out of the dog's line of sight) removed one of the biscuits. The screen was subsequently removed. The length of the dog's gaze at the two remaining biscuits was then measured. On another trial the same procedure was repeated but no biscuits were removed from behind the screen.

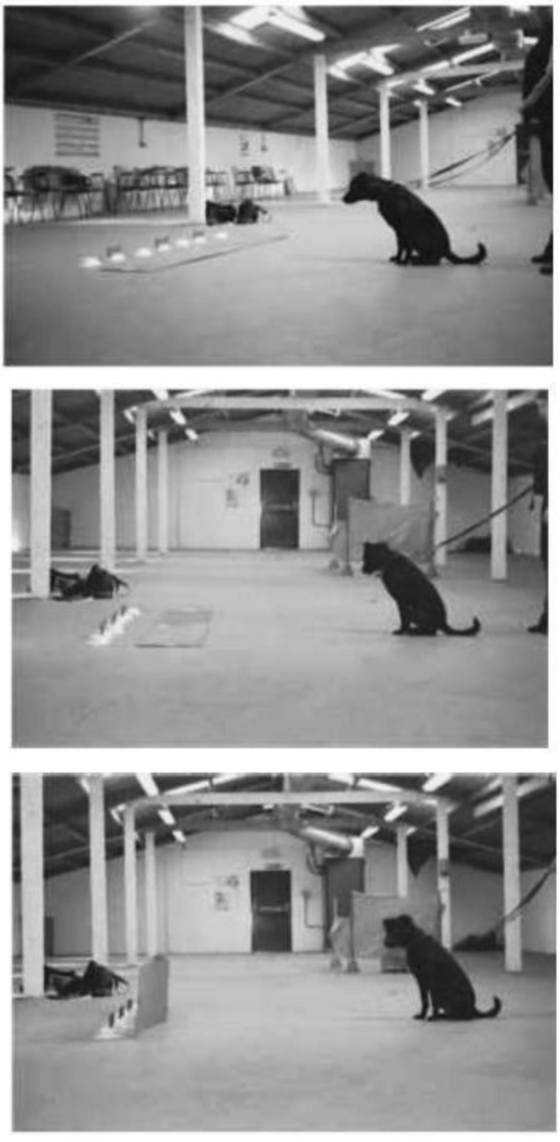

Figure 8 The experimental setting for West and Young's experiment.

West and Young found that the dogs' gaze duration was significantly longer on the trials where a biscuit was removed compared to the trials where all three biscuits were left behind the screen. Measuring gaze duration is a method that Piaget developed for use with children. It is called the technique of observing 'expectancy violation'. West and Young (2002) concluded that their results showed that dogs gazed for longer if there were either more or fewer biscuits than they expected (images from Cooper et al.,2003). The reason for this, they tentatively hypothesised, was that the dogs may have been able to count or use simple arithmetic to determine the number of biscuits there ought to be after the screen was removed. However, there is little direct evidence to support this conclusion from the dogs' overt behaviour. Alternatively, the results may be interpreted as a simple form of object permanence or delayed matching to sample.[3] This interpretation would be fair except that the dogs never actually saw the biscuits behind the screen, but rather the placing of the biscuits. Consequently, they would have had to transfer observed information involving movement to a position behind the screen to location information once the screen was removed, rather than actually having seen where the biscuits were placed. This transfer implies, at the very least, some concept of

[3] In delayed matching to sample, a short delay (or retention interval), typically in the range of 0 to 10 s, separates the sample and onset of the choice stimuli. For example, a pigeon would be presented with a sample, a red square for example. After a short delay, the pigeon would be presented with three squares of different colours, one of which is red. The pigeon must match the choice stimulus to the sample presented earlier.

number of objects, though it would not be fair to infer any more than simple subitising of number.[4] It may therefore be that dogs only represent numbers of objects as “one”, “two” and “lots” (Cooper et al., 2003, pp. 235-236). But, the number of potential confounding variables present in this study renders it very difficult to assess whether it was appropriate to measure gaze duration. For example, when a dog’s sense of smell is focussed he will, if instructed not to move, point his nose in the direction of the interesting scent. The scent of the food rewards would have been strong in this experiment and rather than gazing at the number of biscuits revealed behind the screen, the dogs may have just been sitting obediently focussing on the scent of the food rewards.

This experiment is a good example of why it is often problematic to take human-centred experimental measures and apply them to non-human animals. Measuring gaze duration in human infants seems appropriate. But in dogs it is difficult to assess whether the dogs were gazing longer at the biscuits revealed, or whether the primary sense at play was olfaction since the nose would also be directed toward the area of interest. Therefore, at this stage, we ought to hesitate before we accept West and Young’s conclusions from this experiment, the hypothesis that dogs are capable of even the simplest arithmetic

[4] Subitising refers to immediately knowing how many items lie within a visual scene for a small number of items. It is to have a rapid and confident judgement to know at a glance and without counting to identify the number of items in a group. For example, when a dice is thrown the observer at a glance immediately and accurately knows how many dots lie on the face of the dice without counting.

needs to be much more thoroughly tested. One area of examination is whether testing gaze duration is an appropriate measure in animals whose sight plays a less significant role than for humans.

Such a project is worthwhile though, since at a most basic level it may be adaptive to be able to be able to discern how many dogs there are in a hunting pack or how many members of a rival pack there may be. This most basic ability might be akin to simply being able to act differently depending on the perceived quantity of pack members on a hunt. For example, Bonanni, Natoli, Cafazzo and Valsecchi (2011) examined free- ranging dogs in social conflict situations and found evidence to suggest that dogs could assess the numbers of opponents in another social group. They found that the overall probability of a dog aggressively approaching opponents increased as the size of the opposing group decreased. They write:

> … the probability that more than half the pack members withdrew from a conflict increased when this ratio increased. The skill of dogs in correctly assessing relative group size appeared to improve with increasing the asymmetry in size when at least one pack comprised more than four individuals (Bonanni et al, 2011, p.103).

Based on Bonanni et al.'s study it is possible, therefore, that dogs are capable of some assessment of number. This may be quite different from being able to count, in the human sense, though. For example, the authors note that it is possible that the dogs in their study were basing their assessments of group size not on the number of individuals in the opposing group, but on another variable which is a reliable indicator of the size of the opposing pack. A variable of this kind might be, they write, 'the total surface area occupied by pack members' (Bonanni et al., 2011, p. 113). Another, perhaps more likely, indicator of pack size may be related to the strength of the scent stimulus provided by the opposing pack - for example a stronger, or more complex scent, emanating from the opposing pack could be a reliable indicator of pack size (I will return to this point shortly).

So, even with the results of Bonanni et al.'s experiment, we should be wary of coming to the conclusion that dogs can count. The beauty of Bonanni et al.'s study is the manner in which it was conducted. The authors sought to test a hypothesis by observing dogs in an ethologically appropriate setting to see if they could find evidence of a skill within the dogs' natural behavioural repertoire.

Moreover, Prato-Previde, Marshall-Pescini and Valsecchi (2008) found that dogs could discriminate between larger or smaller quantities of food on a plate. In their study, the dogs would, more times than would be expected by chance, approach a plate holding the larger quantity of food. Moreover, in a later condition, when dog owners encouraged the dog toward the plate holding less food the dog chose that plate over the fuller one. These results, the authors conclude, provide evidence that the dog could discriminate quantities; hence they could choose the fuller plate over the emptier one. But, the dogs would allow human cues to override their perception of greater or lesser quantities when the human encouraged them toward the emptier plate. Horowitz, Hecht and Dedrick (2013) recently asked whether dogs could discriminate quantities using their sense of smell. In Horowitz, Hecht and Dedrick's (2013) study, dogs were also presented with quantity-discrimination, but in one condition the quantities of food to be compared were covered, rather than being visible to the dogs. This was in order to test whether quantities could be assessed by smell, rather than by sight. The first condition gave the choice of two plates to the dogs: one was laden with five pieces of hot dog; the other held only one piece. On the assumption that dogs will, if given the chance, choose more food over less they expected that if the dogs could discriminate between the two quantities presented to them, then they would always choose the larger. The plates were placed equal distances from the dog and the dog was released and allowed to make a free choice between the two covered plates.

Horowitz, Hecht and Dedrick found that in contrast to Prato-Previde, Marshall-Pescini and Valsecchi's (2008) study, the dogs did not reliably choose the plate with the larger quantity of food on it. Only ‘Sixty-one percent of dogs (39 of 64), given a choice between closed plates with one and five morsels of food, approached plates with the larger quantity: not significantly more than approached plates with the lesser quantity’ (Horowitz, Hecht and Dedrick, 2013, p.212). In their second condition, however, they replicated Prato-Previde et al.’s (2008) findings, except the plates of food remained covered. Their results showed that owner enthusiasm over a plate holding less food reliably led the dogs to choose that plate in the experiment. So whether or not dogs do assess quantities such as ‘more’ or ‘less’ on the basis of smell remains uncertain and future research is needed into the issue of whether dogs can assess numerical quantities and how they might do so. What is clear again from the studies I have just outlined is the influence of the cues of a familiar person over the dogs’ responses.

1.3.9 Forming expectations about the near future

It has long been believed that animals are only capable of planning for events in the immediate future (anticipatory planning). ‘Anticipatory behaviour is behaviour that is influenced by expectations about the future, such as future states of the environment, future actions or merely anticipations about the way things work in a given situation’ (Reznikova, 2007, p. 93). Classical and operant conditioning results in an organism being able to anticipate, at least on a sub-personal level, future events on the basis of aspects of the immediate environment or present actions. But the idea that animals could anticipate events further into the future in novel situations has met with much resistance (Gulz, 1991). In support of the theory that animals are capable of basic planning and predictions of future events, Hunter (1912) found that chimpanzees reacted with what appeared to be unhappiness when their preferred rewards were replaced by less desirable items. Being able to form basic expectations about the consequences of behaviour in novel situations would be an adaptive cognitive skill because it would facilitate anticipatory behaviour, so this topic is worth investigation. For a dog to effectively herd sheep she must be able to anticipate the sheep's actions in response to her behaviour. The sheep's behaviour may be novel to the dog depending on the landscape she is working on or the handler's commands. Also when a dog is hunting prey, the prey's movements may not be the same as the movements of prey in previous hunting occasions so it seems possible that there are cognitive adaptations allowing the dog to anticipate future events in situations where operant conditioning alone cannot furnish him with the appropriate response. One mechanism by which the dog may be able to anticipate future events is through the use of context dependent representations of his body's movements and the movements of his prey. I will argue that in this instance, as with many others, the theory of embodied representation that I adopt can provide a possible explanation for how this adaptive behaviour may be achieved.

1.3.10 Categorisation of objects

Some ability to categorise objects in a non-human animal's environment must be innate; to be able to categorise types of foliage as 'food', or 'not food' is fundamental. Zentall and his colleagues (2008) report an experiment conducted on categorisation in chimpanzees (Fujitsa and Matsuzawa, 1985 as cited in Zentall et al. 2008). A chimpanzee was shown a picture on a screen. In order to keep viewing the same picture,the chimp had to continuously touch a response key. Analysis of the intervals between responses and the duration of responses revealed that the chimpanzee preferred to view the photographs which contained people. He or she rarely pressed the key repeatedly to keep viewing photographs that did not contain people. Sands, Lincoln and Wright (1982) conducted a similar experiment with rhesus monkeys. Rhesus monkeys were trained to move a lever in one direction if two successively shown pictures were similar. They found that the monkeys tended to respond 'same' to monkey and human faces, and to trees and flowers. These results seem to suggest that the monkeys were able to categorise the pictures of humans and monkeys into one category and the trees and flowers into another.

Also on this topic, Sands et al.'s study highlights an important point: what are clustered together somehow may be different across animal species. For example, a human participant would most likely have formed two separate categories for the trees and flower, yet the monkey grouped them together. Dogs might choose a different way of grouping again, perhaps based upon scent or the actions associated with objects. Much of how an animal categorises must depend on their perceptual acuity across the senses. For example, humans might use visual features more than any other features to categorise items. Zentall et al. write: 'to our eyes, cats resemble one another much more than they resemble flowers, cars or chairs' (2008, p.17). Dogs, in contrast, might place cats in the same categories as ducks, rabbits and sticks: things to chase. Categorisation by the monkeys in Sands et al.'s study might depend on some kind of representation of features of the previous slide. This would explain their responding 'same' when presented with the slide that they categorised as similar.

Categorisation, being able to sort objects and events into classes of some type, allows the animal to transfer knowledge about previously encountered aspects of the environment to novel yet similar ones: 'if a new environment can be identified as being similar to an old one, then prior learning can be applied, thereby reducing the costs and risks associated with new trial and error learning' (Zentall et al., 2008, p.13). It has seemed, however, that research on human categorisation is disconnected from research on non-human animal categorisation, except perhaps in the work of developmental psychologists (Wasserman and Rovee-Collier, 2001). In their paper, they suggest that the ability to perceive similarity may be something that we are just born with and is an ability that underwrites our capacity to form perceptually based representations. Furthermore, they suggest, there seems no reason why this trait is not built into certain non- human animals either.

Wasserman et al. (1988 as cited in Zentall et al., 2008) did an experiment which examined the relative speeds of pigeons' learning to sort the same pictorial stimuli into human conceptual categories or into totally arbitrary categories. The experiment showed that pigeons learned to sort the pictures into the human conceptual categories much faster than they learned to sort the pictures into the arbitrary categories. Another experiment conducted by Astley and Wasserman (1992, as cited in Zentall et al., 2008) had pigeons learn to distinguish between positive stimuli (those reinforced with food) and negative stimuli (not reinforced) using 60 slides. Twelve of the slides were S+ stimuli (positive stimuli) and 48 were S- stimuli (negative stimuli). All eight birds were given the same S- stimuli: 12 people, 12 flowers, 12 cars, 12 chairs. Different birds had different S+ stimuli: one bird's might be 12 different cars, or 12 different chairs, 12 different flowers or 12 different people. The authors write:

> Assuming that the S+ stimuli are equally similar to all 48 S- stimuli, the errors should be randomly distributed among the four S- categories, including the one from which the S + stimuli were picked. But, if, to pigeons, members of a given human conceptual category more closely resemble one another than they resemble members of different conceptual categories, then errors should be non randomly distributed and should be disproportionately committed to the S- stimuli from the same category as the S+ stimuli (Zentall et al., 2008, p.18).

Zentall et al. (2008) found that the errors were significantly non-random with respect to whether the S+ slides were of people, flowers, chairs or cars. This experiment concludes that pigeons group similar stimuli together even when that grouping is unrelated to them getting reinforcement because the study did not reinforce the pigeons for grouping together the S+ stimuli with the similar members of the S- Stimuli. As we saw, it counted as an error. Here, the birds showed an untrained propensity to commit errors in classing the members of the S- stimuli group with members of the same conceptual category in the S+ group. ‘A strong perceptual basis for conceptualization is clearly implicated by the results of this study’ (Zentall et al., 2008, p.18). Studies into categorisation in non-human animals gained popularity after Herrnstein and Loveland (1964) found that pigeons could be trained to peck at pictures containing humans and not to peck at those that did not contain humans. They suggested on the basis of these results that pigeons were capable of forming a concept of humans.

Very little research has been done, however, on categorisation in domesticated dogs. In fact, before 2008, the only experiment that I could find is Heffner's (1975) study on acoustic categorisation in dogs. Heffner trained dogs to distinguish between two types of sounds: 'dog' sounds, like barks and growls, and 'non-dog' sounds. After training, Heffner's dogs could categorise correctly 'dog' and 'non-dog' sounds which they had not previously encountered during training. In regards to visual categorisation in dogs, the first experiment was conducted very recently. Range, Aust, Steurer and Huber (2008) examined three aspects of visual categorisation in dogs. They looked at whether dogs are able to distinguish between complex colour photographs, on the basis of what they depicted; and whether they could then sort novel photographs according to the same experimenter-intended rule by looking at the visual properties of the photograph. They also examined whether the rule the dogs were using to sort the photographs was similar to one a human would use. Using four companion dogs with basic obedience training, Range and his colleagues trained the dogs to firstly distinguish between a S+ stimulus and an S- stimulus. Their apparatus was a computer touch screen which flashed up the visual stimuli. The dogs were trained to touch the stimuli on the screen with their nose. Correct responses elicited a short tone and a food reward. Incorrect responses elicited a buzz, followed by a red screen and then the stimuli were re-presented. Gradually they trained the dogs to distinguish between landscape pictures (S-) and dog pictures (S+). In their experiment, test one required the dogs to distinguish between novel dog pictures (S+) and novel landscape pictures (S-). Test two had the dogs distinguishing between novel dog pictures on a familiar landscape (S+) and a novel landscape (S-). The dogs were being tested to see if they could classify the pictures by the presence or absence of dogs. In the first test, they found that the performance was excellent. The dogs transferred to the novel stimuli very well and performed at levels significantly above chance. The second test required the dogs to choose a stimulus on the basis of one aspect of the picture (whether there was a dog in the picture). In this test, three of the four dogs' performance was worse on the test stimuli than it was on the training stimuli. Nevertheless all the dogs still gave correct answers at a significant level. A similar study performed with pigeons by Aust and Huber (2001) produced analogous results. In a test like the Range et al.'s second test, the extraneous information in the pictures also did not significantly prevent the pigeons from being able to classify the pictures on the basis of the presence or absence of a target stimulus. The combination of Aust and Huber's pigeon study and the present one, Range et al. write, 'suggests that both dogs and pigeons made use of a category-based response rule with classification being coupled to category-relevant features' (2008, p.

345). However, in their discussion, Range et al. cite several studies similar to theirs which found contrasting results; results which suggest that the subjects weren't responding to the experimenter-intended target at all but were using some alternative response strategy (see D'Amato and Van Sant 1988; Greene 1983; Huber et al. 2000; Troje et al. 1999).

Therefore, it seems that the dogs of Range et al.'s (2008) study could learn to classify the pictures, but it is unclear whether they are classifying them on the presence or absence of dogs or whether they are using some other selection strategy. The worst case scenario is that the dogs were simply basing their responses on items that dependably correlated with the presence or absence of dogs in the stimulus. The same concern applies to all the experiments mentioned above with different species of non-human animal. We must be very careful when discussing categorisation in non- human animals. Rather than trying to figure out the basis upon which dogs are categorising stimuli we should look at how their categorisations are being used in their interactions with their natural environment.

1.4 Summary

In summary, this chapter has made the following main points: If we are to design and conduct experiments to learn about the cognitive skills of dogs, we should be hesitant about applying tests designed for humans to animals. Many of these tests may not be appropriate for non-human animals and it is likely that we need to design species-specific tests for effective investigation into the cognitive skills of animals. Moreover, scent cues and social cues pose an almost immeasurable threat to the validity of experiments on dogs and I believe that much research is needed upon the effective control of scent cues in the experimental setting before we can be sure that they have been effectively addressed. Moreover, in all cognitive skills that we study in the dog, the question should be asked 'how does this skill manifest in the dog's daily interactions?' and 'how might this skill be adaptive?' For example, in the experiments upon whether dogs make deductive inferences it was possible that the dogs learned how to do so in the experimental setting, but less certain was whether they would use this skill in their normal interactions with their environment. An important question to ask is 'Would there be a time when this skill within the dog would be useful to the dog or cultivated for its usefulness to humans?' Lastly and perhaps most importantly, we ought to remember that most, if not all, of the dog's cognitive capacities are action-based and context specific. So while we may or may not see a particular cognitive skill within an experimental setting it may be present in a certain context. For example, the dog's ability to count has proven hard to assess, yet observational studies of dogs may elicit information on this ability in a natural context.

Observational studies can provide a spring board for more rigorously controlled experiments refining our tests for context-specific, action-based cognition that we observe in dogs' diverse walks of life. I will argue in Chapter Two that we should focus on what we do know about the cognitive skills of the domesticated dog. There are philosophical principles from the embodied cognition paradigm that we can use to guide us in thinking about dog cognition. These principles lay the foundation for understanding cognition in dogs, from the ground (or the dog) upwards. In Chapter Two I outline embodied cognition as a set of guiding principles by which we can approach our study of non-human animal cognition. Chapter Three demonstrates how they can be successfully applied to thinking about cognition in the domesticated dog by showing us what we can be confident of when thinking about the cognitive skills of dogs.

Chapter Two: Embodied cognition

A new way of thinking about cognition and representation has emerged called 'embodied cognition'. Although its rise in popularity has been recent, the embodied cognition thesis has roots that go back to early 1900s. Vygotsky wrote:

> The use of notched sticks and knots, the beginnings of writing and simple memory aids all demonstrate that even at early stages of historical development humans went beyond the limits of the psychological functions given to them by nature and proceeded to a new, culturally-elaborated organization of their behavior (Vygotsky,1978, p.39).

Shortly after Vygotsky's English translation of his book was published in 1978, Gibson, in his 1979 work *The Ecological Approach to Visual Perception,* laid further foundations for a more holistic view of the mind. Part of Gibson's contribution was to point out that from the point of view of any human or animal, the environment is simply a series of opportunities for action. The world around is seen by agents as a collection of affordances: 'Affordances of the environment are what it offers the animal, what it provides or furnishes either for good or ill (Gibson, 1979, p.127). Gibson's theory emphasises the interaction between animal and environment. He takes it as fact that the animal agent's cognitive processes and behaviour can be causally dependent on features in the environment and builds upon this notion his theory of affordances. Elsewhere, Gibson remarks that ‘the observer may or may not perceive or attend to the affordance, according to his needs, but the affordance, being invariant, is always there to be perceived’ (Gibson, 1979, p.139). In short, Gibson emphasised cognition as a dynamic interaction between the environment and a human or animal, preparing the ground for embodied cognition. After Gibson’s (1979) book came out, there was a corresponding shift within the growing field of robotics. Researchers began to emphasise routines for interacting with the environment rather than the use of internal representations for thought (Wilson, 2002, p. 625). This kind of approach is fundamental to embodied cognition and consequently, ‘there is a growing commitment to the idea that the mind must be understood in the context of its relationship to a physical body that interacts with the world (Wilson, 2002, p. 625).

Embodied cognition involves a paradigm shift in the way we view the mind, cognition and behaviour. It is often construed as a rejection of the main tenets of traditional cognitive science. While most researchers within cognitive science no longer conceive of the mind as an immaterial substance as opposed to the body as a physical substance, mental processes, according to traditional cognitive science, are still something ‘inner’, separate from physical actions and the environment; the controlling force, responsible for producing behaviour. On this view, the emphasis placed on cognition is restricted to the domain of the brain. Embodied cognition theorists, on the other hand, hold that cognitive processes are not just confined to a person's neural structures within the brain. For advocates of embodied cognition, our cognitive processes are heavily influenced and constrained by and distributed across our physical bodies. In this way, cognitive processes are often played out in the behaviour of a person, deeply affected by the environment a person is in, and, in short, a person's surroundings and physical body are integral to cognitive processing. For example, Rob Wilson discusses the children's puzzle game Rush Hour. Rush hour involves moving rectangular wooden blocks around in a wooden frame. He writes,

> … we solve the problem by continually looking back to the board and trying to figure out sequences of moves that will get us closer to our goal, all the time exploiting the structure of the environment through continual interaction with it. We look, think, we move. But the thinking, the cognitive part of solving the problem, is not squirreled away inside us, wedged between the looking and the moving, but developed and made possible through these interactions with the board (Wilson, 2004, p.194).

And van Gelder elucidates the thought that,

> The cognitive system is not just the encapsulated brain; rather, since the nervous system, body, and environment are all constantly changing and simultaneously influencing each other,

> the true cognitive system is a single unified system embracing all three. The cognitive system does not interact with the body and the external world by means of the occasional static symbolic inputs and outputs; rather, interaction between the inner and outer is best thought of as a matter of coupling, such that both sets of processes continually influencing [*sic*] each other's direction of change (van Gelder, 1995, p. 373).

2.1 Three important aspects of embodied cognition

Three main aspects of the role of the body are emphasised within the embodied cognition thesis. I touched upon these briefly above and will expand upon them further now.

2.1.1 Bodily boundaries

Firstly, the body sets the boundaries and potentials for perception; in other words, our body constrains the sorts of perceptual processes we can have. Clearly, a dog's sense of smell opens up a world of scent which is unattainable to human beings. There are scents and sounds, imperceptible to us, which can be used in a dog's cognitive processes such as the development of a dog's memories and his learning. The bodily structure of human beings entails less developed olfactory-based cognition than the dog possesses. Indeed some forms of cognition may just be impossible to achieve given a creature's physical nature and the limits placed on what she can perceive. For example, dogs' poorer discrimination of colour renders fine distinctions between many shades of colour such as shades of yellow and orange impossible for them. Therefore, tasks which involve discriminating objects based upon their colour may be impossible for dogs when the colours of the objects are shades of yellow and orange. To summarise, the physical body sets the boundaries for cognitive processing; it determines what is possible and what is impossible for an agent to perceive and, therefore, cognise.

2.1.2 Body as regulator

In addition to constraining cognition, it makes sense to suppose that the body regulates cognition. The body acts out our decisions and provides a connection between the environment and an agent's responses which enables quick reactions to the situations we find ourselves in. The type of body we have determines the types of responses we can perform. For example, hunting behaviours of dogs are very different to hunting behaviours of cats. The cat's body is built for stealth: silence, camouflage and fluid motion. The dog on the other hand will typically hunt in a pack and use speed and strength over the cat's stealth tactics. The thought here is that an agent's physical body determines the nature of her responses and the nature of her cognitive processing.

2.1.3 Body as distributer

Lastly, the body takes on some of the work involved in cognitive processing. An often cited example is the use of gesture as an aid to communication. Here, much of the meaning of our words can be conveyed through the gestures which accompany them. Another example of the body distributing cognitive processing to include non-neural structures is when a child is attempting to fit jigsaw puzzle pieces together. She will rarely sit and study the pieces to determine their fit; rather the child will try to join a pair, perhaps fail, rotate one or both of the pieces and then try again. In this way, the child is working out a solution to the puzzle not via internal thought alone, but by getting involved with the pieces and physically rearranging, rotating and refitting.

The three concepts outlined above are a useful, albeit general, way to introduce embodied cognition (Wilson and Foglia, 2011). There are various theories within embodied cognition and what follows next is a discussion of these main views. Later on, I will outline the main principles which underpin these predominant views within embodied cognition. These principles form the most significant strands of embodied cognition within the current literature.

2.2 Embodied action

Varela, Thompson and Rosch’s (1991) book *The Embodied Mind* is a starting point for many who are new to the subject. Varela, Thompson and Rosch reject traditional cognitive science and propose their own theory called ‘embodied action’. Central to the embodied action thesis is the notion that an agent’s body directly affects its perception of the world, and its cognitive processes. For example, a sea mammal such as a dolphin will perceive and cognise differently to a land mammal such as a horse. The differences between the perceptual abilities of these mammals will lead to different actions and different perceptual abilities. The idea at the heart of Varela, Thompson and Rosch's thesis is that perception and action are inseparable. They each determine the other; and it follows that the species-specific perception-action cycle of each type of agent results in accordingly species-specific types of cognitive processes. Here is a quote from their book:

> By using the term *embodied*, we mean to highlight two points: first, that cognition depends upon the kinds of experience that come from having a body with various sensorimotor capacities, and second, that these individual sensorimotor capacities are themselves embedded ina more encompassing biological, psychological and cultural context. By using the term *action* we mean to emphasize once again that sensory and motor processes, perception and action are fundamentally inseparable in lived cognition (1991, p.173).

In this passage, the authors mention that sensorimotor capacities are embedded in a biological, psychological and cultural context. What they mean is that because members of a species share the same types of neural hardware, perceptual apparatus and bodily structures, they will likely share a worldview. The worldview of members of two different species, however, is probably very different. This point highlights further the notion from the discussion in the opening chapter that studies designed to test cognitive capacities of the dog need to be designed for that species; it is questionable whether the application of a study designed for another species (such as humans) is appropriate for testing cognition in dogs given their difference in worldview. The other important point to take from Varela, Thompson and Rosch's passage is that it is not possible to separate cognition from action. Thus, when studying cognitive skills of an animal, like the dog, we are essentially studying their actions also. This is a slight shift in thinking, for often actions are considered an indicator or indirect sign of cognitive processing; but on this view, cognition is manifest in actions, it is literally visible in the actions themselves. An example of cognitive processing being literally visible in action is that form of problem solving in dogs that consists of a dog looking to the human handler for cues regarding the appropriate course of action. In the same way, the search behaviour of a dog can be seen as the visible workings of the dog's cognitive processes as he searches his environment.

Viewing cognition from this alternative angle has implications for how we view representations. Representations are traditionally considered to be an inner, invisible to the observer, structure or process within an agent's brain which may or may not guide behaviour. As I will argue in later chapters, if cognition is visible in behaviour then it makes sense that components of cognition, i.e. representation, are also visible in behaviour.

2.3 Thelen's conception of embodied cognition

Esther Thelen applied dynamical systems theory to cognitive science and her theories are also foundational to the embodied cognition trend. In their 2001 article, Thelen, Schöner, Scheier and Smith write:

> To say that cognition is embodied means that it arises from bodily interactions with the world. From this point of view, cognition depends on the kinds of experiences that come from having a body with particular perceptual and motor capabilities that are inseparably linked and that together form the matrix within which reasoning, memory, emotion, language and all other aspects of mental life are meshed (2001, p.1).

On the face of it, the quote above provides no rejection of traditional cognitive science. Even Jerry Fodor, who adopts an explicitly internalist view of representations, would accept that perception and action influence an agent's cognitive processes. Indeed there are few traditional cognitive scientists who would take issue with this claim. However, the key to understanding Thelen et al.'s comments lies in grasping the fact that for Thelen, as with Varela and Rosch, perceptual and motor capabilities are inseparable from an agent's cognitive processes. The standard cognitive scientist will argue that cognitive processes are a pre-curser to perception and action. For example, my making a sandwich arises from the cognitive decision to make lunch – the making of the sandwich is no part of the cognitive processing surrounding lunch making, rather it's an output of such a process. As Shapiro puts it 'cognition [for Thelen et al.] is embodied insofar as it emerges not from an intricately unfolding cognitive program, but from a dynamic dance in which body, perception and world guide each other's steps (Shapiro, 2011, p. 61). That the relationship between an animal's body and actions is dynamic is the key point here. Moreover, the relationship between cognition, action, experience and perception is holistic; each influences the other in a constant interplay. This strand of embodied cognition helps us to recognise the interconnected nature of environment, experimental settings, past experience and cognitive functioning.

2.4 Clark and Chalmers' extended cognition

Andy Clark and David Chalmers use the phrase 'a coupled system' to describe cognitive processes that incorporate the physical body. They write:

> In these cases, the human organism is linked with an external entity in a two-way interaction, creating a *coupled system* that can be seen as a cognitive system in its own right. All the components in the system play an active causal role, and they jointly govern behaviour in the same sort of way that cognition usually does. If we remove the external component the system's behavioural competence will drop, just as it would if we removed part of its brain. Our thesis is that this sort of coupled

> process counts equally well as a cognitive process, whether or not it is wholly in the head (Clark and Chalmers, 1998, p.2).

Clark and Chalmers' view of embodied cognition is more encompassing than that of Thelen and Varela and Thompson and Rosch. For Clark and Chalmers, cognitive processes involve an agent's body, but also the environment. For some theorists within embodied cognition, such as Clark and Chalmers, cognitive processing is an activity made up of neural and bodily structures and certain aspects of the world. This is often called the constitution hypothesis. It is, in other words, the argument that constituents of cognitive processes extend beyond the brain (Shapiro, 2011, p. 158). Clark and Chalmers' view is a radical version of the constitution hypothesis. They argue that the mind literally extends beyond the body and into the world, a view which is often called extended cognition; a more radical view than embodied cognition. The main challenge for advocates of extended cognition is providing an explanation of how elements of the external world can comprise cognitive processes. The example which Andy Clark gives to defend this point is that of a person doing long division manually. When someone is doing long division manually, they will use a pencil and paper. The cognitive processing here involves the neural structures engaged in the task and the parts of the body which are also engaged in the task, for example looking at the paper, manipulating the pencil and perhaps steadying the paper are all tasks which are undertaken by the physical body. In addition, the tools used - the pencil and paper - are part of the cognitive process of figuring out the long division. That is, according to the extended mind hypothesis, each element involved in the task, the neural structures, the body and the tools, becomes a part of the cognitive process.

Extended cognition has come under fire from several angles. The most notable objection is from Adams and Aizawa who argue that extended cognition commits what they call the coupling-constitution fallacy.

2.4.1 The coupling-constitution fallacy

Adams and Aizawa argue that none of the advocates of the extended mind thesis have yet provided adequate support for the move between a causal connection between the brain and external elements to the claim that the brain, body and environment together constitute a cognitive process. They think that, 'advocates of extended cognition do not take into consideration the possibility that what makes a process cognitive is something internal to the process, something to do with how it works, rather than what it is connected to' (Adams and Aizawa, 2008, p. 99).

Other writers have also criticised the extended mind hypothesis on this point (Block, 2005; Prinz, 2002 and Rockwell, 2010) and there have been some replies. Susan Hurley claims that it is up to the critic to specify the difference between coupling, or causation and constitution. She sees reason to doubt that such a distinction between coupling and constitution exists. Indeed, it does sometimes appear that whether or not an element involved in a process is causally related to or constitutive of that process is to be decided by stipulation rather than appeal to the nature of that element's relationship to the process.

For example, Menary (2006) uses the lack of clarity between constituent and cause to object to the coupling-constitution fallacy. He remarks that Adams and Aizawa's objection begs the question against the extended mind thesis and doesn't take into account how the argument is supposed to work (Adams and Aizawa, 2008, p. 101). In other words, Adams and Aizawa's argument first assumes that there must be a distinction between coupling and constitution in order for the move from an argument about coupling to a statement about constitution to be fallacious. However, Adams and Aizawa do try to demonstrate that there is a difference between coupling and constitution with various analogies. An analogy that occurs early on in Adams and Aizawa's *The Bounds of Cognition* goes like this. The process of nuclear fission involves a large atomic nucleus being broken down into smaller atomic nuclei. Nuclear fission happens when the nucleus is split as a result of being bombarded by neutrons. The process of bombardment with neutrons causes the nuclear fission, *but does not constitute* nuclear fission. Objectors to the distinction between cause and constituent might respond that when we define nuclear fission, we could limit our explanation to the actual splitting that occurs after the neutrons have done their bit. But this would not be a whole explanation; the bombardment of the atomic nucleus *is* part of the process of nuclear fission. The neutrons' movements are part of the overall process of splitting the atom. This is a tricky area and a resolution would be tangential. Until the distinction (or lack of distinction) between cause and constitution is clarified, the coupling-constitution fallacy will remain a live issue in the extended mind thesis. The present discussion accepts the main tenets of embodied cognition, but does not follow Clark and Chalmers' lead into the more radical extended mind hypothesis. The embodied cognition thesis argues for greater emphasis on the part the body and environment plays in cognition, but allows that environmental factors may remain outside the realm of what constitutes a cognitive process.

To my knowledge, the coupling-constitution fallacy has only been directed at the extended mind hypothesis. However, the same objection could potentially be made against the embodied cognition paradigm. For example, a critic might object to the notion that the physical body and its behaviour constitute part of an agent's cognitive processing. The fallacy within the embodied cognition thesis, the critic might continue, lies within the thought that the argument that 'cognitive processing is intrinsically linked to behaviour and the body, therefore the body and behaviour are part of cognitive processing' is a fallacious one.

My take is that the reason the coupling-constitution fallacy is not generally levelled at embodied cognition is because the inseparable role of the body in cognitive processing is more readily accepted than the parallel role of the environment in cognitive processing inherent within extended mind theories. Moreover, the use of the body in the development of cognitive skills is apparent from early childhood. The way a child learns how to do a jigsaw puzzle in my explanation above is one example of many that could be given. Children's interactions with their world are heavily physical. Objects are explored and learned about according to their touch, sound, smell, taste and feel. Knowledge of things is acquired by the physical manipulation of them. Knowledge of cause and effect is acquired by trying things out. In short, beginning in babyhood our cognitive processing relies upon physical movements and manipulation of our environment. As our brains develop we engage more and more in abstract reasoning uncoupled with physical movements, yet still engage in a substantial amount of cognitive processing which involves behaviour and our physical body.

This explanation has not addressed the coupling-constitution fallacy though. The critic could still object that in early childhood cognitive processing is simply *coupled* more frequently with physical movements, tapering off slightly as our brains mature. There is still no basis from which we could argue that physical movements are an intrinsic part of cognitive processing, the slide from coupling to constitution is still fallacious, one might argue.

Accepting Adams and Aizawa's point that there is a distinction between coupling and constitution, (and their point that we cannot assume that because behaviour is coupled with a cognitive process that it is therefore part of it), I suggest that there are instances where behaviour is merely coupled with a cognitive process and instances where the relationship between behaviour and cognition is more intimate.

More precisely, in some cases, cognitive processing is internal and may be coupled with physical movements as an aid but not a necessary component. In other situations, the physical movements of an agent are integral to and constituent of the cognitive process.

For example, in young children, the putting together of a jigsaw puzzle would be impossible without the ability to manipulate the pieces, rotate and refit them until the child finds the solution. To prevent the child from acting in that way would prevent her from solving the problem.

In this situation, the behaviour constitutes an important part of the cognitive process and is not merely coupled with an inner mental state. In adults we can look at the puzzle pieces and, while it might be trickier, the solution can be found using internal thought processes alone. In the event that an adult does pick up a puzzle piece to rotate and refit until she has found its spot, this behaviour is complementary to the cognitive processing, not constitutive of it.

In a nutshell, if a cognitive process cannot take place in the absence of bodily movements and behaviour, then those physical elements are constitutive of the cognitive process. In contrast, if the cognitive process *is* possible (within reason) in the absence of bodily movements and behaviour then those physical elements are coupled with the cognitive process not constitutive of it.

Clark and Chalmers' point from above applies also here: 'If we remove the external component the system's behavioural competence will drop, just as it would if we removed part of its brain' (1998, p.2). In these situations, the behaviour (and in Clark and Chalmers' extended cognition thesis, aspects of the environment) is part of the cognitive process. When a similar effect can be competently achieved without the physical component then the behaviour is coupled with the cognitive process, not part of it.

In summary, nothing in the embodied cognition literature entails accepting that behaviour is always an integral part of cognition. In some cases behaviour does constitute cognitive processing because without certain actions the agent's cognitive processing is impeded. Because the focus of this dissertation is canine cognitive processing, the types of cognitive processing I focus on are those likely to be constituted by certain actions and behaviours, more so perhaps than if I were writing about normal adult human beings where the focus might be more on abstract cognitive skills and inner mental states. The following section outlines the basic principles of embodied cognition and begins to demonstrate the suitability of fit that embodied cognition has in the study of the cognition of non-human animals such as dogs.

2.5 Basic principles of embodied cognition

The environmental niche that a being has evolved to occupy affects the types of cognitive processes it develops. This is not a controversial claim and most traditional and embodied cognitive scientists would agree. In addition, the physical shape and the type of neural structures and networks that an agent has determines the types of cognitive processes he or she is capable of developing and using. For example, Lakoff and Johnson write that every creature categorises; 'even the amoeba categorizes the things it encounters into food or non-food, what it moves toward or moves away from' (1999, p. 17). However, the sorts of categorisation a creature is capable of will largely depend upon that species' perceptual apparatus and on how the creature can move around and manipulate objects within its environment. For example, humans are visual and verbal creatures. On this basis, we tend to categorise our items in the world according to what they look like or according to a verbal definition. Dogs, on the other hand, if they do categorise would probably do so according to the affordances associated with it. For example, the smell and the movements another animal is making may go a long way in helping the dog decide whether it is prey or not prey.

Even in humans, Lakoff and Johnson argue, a large portion of our categorisation occurs subconsciously and automatically but 'most important, it is not just that our bodies and brains determine that we will categorize; they also determine what kinds of categories we will have and what their structure will be' (Lakoff and Johnson, 1999, p.18). Whether or not Lakoff and Johnson are correct in what they say about categorisation being a skill possessed by every living being, an agent's physical body and its natural environment shape cognitive processing. To clarify the embodied cognition movement by making explicit the fundamental tenets, Margaret Wilson (2002) outlines six basic principles that underlie a theory of embodied cognition. Here I loosely follow the structure of her paper with various additions.

2.5.1 Cognition is situated

The claim that cognition is situated is the claim that cognitive processes are inseparable from the environment. Perception and action are fundamental to cognitive processes being situated because so much of our cognitive processing involves receiving inputs from the environment and producing responses that affect the environment. Examples of situated cognition in our everyday lives are plentiful. For example, cooking a meal, driving a car, grocery shopping at the supermarket, all are types of situated cognition. They all involve responses to and from the environment via our bodily actions and perceptual experiences. Clearly, though, there are cases where cognitive processing does not involve task-related responses to and from the environment. For example, doing sums in your head, or imagining what it would be like to win the lottery. These are known as 'offline' cognitive processes and do not count as examples of situated cognition (Clark, 1997).

With regards to human cognition, it could be argued that not many of our cognitive processes are, in fact, “online” or situated ones. But in response to this, some have claimed that situated cognition is actually fundamental to human cognition because early humans would have survived in virtue of situated cognitive processes. As William Calvin suggested, it is likely the case that some of our ‘higher’ cognitive skills may have evolved from having to acquire skills such as accurate throwing and tool-making in order to be successful at hunting (Calvin, 2004, p.102). However, even when our human ancestors did hunt, it is more likely the case that most food was gathered, rather than hunted (Leaky, 1994). This being the case, the role of situated cognition becomes less important since offline cognitive processes such as planning the next day’s search and remembering the locations of areas that in the past have provided food are more likely to have been used. Therefore, the argument that human cognition is situated is not well supported by the evolutionary claim that situated cognition was necessary for survival. However, the debate over the extent to which human cognition is situated is secondary. Some, possibly most, of human cognition is situated, without a doubt and possibly more than critics may think. For example, riding a bike, skiing down a hill or even doing the dishes involve cognitive processing for which immediate perception of a response to the environment is necessary.

2.5.2 Cognition is time pressured

A person in the real world has to cope with events as they are presented to her. As we go about our daily lives, events occur quickly and often our response times have to be fast to ensure our survival. For example, you take a ten minute walk from the train station through the city to your workplace. During those ten minutes, from the second you step off the train, you are required to respond to the physical aspects of the city. It is rush hour. There are many cars on the road that you need to cross so you must attend to what they are doing and assess when it is safe to cross. There are also curbs, lampposts and buildings to navigate your way around. And then there is your social environment. You must be aware of and respond to the people around you too. Don’t bump into anyone; pass those who walk slowly ahead of you in your path; and so on. In this short ten minute walk you are required to respond to your environment continuously and immediately. In this sense, your responding is time pressured. And because your responses to your environment are part of your cognitive processing, your cognitive processes are also time pressured.

The time pressure that our cognitive systems must cope with is one reason why mental representations are thought to play a lesser role, or no role at all, in certain versions of embodied cognition. When situations demand fast and continuously evolving responses, there may simply not be the time to build up a full blown mental model of the environment, from which to derive an action plan. Instead, the claim goes, quicker, more efficient processes come into play. As humans, much of what we do is not time pressured. For example, going for a walk, reading a newspaper or doing a crossword puzzle are usually all performed under little or no time pressure. Time pressured tasks such as changing lanes in heavy traffic or playing a video game may even be the exception in some people's lives. But I wonder if this is the right way to look at it. It seems likely the case that rather than there being either no time pressure or time pressure inherent in an activity, the activities we perform fall somewhere along a 'time pressure continuum'. For example, going for a walk would be somewhere along the low level of the continuum. However, driving down a quiet country road is slightly more time pressured than taking a walk. And mountain biking down a steep track filled with slippery tree roots would fall quite high on the continuum. The time pressured nature of cognition is important within embodied cognition because it serves to further emphasise the dynamic interplay of environment, cognitive processes and physical responding.

2.5.3 Cognitive work is off-loaded onto the environment

Work on embodied cognition draws on the view that cognition deeply depends on the natural and social environment. By focusing on the strategies organisms use to off-load cognitive processing onto the environment, this work places particular emphasis on the ways in which cognitive activity is distributed across the agent and her physical, social, and cultural environment (Suchman, 1987; Hutchins, 1995). Fundamental to embodied cognition is the claim that we manipulate our environment to take some of the cognitive load off our brains. Good examples of this are a child's use of an abacus to help with sums; the use of a pencil and paper when trying to figure out which words you can make with your letters in Scrabble; writing a list of things to fetch from the supermarket and so on. Times when we off-load cognitive work onto the environment are 'typically the cases in which the world is being used as its own best model' (Brooks, 1991, p. 139). In other words, 'rather than attempt to mentally store and manipulate those details about a situation, we physically store and manipulate those details out in the world, in the very situation itself' (Wilson, 2002, p. 629). In humans, gesturing while speaking is an interesting form of off-loading onto the body and provides environmental cues for the listener regarding what's being said. It has been shown that gesturing while speaking adds clarity to what is being verbally expressed and helps the listener to understand more easily what is being said (Goldin-Meadow, 2003). The person gesturing is enabling the listener to understand what she is saying by providing physical cues (gestures) as an aid to understanding. In her book Susan Goldin-Meadow argues that, often, listeners are not even aware of the information they are receiving from a speaker's hand gestures. On the topic of why we gesture when we speak Goldin-Meadow writes that gestures during speech 'reflect a speaker's thoughts in a medium that happens to be relatively transparent to most listeners' (Goldin-

Meadow, 2003, p. 144). Conversely, gestures also reduce the cognitive load of the speaker. Goldin-Meadow conducted a study that asked children and adult participants to solve a maths problem on the blackboard. After having solved the maths problem the participants were given a list of things to remember and then asked, while still retaining the list in memory, to explain how they solved the maths problem. In one condition, the children and adults were allowed to gesture and in another condition; the children and adults were not allowed to gesture. Those participants that were permitted to gesture remembered significantly more items than those who were not permitted to gesture. Therefore, she concludes, 'gesturing reduces demands on the speaker's cognitive resources, thereby freeing cognitive capacity to perform other tasks - it lightens the speaker's cognitive load' (2003, p. 150).

Another example readily used to demonstrate the claim that we can off- load our cognitive load onto the environment is the Tetris player's rotating of the objects to decide whether it will fit into the slot beneath it. Similarly young infants will rotate a block to test whether it will fit into a slot. This physical manipulation of the object saves the effort of rotating the object mentally (Kirsh and Maglio, 1994). In this way we use the environment, not a representation of the environment, to solve problems we are faced with.

Clark's version of the idea that we off-load cognitive work onto our environment is manifest when he remarks 'we reduce the information- processing load by sensitizing the system to particular aspects of the world- aspects that have special significance because of the environmental niche the system inhabits' (Clark, 1997, p.24). We can use Clark's idea to great effect when we consider the ways in which dogs may use their environment as an aid to problem solving. For example, in the opening chapter I outlined several studies conducted on problem solving in dogs. In a few of them, it was commented upon that dogs' problem solving ability seems to rely more upon human cues than wolves'. This is a great example of how dogs have come to off-load some of the work involved in a task by relying on humans' cues. That is, they are off-loading cognitive work into their environment. While it may appear that dogs' problem solving abilities are diminished in comparison to wolves, it may be that dogs have learned a different, more efficient, method by which to solve problems.

2.5.4 The environment provides the agent with affordances

How an embodied cognition theorist treats this claim is the best indicator of where he or she sits on the moderate-radical scale of perspectives within embodied cognition. The moderate way to interpret this claim, the route that this thesis adopts, is to assert that the environment plays a fundamental role in cognitive processing, yet aspects of the environment are not constituents of cognitive processes. Extended mind theorists, as we have seen above, claim that certain bits of the physical environment form part of a person's cognitive processes. On this view, the paper and pencil that you use for your long division are just as much a part of your cognition as the neurons that fire inside your brain.

Whether or not one ascribes to the extended mind hypothesis, the organism's interactions with the environment are emphasised to the extent that cognition is seen the dynamic interactions between an agent's neural hardware, body and its environment. However, we need to be clear on what counts as a system. Systems are comprised of elements that interact in significant ways so as to support activities at the level of the whole. The elements must be affected by their role within the system and we must also take into account the fact that these systems are situated. Consider glow-worms. Here in New Zealand there are limestone caves that are home to glow-worms. All day and night they hang on the ceilings of the caves with glowing bottoms. To catch their prey they release a sticky string which captures moths that enter the caves attracted by the light the glow- worms emit. One way of characterising the glow-worms' system is as a system comprised of the glow-worm, his sticky string, and the moths he feeds on. But we must recognise the fact that the glow-worms' system is situated in the cave's system, which includes the water within these caves that provides the glow-worms with the damp environment they need and so on. In the same way cognition may be a system, situated within a larger system - the biological environment. This is analogous to the moderate embodied cognition thesis and is, for our purposes here, the most useful approach to take. My overarching aim in this project is to show how embodied cognition can helpfully inform the study of non-human animals' cognitive abilities, and to adopt the extended mind thesis does not enhance this. Recognition that cognition is irrevocably situated within the environment is enough. The agent's cognitive processing is a system involving neural processes and behaviour within the larger system of her environment.

When considering the agent-environment system in cognition, we should also be clear on the context in which the system is situated. Often, what count as the constituents of a system is a matter of judgement and, as the organism moves around its environment, the constituents of the system change. As suggested above, the distinction between the role of the environment in a moderate embodied cognition thesis and a more radical extended mind thesis lies in the extent to which the environment is part of the cognitive processing system. For Clark and Chalmers, the cognitive processing system includes parts of the environment. For moderate embodied cognition theorists, the cognitive processing system is a system of its own situated within a larger biological, cultural or psychological system. In other words, the cognitive system would be a system consisting of interacting neurons in a network. But, 'in order to guarantee a proper functioning of cognition, the process has to be synchronised with the environment' (Riegler, 2002, p.344). Furthermore, we should notice that systems can be multi-agent systems. For example, when a dog and human come together, or when two dogs and a human come together, they form a unit which jointly use aspects of the environment. This can be something as simple as a dog and a human walking together down a footpath. Both are successfully navigating their way together through their environment by using the path. Thus, the system consists of the dog, the human and the path that they are using to find their way through the park. Recognising that systems can be multi- agent is important for social creatures. We must not omit pack mates and other agents from the system if we are to understand it, for they are an important part of the larger system in which an agent is situated.

2.5.5 Cognition is for action

Our cognitive processes have evolved to help us with successful interactions with our world. So it makes sense to say that a large part of cognition is for action, and this is especially the case with non-human animals like dogs. Many of our cognitive processes are taken up with bodily actions and reactions for one purpose or another. However, within embodied cognition, the ties between cognition and action run deeper than this might imply. For example, studies with human infants have shown that knowledge is action-specific. Infants will learn to be wary of steep slopes when crawling, but when they start to walk, they have to learn about steep slopes all over again (Clark, 1997, p.37).

This shows that infants do not use their experience during crawling to acquire knowledge about slopes in general. Rather they acquire knowledge about how slopes figure in contexts involving specific actions. There are many examples of this; even memory can be situation specific. For example, it is easier to remember someone's name when you can recall the context in which you met her. Also a useful way of remembering what you did with your lost car keys is to retrace your steps and act out what you did the last time you remember having them.

Moreover, perception seems tied to specific motor routines. The example that Clark (2007) gave above of infants' perception of the slopes was connected to whether they were walking or crawling. Perception, viewed this way, is no longer the passive reception of information, but is another cognitive ability which is linked to action. Svensson, Lindblom and Ziemke (2007, p. 242) argue that 'many, if not all, higher level cognitive processes are action-based in the sense that they make use of (partial) simulations or emulations of sensorimotor processes through the use of neural circuitry that is also active in bodily perception and action'.

An example of this is the action-sentence compatibility effect. In 2002, Glenberg and Kaschak conducted a study that supports the case for the involvement of the motor system in understanding language. In their study, Glenberg and Kaschak asked subjects to indicate whether or not a sentence made sense by making a response that required either movement toward or away from their bodies. For example, the sentence might read 'close the drawer' and the bodily counter movement required the subject to draw his/her arm toward their body. They found that response times were longer when the bodily movement required was incompatible with the movement suggested by the sentence itself. Furthermore, recent studies have shown that perceptual input stimulates motor neurons thereby enhancing the link between action and cognition (Svensson et al., 2007).[5] In recognition of the fact that cognition in humans and animals is largely action-based, studies into cognitive skills of dogs can take into account the fact that certain cognitive skills such as object permanence, may only manifest in certain contexts involving certain actions. This will be discussed in more detail below.

2.5.6 Cognition has evolved

While most will agree that cognition has evolved, Michael Anderson takes an explicitly evolutionary approach in his version of embodied cognition. His emphasis is on the thought that cognition is an adaptive process; it has contributed toward our reproductive success as a species. Anderson remarks that cognition has evolved because it is adaptive and like any other adaptation, it has an evolutionary history. From this, we can reason that cognition 'evolved in specific environments and its solutions to survival challenges can be expected to *take advantage of the concrete structure or enduring features of those environments'* (2005a, p.2) He then points out that *'*cognition evolved in organisms with specific physical attributes, bodies of a certain type with given structural features, and can therefore be expected to be shaped by and to

[5] Lawrence Barsalou, a prominent defender of embodied cognition, also argues that cognition is rooted in perception. Cognition is rooted in perception because, according to Barsalou, it shares many of the same neural systems. He writes, 'perceptual states arise in sensory–motor systems. A perceptual state can contain two components: an unconscious neural representation of physical input and an optional conscious experience' (Barsalou, 1999, p. 577).

take advantage of those features for cognitive ends' (2005a, p.2). As we know, certain cognitive traits do aid the organism in survival. Because of this, they have been preserved by evolution. These cognitive traits are likely to have been those that enhanced existing traits of the organisms such as already established dispositions to manipulate the environment in a way that is beneficial to the organism. Therefore, many of the evolutionary solutions to cognitive problems involve tight perception-action feedback loops, the reliance on and even the intentional alteration of environmental structures to reduce cognitive load and the use of other cognitive scaffolds. It is this phenomenon which we see in dogs' use of human cues as an aid to problem solving. We can recognise that the dog's close association with us on an evolutionary timeline has led him to use humans as an information source.

2.5.7 Cognition is body-based

Embodied cognition advocates the idea that cognition deeply depends on aspects of the agent's body other than the brain. This is not a radical claim on reflection, for without the involvement of the body in both sensing and acting, thoughts would be empty, and mental states would not have the characteristics and properties they do. For example, remembering the walk we had with our little Terrier this evening involves the smell of the leaves on the ground, the sounds of the river and the training wheels on my son's bike, the feel of my dog tugging determinedly at a stick I was trying to get from him to throw. These are all bodily sensations which comprise to a large extent the content of my memory of this evening's walk. In other words, 'the nature and structure of perception, cognition and its constituents (e.g. our representations and concepts), as well as procedures of thinking, logical rules and the like, depend on (or are grounded in) the nature, structures and behaviours of the body' (Wilson, 2002).The idea that cognition is body-based does not depend upon any particular claims about mirror neurons. However, as part of their project Lakoff and Johnson (1999) develop a position in light of the research on mirror neurons called embodied realism. Basically, this is the idea that the neurons that control perception and motor skills are also responsible for the formation of representations. In their words, 'our concepts [representations] cannot be a direct reflection of external, objective, mind- free reality because our sensorimotor system plays a crucial part in shaping them' (1999, p.44). Lakoff and Johnson are not alone in this theory. Gallese (2007) also tells us that the 'so-called "motor functions" of the nervous system not only provide the means to control and execute action but also to represent it' (Gallese, 2007, p. 23).

In primates, two classes of visuomotor neurons (neurons that are involved with vision and motor skills) have been found in a structure of the brain called the premotor cortex. These two classes of neurons are canonical neurons and mirror neurons (Garbarini and Adenzato, 2004, p.101). The canonical and mirror neurons fire when an organism is manipulating an object.[6] But they have also been found to fire when the organism is watching the object being manipulated (Kohler, Keysers, Umilta, Fogassi, Gallese, and Rizzolatti, 2002 and Rizolatti & Craighero, 2004). More interesting, though, is studies have shown that the canonical and mirror neurons fire when an identical object is being manipulated (or that manipulation is observed) are the same as those that fire in response to a group of objects that can be used or interacted with in the same way (have the same affordances) (Garbarini and Adenzato, 2004, p. 102).This suggests that an object is identified and represented with regards to the types of interactions that it invites. It does not seem to be a big leap, therefore, to wonder if the types of affordances an object offers an organism become a major part of an organism's representation of it. 'In other words, different objects can be represented in function of the same type of interaction they allow' (Garbarini and Adenzzato, 2004, p.102). In the same paper, Garbarini and Adenzato go on to remark that the ability to represent different objects, in terms of the affordances of that object, relies on the ability of the brain to *simulate* the neural responses as if the organism were interacting with it: 'what makes this type of object representation possible is a mechanism of *as-if* neural stimulation: while observing an object the neural system is stimulated *as-if* the observer were interacting with it' (2004, p.102).

[6] Canonical neurons respond to presentation of an object while mirror neurons respond to performance of an action and observation of an object directed action. The mirror neurons are triggered by any action that involves the interaction between a the body and an object.

This idea is the beginning of the notion of representation which I will argue for in later chapters. The way we think about representations in the light of the embodied cognition paradigm leads quite naturally into the view that representations of the sort an animal can use are body-based representations of affordances, or actions surrounding a particular state of affairs.

In summary, the action of mirror neurons that help us simulate actions we observe provides a way of understanding the relationship between performing an action and representing it. Garbarini et al. (2004) tell us that ‘a motor schema allows us to execute an action as well as represent the object the action refers to’ (2004, p.103). Embodied cognition opens up a new way of approaching cognition. The hypothesis is this: the internal, neural states are coupled with external states of the body and environment to form a system. The neural states exhibit causal dependency on the external states thus creating what Clark and Chalmers call a coupling, or what Haugland (1995) calls integration. Furthermore, this integration or coupling of the brain and behaviour counts as a cognitive process in embodied cognition. In short, the bodily movements that an agent uses to cognise become part of the cognitive process. In this chapter I have begun to suggest how greater emphasis on the principles of embodied cognition may help us to study and understand dogs’ cognitive skills. In this next chapter I expand upon these points.

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Chapter Three: Embodied dog cognition

Until now, studies within the framework of embodied cognition have largely focussed on humans. The study of animal minds, however, can and should be enhanced by approaching non-human animal cognition using the principles being developed in embodied cognition. This chapter demonstrates that embodied cognition is well suited to clarify the study of non-human animal cognition and provide useful and productive ways forward in understanding animal thinking.

3.1 The value of applying embodied cognition to dog cognition

In the context of human cognitive capacities, embodied cognition meets with some criticism. For example, Benjamin and Bjork argue that an embodied interpretation of memory 'underestimates human capabilities' (1997, p.20). They argue that while some representations and processes used by humans may be embodied, not all of them are. They argue also that there is danger in thinking that memory is embodied. The danger stems from the assumption that if memory can be embodied all memory is embodied, an assumption which will ultimately constrain psychological research. In addition, Habel, Kaup and Kelter (1997, p.26) write that 'we ought to combine the level of embodied representations with representations of a more abstract character in a heterogeneous level'. Many of these worries do not arise when we are discussing animals. This is because we do not so readily attribute abstract concepts such as higher mathematical concepts to animals and it is more generally agreed thatmost animals have little use for abstract concepts. How well this applies to great apes though is questionable. What is more, thinking about embodied cognition and dog cognition in particular is especially interesting because the domestic dog's natural environment tends to be one in which they regularly communicate and interact with people. As a species, dogs have more overall interaction with humans than any other animal and human-dog interactions have shaped dog (and possibly human) cognition over time.

For example, studies outlined in Chapter One show that dogs rely heavily on cues from their owners in their solving of tasks, especially novel tasks (Topál et al., 1997, see page 58; Kubinyi et al., 2007, see page 40; Soproni et al., 2000, see page 41; Byrne, 2003, see page 41; Miklosi et al., 2003, see page 42). The cues supplied by the human counterpart play a significant role in the dog’s finding a solution to problems to the extent that in some experiments, human cues were used by the dog over and above the use of environmental cues. In fact, the preference of dogs to use human cues as an aid to problem solving is a significant confounding variable in studies where it is not controlled for. Recall, for example, Lit et al.’s (2011) study on page 73 which found that handler beliefs can inadvertently affect scent detection in dogs. In this double blind study, cues unintentionally given off by the handler caused the dogs to register false alerts at the spots where the handler thought there was a target item. This occurred even though there were some real scent targets in the same building. The dogs and handlers in the study were experienced scent detection dogs and their handlers and the results were remarkable in their demonstration of the extent to which human cues are used by dogs. Lit et al.'s study suggests that dogs will use human cues as a more reliable indicator of the correct course of action than their own perceptual cues.

The dog's ability to use human social cues probably springs from a much older disposition (older in evolutionary terms). Before domestication, the dog would have made use of his pack mates' social cues as information about the environment and as an aid to survival. It is therefore unsurprising that they have developed the ability to use humans as providers of cues for problem solving. The trouble is that the dog, in comparison to wolves, will rely on human cues for problem solving to the extent that they will not attempt to solve a task without them as readily as wolves as we saw on page 44 (see Udell et al., 2008).

The fact that the dog does rely so much on human cues in problem solving has led some to the conclusion that problem solving ability in the domestic dog has been reduced by domestication (Fox, 1982). However, the guiding principles of embodied cognition can lead us to view the use of humans for cues in problem solving tasks as problem solving nonetheless. It is an example of the dog off-loading cognitive work onto an aspect of his environment (the human). This is not much different to a human looking up an answer in a book, an action which is problem solving by calling on environmental resources. In what follows, I show in more detail how the study of animal cognition can benefit from the adoption of the principles of embodied cognition.

3.1.1 Dog cognition is situated

Cognition is situated when it is inextricably tied to the environment. The environment, perception and action are dynamically interacting in situated cognition and examples of situated cognition in humans are legion. For example, walking down a busy street, building a structure from wood, baking a cake, talking to someone, are all types of situated cognition. They all involve responses to and from the environment through our bodily actions and perceptual experiences. Many of a dog's cognitive processes are involved with responding to and interacting with the environment, possibly more so than in humans. There may be times however when the dog remembers past events or locations that have been important to him. Moreover, there may be occasions when he formulates some kind of plan for upcoming actions. But the frequency of these non-situated cognitive events is more likely lower than those times when the dog's cognitive processes are online and situated. In fact, when we think of the types of cognitive processes dogs are likely to be capable of a large majority of them seem to be situated.

For example, a day in the life of a working farm dog is guided heavily by cues from his handler. By environmental cues (supplied by a human) he is directed through tasks. His first task might involve a sheep muster across hill country. Using a series of whistles, verbal cues and body movements the handler communicates to the dog actions required of him.The dog responds to the handler's commands, to the sheep's actions, and the terrain he is working on. Every second the dog is out mustering sheep there is a stream of rich environmental information to be perceived and responded to. His responses must be fast, accurate and goal-oriented – his goal being the movement of the sheep in the direction indicated by the handler. The dog's cognition can be thought of as situated. Rather than viewing the dog's brain as an isolated control centre for the dog's sheep mustering, recognising the situated nature of cognitive processing in this context allows us to see that cognitive processing is a dynamic interplay of the dog's brain, body and environment. It is a fluid system in which the parts - the dog's physiology, the environmental cues and features - are interdependent and his behaviour and responses constitute his cognitive processing. Viewing cognition this way will hopefully lead us to a realistic notion of representation for non-human animals and allow us to generate ethologically appropriate hypotheses on their nature and use within animal cognition. The next chapter discusses this point further.

Because cognition is situated, it is important to note that cognitive skills may be tied to a particular situation. Recall from above that it is often the case that learning can occur in one scenario but not be automatically transferred to a different context. Take, for example, housetraining a pup. Often a pup must receive additional training to help him transfer what he has learned at home to different locations. It is common (yet embarrassing) for young dogs to be fully housetrained in their own home, yet urinate in another house. The situated nature of cognition is also important to remember when considering the cognitive skills a dog might possess. Many cognitive skills, such as object permanence, an understanding of the connection between the means and an end, the ability to attend and respond to verbal cues, the ability to count (in an ethologically appropriate interpretation of the word) and so forth may not be seen in certain experimental settings, or not conclusively anyway. To review the experiments conducted on object permanence in dogs, see page 61. This is not to say, however, that dogs do not possess such cognitive skills. The point to take from the situated nature of embodied cognition, with regards to studying non-human animal cognition is that if we are to look for evidence of particular cognitive abilities then we should study the dog in his normal interactions with the world, because often a cognitive skill may be tied to a situation and not transferred to the laboratory setting.

3.1.2 Dog cognition is time pressured

A hunting dog, in the depths of a mountain range with his handler, must respond quickly to the scents of various animals. He must decide which to follow, which to ignore. At the same time, he must safely move around the terrain, navigate around fallen trees, through thick parts of bush, streams, rivers and over slippery tree roots. On top of this, his handler is sending him signals which he must attend to related to their direction or speed. All of this, the dog must be aware of and respond to continuously. This dog at work does not have the luxury of considering his responses; the demands of his environment are constant and immediate.

But, as with humans, some of the dog's cognitive processes are not under time pressure. When a family dog is hanging out in the living room or eating and drinking, there is little time pressure. These activities do not require much in the way of immediate and effective responses. And most of the cognitive processing of domestic dogs that live as family pets will be like this. Their actions are unhurried; their cognitive processes are not required to interact with their environment under much time pressure at all. On the other hand, for working dogs these times could often be in the minority during daylight hours. Time pressured cognitive processes are behind most of the work that these dogs have. To call on an earlier example, herding sheep would be highly time pressured especially if the sheepdog is working as part of a gang of sheep dogs, with large flocks of sheep and so on. Not only would the dog have to respond quickly to the sheep's movements, but those of the other dogs and his handler too. Similarly, a guide dog out with his owner has to constantly attend to his master and the environment and produce immediate and effective responses to both. The police dog tracking an escaped convict, too, must constantly interact with his environment and respond as quickly as possible to track a scent.

3.1.3 Dogs off-load cognitive work onto the environment

As discussed in Chapter One, humans off-load cognitive work on to the environment frequently. One way is through the use of gesture in speaking. Gesturing is communication through physical actions, it can be more effective than verbal communication and by, for example, gesturing to an object rather than naming it, the speaker is essentially off-loading cognitive work onto her environment. Gestures also provide the listener with environmental cues to aid understanding of what is being said. The reciprocal effect of gestures is a way in which the speaker facilitates the offloading of cognitive work onto the environment for the listener.

There are numerous ways in which domestic dogs off-load some of their cognitive work on to aspects of their environment. As social animals dogs can use the actions of other members of their social group as a short cut for learning about a situation themselves. For example, see the studies on learning by imitation in the opening chapter, page 65. When confronted with a problem, humans will often ask an expert or look it up on the internet rather than spend time and energy figuring out something ourselves. When confronted with a novel problem, they often refer to members of their social environments (both human and canine) as an aid to problem solving, instead of possibly expensive trial and error learning.

For example, scent is a predominant way in which dogs use the environment for communication. Scent cues perform a variety of functions. Scent markers are maintained for boundary marking. By conveying the gender, reproductive situation, age and social position of a dog a scent marker provides other dogs with a wealth of information which can save a costly encounter (in the case of an accidental territory transgression) and assist with finding a suitable mate. Moreover dogs will use scent trails in their environment to track prey or objects, animals and humans they have been trained to track. The use of scent is probably the most significant way in which a dog uses the environment to convey and receive information necessary for daily life. Even domesticated dogs rely upon scent trails. Rather than a time consuming and labour intensive trial and error search, our Terrier will frequently put his nose to the ground and track scent trails to find my son wherever he is hidden. One notable time when our Terrier used scent cues in his environment was when he tracked my son and me through a large department store full of people covering multiple levels. Having got fed up with waiting by the door, he entered the store and must have weaved his way through the racks and sections of the department store, up an escalator following the scent trail my son and I had inadvertently left. He quickly and efficiently found us despite the presence of many thousands of scent trails from other people and no visual information or past experience to rely on. Unfortunately the store's security guards were not so impressed and we were asked to leave. But I didn't mind, impressed as I was by how he found us.

Not only do dogs use scent as information about the environment, but auditory cues can play a large part in telling dogs quickly what they need to know. In the opening chapter, we saw that dogs are capable of understanding barks in different contexts, and can encode information in growls by varying the pitch and length of a growl. It may even be possible for dogs to assess the size of an opposing pack based on an environmental cue. They may then base their decision regarding whether or not to engage with the opposing pack on their assessment of its size (Bonanni, Natoli, Cafazzo and Valsecchi, 2010, see page 147).

As another example, many dog trainers will tell their human pupils that a dog's response to a new stimulus depends largely on the reactions of those around him. For example, when dogs first encounter a heavy storm with thunder, their responses depend greatly on the responses of other members of their social group. It is likely that young dogs determine the nature of this new state of affairs (whether it be dangerous or not) by the reactions of those in their social environment. This is another way in which a dog off-loads cognitive work on to his environment. A good dog trainer is careful to behave as if everything is normal in potentially fearful situations for a puppy, such as loud thunder. 'Normal behaviours' can include behaviours which are not associated with frightening episodes - this may include making the dog some dinner if it is his usual dinner time, or by engaging in play if that is something you would usually do. By doing so, the pup may learn more quickly that it is nothing to be afraid of than he would with repeated exposure to the stimulus in isolation. Note, though, that once a phobia has been created and a fear response has been learned additional training measures may be necessary to work through a situation. In this respect, learning by imitation (discussed in Chapter One on page 65) can be seen as a method of off-loading cognitive work on to the environment. The dog can use a human or canine as a model for successfully performing tasks and solving problems.[7]

Much of a pup's early learning comes from copying the reaction of the bitch and litter mates. The extent to which dogs use social cues over and above trial and error learning has been demonstrated in recent studies. For example, the dogs in Collier-Baker's (2004) experiment explained on page 75 attended to the experimenters' bodily positions to 'solve' object permanence tasks. These findings highlight the fact that experiments into the cognitive skills of a dog, particularly problem solving tasks in which humans are (and have been) typically present need to take into account that, at least initially, dogs will attend to human social cues rather than directly try to problem solve by themselves. Recall from Chapter One, page 67, that Range et al. (2012) set up an

[7] We will return to this situation in Chapter Six, where I discuss the implications of embodied cognition for dog training

experiment to test the problem solving abilities of dogs and wolves. The species were separated into two different cages; both the dogs and wolves were well socialised. Then a piece of string with a chunk of meat attached to the end was attached to the dogs' and wolves' cage within their reach. Members of both species began to pull at the rope to try and get the meat, but the dogs quickly started to look at the human who was present. The young dogs looked sooner and for longer than the young wolves suggesting that the dogs were more inclined to use human cues as an aid to problem solving than their wild counterparts.

Structurally, the dog's brain has developed in direct relation to its external environment, so it is not surprising that dogs are more inclined than wolves to look to humans as a source of information, given that humans are now part of the domestic dog's natural environment. Moreover, puppies especially after weaning learn that humans are a food source, source of activity, play and security. What starts with a behavioural tendency passed down through years of his ancestor's domestication is confirmed and strengthened throughout his life in human society. As Clark and Chalmers write, 'within the lifetime of an organism, too, individual learning may have moulded the brain in ways that actively anticipate the continued presence of those ubiquitous and reliable cognitive extensions that surround us as we learned to perform various cognitive tasks' (1998, p. 5). We should take this into account when designing experiments into the cognitive skills of the domesticated dog and never underestimate the extent to which a dog might use human cues (perhaps inadvertently given) as an aid to problem solving. For example, humans are generally providers for dogs. In most cases, it is a human that provides food to the dog on a daily basis; excepting strays few dogs living in domestication need to hunt for their food. Thus it is particularly important to take into account the fact that an individual dog's learning may dispose him to look to the human as a food provider during experiments involving food.

It would be interesting to study the use of humans as an information source by dogs who have not learned by experience that humans can help them. This might be achieved by human-neutral environments. For example, from weaning, the enclosures could be set up in such a way that the humans are neutral; food could be supplied via an automatic feeder, the pups housed in a large stimulating enclosure with access to space to run and play with other dogs independently from humans. The resulting study would demonstrate whether the dogs were still inclined to use human social cues for solving tasks despite a lack of individual experience of using humans in this way.

In summary, when we are thinking about the effect of dogs' use of people as an information source, we should consider the importance of separating what an individual is genetically designed to do via evolutionary history versus what is learned at an individual level through experience. This is because the dog's use of human social cues will be a result of both an inherited tendency and individual experience.

As we have seen with scent, dogs also off-load cognitive work on to their environment independent of human cues. When dogs walk in parks with their owners, if given the choice, most of the time the dogs will be in front. Aside from places where the path splits, the dog does not need to maintain his attention on his owner for information about which direction he is to go in, even if the path is novel. This may be an obvious point but the dog is using his perception (probably guided by olfaction) of the path to judge which way to go. There is little input needed from the owner on the matter of direction when it comes to following a path because the scent of the hundreds of people and dogs who have followed it in the past will make the trail very obvious to him (Laurier, Maze & Lundin, 2006). The minor role that vision plays in path following is clear when following a path through a heavily wooded, or deep area of bushland. The way is clear to the dog if there are scent trails to follow from previous hikers and it has become a regular practice for our family when in thick forest and poor lighting to just follow the dog. Occasional detours aside, he generally keeps us going the right way, and this is one of many examples of people off-loading cognitive work onto dogs.[8]

[8] People off-load cognitive work on to dogs just as dogs do to people. Guide dog owners are the best example that springs to mind. For people with physical impairments dogs literally serve as a replacement for human physical functioning. And it is truly remarkable how much and how willingly and effectively dogs can do this

3.1.4 The dog perceives the environment as opportunities to act

But, we must be careful when we identify which features of the environment dogs are interacting with in their cognitive processing since their perceptual world and the affordances of their environment are vastly different to our own. A path for us probably consists of a range of visual cues; the footsteps of previous people, perhaps some flattened grass or forest floor weaving through the trees. For our dogs the path is predominantly a range of scents, with maybe some visual cues as an extra. West and Young's (2002) study outlined in Chapter One on page 83 described the use of a measure called 'gaze duration' in the assessment of a dog's ability to count. The idea was that if the dog looked for longer at the biscuits revealed from behind the screen when one of them had been secretly removed, then the dog had an expectation about the number of biscuits there should be (West and Young, 2002). In the light of what we know about dogs' perceptual apparatus, however, it is questionable whether gaze duration is an appropriate experimental measure. Moreover, the animal perceives the environment as a series of opportunities for action and the perception of these affordances will be guided by the physical nature of his perceptual apparatus. Humans are visual creatures, and it makes sense to base a measure of expectancy in humans upon gaze duration. But for dogs, especially in visual perception is not the main sense; smell is the dominant sense.

In short, each species' perceptual world is unique. The way in which the dog perceives the same scene as us is vastly different. Therefore, experiments into the cognitive skills of a dog should be designed for dogs. Using human measures and designs seems inappropriate.

3.1.5 Dog cognition is for action

Nowhere is the point that cognition is for action more salient than in non-human animal cognition. If animals have cognitive processes, then they arise to allow them to act in such a way that they can exploit their environment for their own benefit. Thus, much cognition is specific to a particular situation or action. Moreover, cognition can be specific to a particular part of the body. For example it is possible to teach a dog to raise a paw, but the teaching will likely have to be repeated for each paw you want him to lift, although as with house training, learning should occur more quickly than with a totally novel lesson. Moreover, because cognition is action based, our cues will be more effective if they reflect the action being requested. For example, a downward physical cue, coupled with a lowered tone in the verbal cue can be used to request a cessation of movement or decrease in activity. Most people will intuitively do this, for we have a natural understanding that our actions and thoughts are related. But it is good to be aware of why we do this naturally (because actions and cognition are intrinsically linked) so we can consciously apply it to our communication with dogs.

Moreover, when we are thinking about dogs' understanding of verbal cues it is most likely that for a dog a verbal cue is a request for action. Even a word such as 'ball' which obviously denotes an object to humans is probably associated with an action in dogs. In Chapter One, we saw some astonishing evidence of dogs reportedly being able to learn the names of many objects. However, given the action-orientation of cognition, particularly cognition of non-human animals it is difficult to prove that words are associated with discrete objects, not the actions that surround them. This is especially the case when we consider dogs' association with humans over the course of history. For a dog to be useful as a hunting tool or for work on the farm he must be able to readily acquire associations between commands and particular actions. There is little value in teaching a dog the word for an object which is not the subject of an action. For example, guide dogs are taught to fetch the house keys, find the slippers and so on. Each command revolving around an object involves the dog performing a task related to it. Therefore, the dog's inherited tendencies plus his individual learning renders it more likely that he will come to associate words with actions and not objects.

Similarly, when we consider that cognition is for action, it makes sense that representations are also for action. Thus, theories of representation which may have explanatory value and be useful in their attribution will also be focused on actions, rather than static representations of objects as is the case with many human-based theories of representation.

3.1.6 Dog cognition has evolved

The dog's cognitive skills have adapted over time to allow them to flourish in their environment. One of the factors that allowed dogs to adapt so successfully into our human world was sensitivity to social cues from members of other species. Another possible factor was the presence of a reduced fear response to people in certain individuals which may have sparked a closer association. Dogs are also adaptable; most dogs will adapt into diverse walks of life, even those they are not bred for, and this adaptability into diverse human societies has surely contributed to the dog's success.

The dog's close association and long cohabitation with human beings have influenced the dog's cognition heavily because the environment plays a crucial role in developing and constraining canine cognitive processes. On this point, Clark writes, 'minds make motions, and they must make them fast - before the predator catches you, or before your prey gets away from you. Minds are not disembodied logical reasoning devices' (1997, p.1). In other words, the types of challenges and situations the dog faced over the course of history have shaped his body and cognitive processes alike.

In summary, dogs' cognitive processes reflect a history of interactions with the environment. For example, the methods by which dogs and humans can communicate are a result of evolution and individual learned experience. The dog's ability to understand human pointing cues, verbal cues and to follow human gaze is possibly a result of his long association with humans, coupled with individual learning. Furthermore, the dog's reliance on human cues as an aid to problem solving may have also evolved over time, possibly leaving the dog with less independent, although not necessarily inferior, problem solving skills to wolves. By studying the history of the dog's interactions with his environment we can make progress into understanding the nature of his cognitive skills since such interactions will reflect the nature of dog cognition. A fruitful approach to the study of dog cognition would be to look at the types of interactions which evolution has equipped him to be successful in and take what we can from these. We can also ask this question about the cognitive skills which are currently under investigation in dogs. For example, is it the case that an understanding of object permanence would help the dog interact successfully in his or her environment? If so, then embodied cognition teaches us to first identify and study the contexts in which such a cognitive skill would be adaptive rather than trying to elicit evidence of the skill in a context which the dog has not evolved to encounter.

3.1.7 Dog cognition is body based

As we have seen in the embodied cognition paradigm, cognition involves bodily structures and is not constrained to neural hardware. Therefore, the types of cognitive processes open to the dog are constrained by his physical nature. For example, dogs' perceptual experiences are a huge part of the content of his cognitive processing. As we saw in the opening chapter dogs' sense of smell is inconceivable to people; we cannot imagine what it might be like to smell as acutely as our dogs. Yet dogs' vision is poorer than ours for detail of stationary objects and colour discrimination (Miklosi, 2008) but their visual acuity is better than ours for moving objects. And this makes sense; dogs are hunters and have little use for things which sit still in broad daylight, unless scent cues indicate that there is an opportunity for scavenging.[9] Therefore in experimental settings the constraints and influences of the body upon cognition cannot be overestimated. This is especially the case in terms of controlling for scent cues, which may be almost impossible under any but the most rigorous of settings.[10]

In von Uexkull's (1957) paper, ''*A Stroll through the Worlds of Animals and Men: A Picture Book of Invisible Worlds*' he argues that each species has its own worldview, or umwelt, a notion which heavily influenced Konrad Lonrenz (1903-1989) and Nico Tinbergen (1907-1988). He asks his reader to walk with him .through a meadow, one which is alive with humming insects and fluttering butterflies:

[9] Some prey animals, rabbits for example, play on this and will often freeze if they detect a dog. By doing so the rabbits around our house regularly go unnoticed by our three dogs
[10] I return to ways in which we can control for scent cues in the final chapter. I also give suggestions for optimal lighting conditions and target object placement in experimental settings

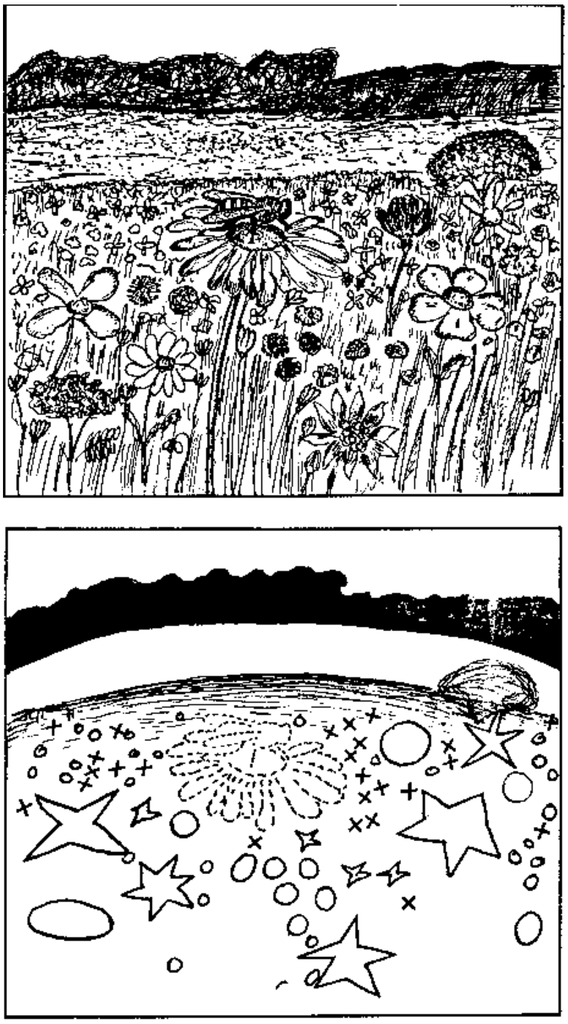

Figure 9. The top image represents the meadow as it is perceived by people. The bottom image depicts the bee's perception of the same meadow (von Uexkull, 1957).

First blow, in fancy, a soap bubble around each creature to represent its own world, filled with the perceptions which it alone knows. When we ourselves then step into one of these bubbles, the familiar meadow is transformed. Many of its colourful features disappear, others no longer belong together but appear in new relationships. A new world comes into being. Through the bubble we see the world of the burrowing worm, of the butterfly, or of the field mouse; the world as it appears to the animals themselves, not as it appears to us. This we may call the phenomenal world or the self-world of the animal (von Uexkull 1957, p. 5).

The perceptual focus of a human or non-human animal is that which is meaningful for them perceived through a diverse range of perceptual abilities. In von Uexkull's description, bees land on figures that exhibit broken forms, such as stars and crosses, and avoid compact forms, such as circles and squares. The figure,

> … which was designed on this basis, contrasts a bee's environment with its umwelt. The bee is seen in its environment, a blooming field, in which blossoming flowers alternate with buds. If we put ourselves in the bee's place and look at the field from the point of view of its Umwelt, the blossoms are changed to stars or crosses according to their form, and the buds assume the unbroken shape of circles. The biological significance of this newly discovered quality in bees is evident. *Only blossoming flowers have a meaning for them; buds do not* (von Uexkull, 1957, pp. 350-1, emphasis added).

As the dog moves through the meadow above, he would be bombarded by hundreds of thousands, if not millions of scents, layered on top of each other, some from creatures that passed through long before, some recent. He will notice those scents which may be relevant to him, those of potential prey, other dogs, human scents, scents of food on which to scavenge and so forth. In short, a dog's umwelt is made up of the affordances that the environment presents to her, mostly through scent. The affordances presented to the dog are shaped by the individual dog's history of interaction with her environment and those that are innate. Over time, the dog's perceptual apparatus has been fine tuned to detect these affordances and make them salient to him. The cognitive processing of which he is capable is determined by the sorts of things he perceives and the sorts of responses he can make. Clearly, aspects of cognition, such as the use of representations will also be affected and constrained by the dog's body. Therefore, if we are to suggest that dogs might use representations to interact in the world, it makes sense to suppose that these representations are body based. That is, representations are influenced, constrained by and manifest in the dog's physical body. In the following chapters the theories of representation I outline are theories of embodied representation; they are body based and I will show how they can be applied to dogs.

3.2 Summary

I have argued so far that our studies into the cognitive skills of the domesticated dog and other non-human animals would benefit from adopting the principles of embodied cognition by bringing to the foreground important aspects of dog cognition. The principles can also help us draw appropriate conclusions from the studies which have been done and help us to design studies which take into account the constraints and influences on dogs' cognitive processing. The main points to take from the embodied cognition paradigm to a study of cognition in non-human animals are:

1. *Cognition is situated*

Dogs' cognitive capacities such as understanding object permanence, categorisation, an ability to reason by deduction, counting and attention to human states are likelyto be situation specific and may not be generalised to other contexts including laboratory settings. Genuine evidence of these capacities may be hard to obtain, therefore, in an artificial experimental setting as seen in the discussions of the opening chapter.

2. *Cognition is time pressured*

Time pressure pushes on dogs' cognitive functioning in certain situations such as hunting as a pack, or mustering sheep. In these situations the cognitive processing must be immediate and effective. This point becomes salient in the next chapter when considering representations. For representations to be useful, they must assist the dog in situations where his cognitive processes must be fast and efficient.

3. *Cognitive work is off-loaded on to the environment*

Recall from Chapter One that dogs, like humans, use their environment as an aid to problem solving. Humans are part of the dogs' environment and it is no surprise, therefore, that dogs will refer to human cues when confronted with a task. The extent to which dogs will use human cues ought not to be underestimated since the natural tendency to do so coupled with an acute sensitivity to human body language, posture and perhaps even hormonal changes may confound experimental results.

4. *The environment presents opportunities to act*

The affordances which an environment offers to an agent differ among species. Each species has its own worldview and the key to understanding the cognitive skills of another species lies in understanding the affordances that their environment presents to them. The perception of, and responses to, affordances are influenced and constrained by the physical make-up of an agent. For dogs, their sense of smell is so much superior to ours that some of the affordances within their environment are imperceptible to us. We should remember this when studying dog cognition since they may be using aspects of their environment of which we are not aware to guide their behaviour. These may include shifts in air currents in a laboratory-based study into object permanence, scent cues and unintentional handler cues.

5. *Cognition is action-based and body-based*

Cognitive processing for dogs revolves around actions. Therefore it makes sense to suppose that their understanding of words is also action based. The association is probably word/action rather than word/referent as it is in humans. Moreover, our verbal cues can be more readily understood when they embody the required action in some way. For example, an upward hand signal will more readily elicit an upward response from the dog, such as when requesting the dog to stand from a lying down position.Similarly, aspects of cognition such as the use of representations is likely to be action based.

6. *Cognition has evolved*

The dog has evolved to cope with his environment and these required responses have shaped his body and cognitive processes alike. The example used above of the dog's ability to understand human pointing cues, verbal cues and to follow human gaze is possibly a result of his long association with humans, coupled with individual learning. By looking at the history of dogs' interactions with his environment we can make progress into understanding the nature of his cognitive skills. With this in mind, the following investigation into representation in the domesticated dog will be ethologically appropriate and follow the basic principles of embodied cognition outlined.

The next chapter introduces two accounts of representation to come out of the embodied cognition paradigm. I will explain them both and begin to show how they might be applied to the domesticated dog.

Chapter Four: Embodied representations

The literature on representation in animals is diverse, but a common view is that internal abstract representations are required for flexible behavior. Beigler and Pfuhi write 'A hallmark of higher cognition is the flexible use of information. This requires an abstract representation of the information' (2012, p. 833). The flexible use of information underlies the ability to use environmental and social cues to problem solve. It also underpins the ability to learn new behaviours and respond effectively in novel situations by applying past successful responses to a new situation or by generating new responses to the novel situation. In short, the flexible use of information is the foundation for being able to behave flexibly; a skill which gives an animal a higher chance of survival in unpredictable circumstances and problem solving skills that extend beyond trial and error learning.

> Behavioral flexibility is an important adaptive response to changing environments for many animal species. Such plasticity may also promote the invasion of novel habitats by introduced species by providing them with the ability to change or expand their ecological niche, a longstanding idea with recent empirical support (Wright, Eberhard, Hobson, Avery and Russello, 2010, p. 393).

In the case of many dogs with active lives the ability to make flexible use of environmental and social cues is an advantage; there will be novel situations to be navigated and problems to solve. Representations can be used in these situations. But what these representations are in non-human animals such as the dog is unknown: 'domesticated dogs likely utilise representations of objects in their everyday life for such tasks as searching and retrieving objects. Yet, we largely lack information to judge how similar or different their representations are from our own' (Kundey et al., 2010, p.497-505). As with Beigler, cited above, it is commonly thought that representations are internal, mental entities. This is the standard view of human mental representation. But theories of representation developed with human cognition in mind are not always helpful in the explanation of non-human animal representation because they often involve language- based representations to explain internal categorisation and higher order cognitive functioning.

Since Von Frisch (1937) discovered that honeybees can communicate information about distant resources to their hivemates and Baerends (1941) suggested that wasps could calculate and remember how many caterpillars were needed to fully stock a nest, representation in non-human animals has been the focus of much research. The general upshot of this research is that of members of the animal kingdom, primates might not be alone in their internal representation use. For example**,** Herrnstein (1964) concluded that pigeons can learn concepts such as FISH, TREE or HUMAN in tests that required the birds to categorise objects based on an abstract property that was independent of the exemplar they were shown originally. Herrnstein's notion of a representation is similar to the Prototype Theory, a theory which is commonly used to describe or test representation in non- human animals. Prototype Theory was formulated in the 1970s in response to data from recent human psychological experiments. According to the Prototype Theory, concepts such as FISH are mental representations 'with a probabilistic structure, in that something falls under C just in case it satisfies a sufficient number of properties encoded by C's constituents' (Margolis and Laurence, 2012).

In other words, encoded into mental representations is the likelihood that an object, person or state of affairs will have certain particular features and resemble a prototypical member of that category. The Prototype Theory has roots in Wittgenstein's (1953) idea that things which share a category such as 'game' bear what Wittgenstein called 'a family resemblance' to each other. In short, the structure of a mental representation is determined by the resemblance that objects that fall under that concept bear to the prototypical item of that category. If an item bears enough resemblance to the prototypical representation, then it is judged to fall under that concept (Medin, 1989). For example, a magpie would be classified as a bird because it bears enough of a resemblance to the prototypical member of the bird category. (The prototypical member might look something like a blackbird, for instance.)

The types of representation under discussion here - internal ones, from traditional theories of cognitive science - would, if they exist, play an intermediary role between a dog's behaviour and his environment. Assuming their existence, their role is to be the cause of certain adaptive behaviours.

However, representations so construed are internal. The actions are caused by representations; the actions are not representational in themselves. In contrast, taking an embodied approach to cognition and representation can lead to an entirely different view of representation in animals. Embodied cognition, as we have seen, emphasises the action- based, body-based, situation specific nature of cognition and this view covers representations also. Thus, there is an alternative way of thinking about representation and representation use in animals. It is one that recognises the body-based and action-based nature of representations, and which emphasises the interconnectedness of representations, the body and the environment. In some instances representations may be situation specific. Representations of this kind are likely to be more common, I believe, in animals because they are something the animal can use on a daily basis and will aid in her direct, time pressured responses to an immediate situation.

I do not deny that animals may possess internal representations which may also serve to guide behaviour such as those posited by Prototype Theory. My view is that our starting point for investigating representation use should be with those possible types of representation which are, like most other aspects of animal cognition, embodied.

Most work on representation in the philosophy of mind has developed by focussing on the most high-end cognitive abilities; rational thought and deliberation. But much cognition in the broad sense cannot be much like that; for example, the mental lives of young children, of adults in unreflective activities and non-human animals. Much of this cognitive processing involves fast and adaptive responses to the environment, but human-based theories of mental representation such as the Prototype Theory do not give a very convincing idea of the majority of cognitive processing in such agents. As I have outlined in earlier chapters, embodied cognition gives a better picture of unreflective, but still skilled human cognition. When we apply the embodied cognition approach to animal cognition, the advantages become clearer still.

The following discussion contains the argument that the attribution of embodied representations gives a productive picture of dog cognition, one which can explain flexible behaviour and cognitive capacities such as problem solving, short-term planning, forming expectations and making predictions about possible environmental events and the actions of others. I also suggest that embodied representations can provide a deeper explanation of dogs’ use of human cues as an aid to problem solving, learning by imitation and cooperative behaviour such as is seen by pack members hunting together.

4.1 Embodied representations: Background notes

Embodied representations, I will argue, can enable a creature to plan, form expectations and make short-term predictions about possible environmental events and the actions of others. They can facilitate problem solving and in short, aid the agent to adapt his or her behaviour to the demands of the environment. In virtue of embodied representations a creature might be able to transfer learning from a previous situation and apply it to a novel yet similar one, thereby reducing the amount of time spent on trial and error learning. In short, being able to represent and store representations for future use increases an animal's chances of continued survival; therefore embodied representations retain this advantage usually attributed to the possession of internal mental representations.

It seems likely that when we are thinking about representation use in non-human animals such as dogs there will be some cases where there is not enough evidence to say for sure whether they are using representations, some cases that are borderline and some cases when they clearly are. Representation use, like other aspects of embodied cognition, is bound to the dog's interactions with his environment, since the dog's cognitive capacities come from perfecting his behaviour in response to real world events (for a discussion of this in relation to people, see Clark, 1997, p.4). The preceding examination of dog-environment interactions therefore underpins the present discussion of representations.

> In place of abstract representations of formal logic expressed in propositional format, representation proves to be intrinsically linked to the sphere of action and is expressible in the same terms that control it. Therefore representation does not consist in a duplicate of reality, but in the virtual activation of perceptual and motor processes that, when actually executed, allow us to recognise objects and interact with them (Garbarini et al., 2004, p.106).

In other words, embodied representations are the sorts of things to exist in behavioural, perceptual or motor processes. They are not internal abstract representations of objects. They are not confined to mental states and neural structures. The types of representations dogs use will be ones that aid successful dealings with the dog's environment, and are therefore based on what he can perceive.

4.1.2 Two theories of embodied representation

To recap, traditional theories of representation have confined representation to the agent's brain and until the rise of embodied cognition, there had been little discussion of the possibility that representation might not only be found in an agent's neural structures. Embodied cognition, however, leads to the hypothesis that as a cognitive state, representation can be distributed over the body.

The possibility remains open that in navigating the world an agent uses a combination of neural and non-neural representations. Recent theorists have attempted to provide accounts of non-neural, body-based representation. The following discussion outlines two notions of representation from the embodied cognition approach: the theory of minimal representations and the theory of representation in action. These are the leading theories of representation to come from the embodied cognition framework. Although they are separate theories, they were developed from the same basis; that representation can reside within movement and behaviour. No attempt was made in their formulation by their authors to make the theories compatible; however I will argue here that they are. My main point is that both representation in action and minimal representations can be useful in the way we think about representation in non-human animals.

4.1.3 Body and action-based representations

Embodied representations are quite different from traditional representations. In traditional cognitive science, the plethora of theories of representation which exist all locate representations solely inside the agent's head; carried by internal neural structures.

As Keijzer puts it, 'being a form of internal modelling and being the source of behavioural regularities [are] the defining conceptual criteria of traditional representation in traditional cognitive science' (Keijzer, 2002, p. 280). So what becomes of the way we think about representations if we accept embodied cognition? There are few cognitive processes which are not distributed across an agent's body and behaviour in embodied cognition and this statement includes the way we think about representation. In fact, representations within the embodied cognition paradigm might be unrecognisable as representations in the traditional sense, given that the embodied cognition theorist adopts the idea that representations are body or action based, situated and closely tied to the agent's environment.

However, I argue that at the most basic level, across all accounts of representation, a representation by nature is a mediating state of some kind (Markman and Dietrich, 2000). Traditional theories of representation claim that representations are inner brain states that stand between an agent's behavioural goal and environmental stimuli. In theories of embodied representation, representations are mediating states which may include non-neural structures such as the body.

Based upon Markman and Dietrich's theory, there are three conditions under which a system, or agent, uses representations, (aka mediating states):

1) The agent has internal states (including goal states) which undergo changes. (A goal state is a desired state to which the agent can compare the current state of the environment);

2) The agent has representational states that are affected by the environment; and

3) Information must be able to pass back and forth between the agent's environment and the representational states (Markman and Dietrich, 2000, p. 144).

Regardless of whether you think that representations are exclusively neural entities or action based entities, they are mediating states for an agent, providing they meet the three criteria above. Rowlands also lists five criteria which he tries to demonstrate that representations in action can meet in order for them to count as representational states. In what follows I will outline the criteria and explain how Rowlands' representation in action might be thought to meet these criteria. Note that the five criteria he lists are applicable to neural representational states too. They are reasonably well accepted standards which a state must meet in order to count as representational.

4.1.4 Representation in action involves the action carrying information about something other than itself

Informational approaches to representation claim that what makes X a representation of Y, something in the world, is the fact that it carries information about Y. Some argue that the simple fact that there is a causal relation between X and Y is not enough to warrant the claim that X carries information about Y. The example Rowlands uses to illustrate this point is smoke and fire. We cannot say that smoke (X) carries information about fire (Y) on the basis that there is a causal relation between fire and smoke. The reason that the causal relationship between X and Y is not enough to claim that X carries information about Y is the fact that X might obtain in the absence of Y. That is, there may be smoke but no fire. So, yes there is a causal relationship between smoke (X) and fire (Y) but the thought is that smoke can also arise in the presence of other states of affairs and thus is not a reliable signal for fire. Smoke does not reliably carry information about the presence of a fire. This leads some informational approaches to representation to make this stipulation: That X is a representation of Y (X carries information about Y) if and only if it is a law that if X then Y obtains.

Theorists differ as to whether the laws in question need to be exceptionless. For example, Dretske asserts that the probability of Y given X must be 1. So what makes X a representation of Y is the necessary connection between X and Y, in other words, where there is smoke there is always fire. But Rowlands points out that we need not adopt Dretske's strict approach when putting representation in terms of information. Lloyd (1989) argues that there need not be a necessary connection between X and Y for X to count as representational of Y. Instead, it needs only to be more likely that Y obtains, given X but this probability does not need to be (Rowlands, 2006, p.115-116).

4.1.5 Representation in action is teleological

This is the claim that an action counts as representational only if it has the function of representing the state of affairs that produces it, or if it facilitates the achievement of a goal by tracking that state of affairs. Let us look here at Millikan's notion of function:

:

> An item X has proper function F only if (i) X is a reproduction of some prior item that, because of the possession of certain reproduced properties, actually performed F in the past, and X exists because of this performance; or (ii) X is the product of a device that had the performance of F as a proper function and normally performs F by way of producing an item like X (Millikan, 1993, p.123 as cited in Rowlands, 2006, p.127).

For example, an action such as the growl of a dog has the function of representing a state of affairs (i.e. the presence of a potential threat) only if in the past the dog's growl has represented the presence of a potential threat and the growl behaviour exists to indicate this threat. Or, the dog's growl is the product of a behavioural sequence which includes the growl to indicate the presence of a threat. For Millikan, what a representation

should do is determined by evolution, a representation represents because it has been selected to do so. That is, the functions of representations are determined by the environment and evolution, which for the dog has included the process of domestication possibly spanning three hundred thousand years.

Central to Millikan's account is the idea that there are representation'consumers' and 'producers'. The producers are the agents or mechanisms which produce the representation and the consumers are those which use it. For Millikan, what determines the function of a representation is how it is used by consumers, those who perceive and use the representational behaviour. There are two levels at which a representation may be consumed. For example, personal-level consumers are the beavers who jump into the water at the sound of another beaver's tail splash. However, there are stages of cognitive and motor processing that must be passed through before the end result is achieved, before the beaver succeeds in jumping into the water. For example, the sound of the tail splash must be registered by the beaver's ear and the signals passed onto different parts of the beaver's brain and motor systems. The beaver's auditory mechanisms and motor processes are consumers at the sub- personal-level.

As another example, let's look at Dretske's example of a sort of marine bacterium that contains magnetosomes. The magnetosomes ensure that the bacteria move toward magnetic north in northern hemisphere bacteria. In the southern hemisphere, the bacteria move toward magnetic south. In doing so, the bacteria are moving away from oxygen-rich sea water. The oxygen free water is what the bacteria benefit from, but the stimulus that provokes the movement away from oxygenated water is the geomagnetic pole.

Whether we focus on the benefit to the organism or the stimulus that produces the movement determines what type of account of representation we give. For Millikan, what the magnetosomes represent is the direction of oxygen free water, for that is what the consumers need in this system (Millikan, 1989). However, an alternative way of looking at what the magnetosomes represent is provided by Dretske. He argues that what the magnetosomes represent is the direction of magnetic north (in the northern hemisphere bacteria), for this is the stimulus that produces the movement (Dretske, 1988).

On the face of it, these look like opposing accounts but they can be seen as compatible. And this compatibility lies in the notion that to attribute fully fledged representational systems to an organism, the organism needs both to be a consumer at the personal-level and, in the case of animals, to have components such as perceptual apparatus and automatic behavioural responses to stimuli that are consumers at the sub-personal level. Consumers at the sub-personal level respond to representations of stimuli, whereas consumers at the personal level respond to representations of states of affairs beneficial to the organism. The beaver's jumping into the water relies on his auditory systems and motor systems responding to another beaver's tail splash. His auditory and motor systems are consumers of a representation. These consumers are sub-personal and track the stimulus (the actual sound and sight of the tail splash). On the other hand, the beaver jumping into the water at the sound of a tail splash is also indicative of the beaver, at the personal level, being a consumer of the representation (the tail splash) - the beaver takes the tail splash to mean “danger”.

The distinction between the sub-personal and personal levels of responses to representation is useful because animals have sets of motor programs that respond to stimuli reflexively. For example, the horse’s perceptual mechanisms will perceive a threat provoking the flight response from the horse as a reflex motion. The motor response can occur concurrently or even before the personal level response from the horse, much in the same way that our arm muscles pull our hand away from a hot object almost before we are conscious of the object being hot and potentially dangerous. Conversely, there will also be times when the sub- personal level of responding is driven by a response at the personal level. For example, a great need for water will have me reaching for my cup on the sub-personal level. It is important to note that while sub-personal behaviour may sometimes be the case, it is not always so and can be non-reflexive behaviour such as reaching for a glass of water, moving around one’s environment, navigating obstacles on the way to work and so on. The key distinction between sub-personal and personal level processes lies in the location of the explanation of the behaviour. Personal level processes are located within a larger realm of rational activity, whereas sub-personal processes are explained typically with reference to the working of the body for example.

4.1.6 The representational action can misrepresent X

It is a standard feature of what might be called *intentional* representation that it can be mistaken. I can have “goat” thoughts in response to sheep seen at a distance under bad lighting conditions, for example. Or a beaver’s tail-splash might communicate ‘Danger’ to another beaver on an occasion on which there is no danger. Compare this to what is sometimes called ‘natural meaning’: if those spots mean measles, then the person with the spots must *have* measles - if you discover that they haven’t, then you stop thinking that the spots mean measles (Grice, 1957).

4.1.7 Representations may be decoupled from the environmental stimulus

Clark and Toribio (1994) talk about certain states of affairs that are what they call representation-hungry. An example of a representation- hungry state of affairs is a dog’s pursuit of a prey animal. There are times when the creature of prey moves out of sight, smell and/or hearing to the dog. During these times, the dog must continue to conceive of his prey even as it is absent. In this case, something must ‘stand in’ for the object of prey and be decoupleable, capable of standing in for the prey even when it is not perceptually present to the dog. In humans, much of our offline thought appears to involve decoupleable representations, from planning next weekend’s activities to wondering what to make for dinner and it is no surprise that philosophers and cognitive scientists have often thought that any representations worth having are decoupleable.

The decoupleability criterion is also present in John Haugeland's (1995) claim that representations should (i) facilitate the coordination of the agent's behaviour even at times when relevant environmental information is not available to him or her and (ii) do this in virtue of their being able to represent in the absence of the represented. That is, a representation must be able to stand in for an item when the item is not present to the agent. Haugeland expressed his position in this way:

> An organism is using a representation if it can (i) co-ordinate its behaviours with environmental features which are not always reliably present to the system via some signal; (ii) cope with such cases by having something else (other than the signal directly received from the environment) stand in and guide behaviour in its stead; and (iii) the 'something else' is part of a general representational scheme which allows the standing in to occur systematically and allows for a variety of related representational states (Clark and Toribio, 1994, p.404).

Clearly, there will be times when representations are neither necessary nor used. For example, at times when the environment serves as a model and affordances are present to the animal agent she does not rely on representations in order to deal successfully with the situation. However, when the significant environmental feature is absent, then representation of those absent features would facilitate successful interaction with the environment.

The decoupleability criterion rules out cases where the environmental signal alone controls an animal's behaviour, for example if an action is directly controlled by the environment and is not elicited in the absence of a stimulus then it is not likely to be representational. Haugeland’s second stipulation (ii) says that a representation can simply be anything that stands in for the environmental state of affairs. But, then he (iii) limits representations to only those entities which stand in for objects, states of affairs or other agents as part of a system of other things which also play the same role; so gastric juices cannot be representations of future food because gastric juices are not part of an overall system of representing entities.

Rowlands remarks that this feature of representation, decoupleability, is most pressing in offline situations such as the planning of an action that is distal. Planning a trip to Australia in six months’ time, to use Rowlands’ example, will require the use of decoupled representations. In addition, decoupled representations could also come into play during online cognitive processing, such as when the dog is hunting prey yet relevant environmental stimuli are perceptually absent to him.

Decoupleability for Clark and Grush is necessary for what they call ‘full blooded representations’. On this topic, they note ‘our suggestion is that a creature uses full-blooded internal representations if and only if it is possible to identify within the system specific states and/or processes whose functional role is to act as *de-coupleable* surrogates for specifiable (usually extra-neural) states of affairs' (Clark and Grush, 1999, p. 8, their emphasis).

4.1.8 The combinatorial constraint: Representation in action must occur as part of a general system of representation

Behaviour can be thought of as composed of simpler units of behaviour that combine to form a more complex bodily movement. For example, a dog's search behaviours are comprised of a particular set of postures, with olfaction as the main search tool. Rowlands even claims that certain actions such as the scan paths of people's eyes when observing a picture can be broken down into smaller units of behaviour. On this point he writes:

> Crucially, it is not simply that the scan path carries information about the shape of an object, and has the function of tracking objects of this shape, but also that the scan path is decomposable into aspects or vectors, and these carry information about aspects of the shape of theobject, and, indeed, have the function of tracking aspects of this sort' (Rowlands, 2006, p. 222).

If an action is representational, then the representational nature of it can be viewed upon two levels: the level of the whole behavioural sequence, and the level of the units of behaviour which make up the overarching behaviour. For example when you catch a ball, the individual movements of your hands and arms in their reach toward the ball can be seen as representational of the ball's trajectory. In addition the whole smooth action of your reach and catch of the ball is also representational in virtue of their meeting the same criteria. In this way, Rowlands argues, representational actions meet the combinatorial constraint: the smooth movement of catching a ball can be broken down into component parts (say, the movements of your arms and hands, and possibly legs and feet). These component movements carry information about the ball's trajectory and in combination comprise a representational action.

A slightly different way of looking at this stipulation is that a representation must exist *as part of a system* that can be broken down into units. In other words, a representational system is homuncular, which means that 'it can be compartmentalized into a set of hierarchically organized, communicating subsystems, each of which performs a well- defined subtask that contributes toward the collective achievement of an adaptive solution' (Wheeler, 2005, p. 218). For instance, in the dog's search behaviour, a sub-system of the overarching system could be the lowering of the head to the ground, which involves engaging the nose at ground level. Another subsystem of the search behaviour could be the quick multi-directional movements which occur when tracking a scent.

Each of the sub-systems of the overarching behaviour retrieves environmental information which is passed from one subsystem to another and together they generate the complete search behaviour. On this, Wheeler writes: ‘such an arrangement surely warrants a description according to which the homuncular subsystems use the information- bearing elements to *stand-in for* worldly states of affairs in their communicative dealings’ (Ibid, p. 219). Another way of thinking of the homuncular subsystems Wheeler describes is to remember Millikan’s personal and sub-personal level consumers. The idea here is that there is a sub-system, or sub-personal consumer, which can use representations to contribute to an overarching behaviour. In the dog, a sub-personal consumer would be his nose and the structures contained within it. The dog’s olfactory apparatus, plus his other perceptual systems at work all contribute toward making the dog carry out search behaviour.

4.1.9 Summary

In summary, there are five generally accepted criteria that an action or bodily state should meet if it is to count as representational. Actions themselves may be representational if they meet the five criteria above; moreover, Millikan argues that bodily states (in the form of sub-personal consumers) can use representational states from the environment to contribute to an overarching system of action.

4.2 Rowlands' representational actions

Next, let us turn to Rowlands' theory of representation in action. This theory is an account of how actions can be representational. I will explain it here and show in the next chapter how it can be productively applied to the study of dogs.

Certain types of actions are representational according to Rowlands. He states that 'certain sorts of deeds form part of the activity - the *deed* - of representing the world [...] Deeds can represent the world to no lesser (and no greater) extent than internal representations traditionally construed [...] Certain ways of acting can *literally* be representational' (Rowlands, 2006, p.12-13). This is not too controversial a claim on the face of it. As Goldin-Meadow made clear, many gestures we make during speech are representational, such as the nod or shake of a head, and by representing what they do, they contribute to the meaning of what the speaker is saying (Goldin-Meadow, 2003).

Rowlands explains that bodily movements and structures can carry representations. Rowlands goes a step further than Millikan who argues that bodily structures can be the sub-personal level consumers of representations. That is, a bodily movement on Rowlands' theory could be representational of something within the environment of relevance to the agent. For example, when I was asked last week how tall my miniature pony is, rather than give a measurement figure in centimetres, I automatically indicated with my hand and arm her height from the ground. In this example I use an action to quickly and effectively represent an aspect of the environment; namely the height of a mini pony. We do this naturally and frequently: measurements of, say, five centimetres can be visualised using thumb and forefinger; giving directions to someone on the street is naturally done using hand and arm gestures and so on. The frequency with which we use actions to represent is such that to consciously not perform them in a direction giving, or mini pony describing, situations feels terribly unnatural.

Rowlands makes several key claims which are outlined and explained below.

1) 'The world is an external store of information relevant to cognitive processes such as perceiving, remembering, reasoning and so on' (Rowlands, 2006, p.33).

This claim is hard to deny. That there are aspects of the environment that bear information relevant to an agent's cognition is obvious. As Rowlands points out, information in the environment can be natural (such as the presence of dark rainclouds signalling imminent rain) or non- natural, like writing on a computer screen. In addition to the environment offering the agent information relevant to her adaptive fitness:

2) 'Cognitive processes are (often) hybrid - they straddle both internal and external forms of information processes' (Rowlands, 2006, p. 34).

Again, this claim must also be right if we agree with embodied cognition. This information processing can occur internally to the agent and externally. Recall, the earlier example of a children's game whereby a box has different shaped holes in the top and there are corresponding blocks for each hole. In figuring out which block will fit through which hole, my young son rotates the blocks manually and attempts to put them in the hole. After several attempts at the different holes, he succeeds and moves on to the next block. Rather than work out a solution to the puzzle internally, the child manipulates his environment, specifically the block, to come to the solution. In this example, the child's cognitive processing is happening externally. And we continue to do this into adulthood: generally people figure out the best arrangement for furniture not by sitting down and thinking about it but by heaving it around the living room until a satisfactory arrangement is found. Also, my husband's disregard for reading and internalising the instruction manual for putting together our son's cot in favour of assembling the pieces and trying to fit them together by trial and error can (charitably) be seen not as a male quirk but as him finding a solution to the task at hand via external cognitive processes rather than internal ones. Therefore, cognitive processes are not limited to being internal brain processes; they can also be external, or action-based. These examples also demonstrate the following statement that Rowlands makes:

3) 'The external processes involve the manipulation, exploitation and transformation of environmental structures that carry information relevant to the accomplishing of the cognitive task at hand' (ibid, p.34).

That is, information in the organism's environment is available to the organism for use within its online cognitive processes when it is performing a certain task. As I mentioned, Rowlands' conception of representation is based on the three principles above, principles which are already familiar from the earlier discussion of embodied cognition.

Much hinges on the third point for Rowland, the thought that environmental structures carry relevant information, or affordances, about the task at hand, coupled with the thought that representation can be thought of in terms of action, rather than internal mental states. On this point he writes:

> Representation is not *essentially* a relation between inner representing item and outer represented item. Representation exists out in the world as much as in the head - or, to put the same point another way, there is no principled way of separating action from representation (Rowlands, 2006, p. 49).

We ought to think about representation as being located not just inside the agent's head but also in the agent's body and behaviour, representations in embodied cognition are not just internal causes of behaviour, they can also be seen in the agent's behaviour. 'Representation is not simply what guides behavior. Rather, it extends into behavior. Representing is representational *all the way out* '(Rowlands, 2006, p. 49). In short, Rowlands argues that we ought to recognise the tie between representation and action to the extent that there are what he calls 'deeds': actions which are representational. For example, take a batsman in cricket. The eyes of the batsman and the other movements he makes all carry information about the path that the ball is taking and will take. The scan path of a person's eyes as he or she is trying to determine the shape of an object in the foreground is:

> … related to the shape in such a way that it carries information about that shape. Specifically, to establish whether a shape of a given type is present, one must perform head movements of a certain type... The presence of such movements in the determining phase of the process [where the person establishes the shape of the object], therefore, raises the probability that a shape of a given type is present in the foreground of the visual scene. Therefore, given the first concept of information [that X carries information about another item, Y, when the occurrence of X increases the probability of the occurrence of Y], the

movements carry information about that shape (Rowlands, 2006, p.213).

The thought that the batsman's actions carry information about the trajectory of the ball forms part of Rowlands' claim that the batsman's actions are representational. The types of actions that are representational, Rowlands calls *deeds*. He argues that deeds (representational actions) can meet each of the five criteria explained in this chapter's opening section.

4.2.1 Pre-intentional actions

To illustrate his notion of representation in action, Rowlands distinguishes between intentional actions, sub-intentional actions and pre- intentional actions. Sub-intentional actions are non-intentional movements such as moving the mouth while reading silently to oneself. Pre-intentional actions are the deeds which Rowlands claims are representational. For example, raising your hand to catch a ball, reaching out to grasp a cup of tea or throwing a ball of paper into the rubbish bin are all examples of a pre-intentional act or deed. They include 'an array of on-line, feedback-modulated adjustments that take place below the level of intention, but collectively promote the satisfaction of [an] antecedent intention' (Rowlands, 2006, p. 103).

In some detail, Rowlands gives the following example of representation in action, where the deeds are the saccadic eye movements recorded in Yarbus' (1967) experiment. Yarbus presented participants with a painting of six people, five women in a room and a male visitor. They are each asked to look at the picture with their set task in mind, which is one of the following:

1) View the picture at will
2) Estimate the family's wealth
3) Judge the age of the people in the painting
4) Guess what the people had been doing prior to the arrival of the visitor
5) Remember the clothing worn
6) Remember the positions of the objects in the room
7) Estimate how long it had been since the visitor was last seen by the people in the painting.

Yarbus demonstrated in his experiment that the eye movements of each participant varied according to which task they were assigned. But rather than the eye movements being intentional, Rowlands argues that the participants' saccades are pre-intentional - we don't consciously move our eyes in patterns such as the above when observing the painting and these deeds are representational. The movements of the eyes track what the participants have been instructed to examine.

Like saccadic eye movements, deeds, argues Rowlands, are pre- intentional. They are not conscious movements of the body; they are unintentional actions in direct response to an external stimulus and this makes them representational. For example, the position of the cricket fielder's hand is a direct and pre-intentional response to the path that the ball is taking through the air. In theory it should be possible to judge from the position of the fielder's hand the trajectory of the ball: the fielder's movements are generally representational of the ball's flight path, the fielder's subtle bodily movements track the path of the ball.

Of course, this is not necessarily the case: the fielder may miss the ball by a fraction and fail to catch it; his hands may misrepresent the flight path of the ball, thus deeds meet another criterion for being representational, they can sometimes misrepresent.

In summary, Rowlands has made a remarkable contribution to the way we approach representation. Rather than relying upon internal representations alone, our actions can be representational. The beauty of Rowlands' work is that representing is not just a feature of certain internal mental states; representations can be distributed beyond the neural body and into our behaviour. For Rowlands, certain actions (deeds) are representational, but the representational nature of these actions stems not from any prior representational states, but is inherent within them. Deeds, he argues, are not representational in virtue of other, logically prior representational states such as a belief. For example, the actions of hitting certain keys on the piano keyboard are related to a prior representational state, a belief that this key correlates with a particular note. The intention is then formed and that particular key on the piano is hit. However, catching a ball is ‘typically a matter of online adjustments made through the process of trial and error acts independently of intention formation ... Deeds formed independently of intentional states ... provide far and away the best examples of our representational activities’ (Rowlands, 2006, p.111).

Rowlands claims that the saccadic eye movements in the painting experiment discussed above meet the criteria for representationhood:

1) They carry specific information about people in the painting,
2) They track a feature in the painting, for example the type of clothing that each person in the painting is wearing.
3) The saccadic eye movements can misrepresent. For example, it is possible that saccadic eye movements may not track the feature in the painting the person claims to have attended to.
4) The eye movements can be combined into a more general representational structure, for example a participant can continue to scan a painting systematically
5) The saccadic eye movements are decoupleable from the painting (the participants could in theory remember the painting and their eyes could scan the imagined painting following the same scan paths).

Rowlands’ view is particularly appealing to a theorist of animal cognition wishing to explain animal cognition in terms of representation since it defends the thought that representational states can exist within behaviour. Perhaps dogs also possess representational internal states, possibly modal cognitive states, which arise from canine neural structures. My point here in discussing Rowlands' view is that we shouldn't stop at the brain in our investigation into animals' use of representation; rather representation can, if Rowlands' theory is right, be inherent within dogs' actions too and these types of representations are the sort that are useful to dogs in a variety of situations. I will return to this point in the next chapter.

Moreover, the notion that representation might exist in action, means that we are no longer faced with the controversial (especially with regards to non-human animals) claim that representations must be bound up with other prior intentional states such as beliefs.

Furthermore, deeds are mediating states. Recall that there were four criteria by which an agent could be judged as using a mediating state. These are: 1) the agent has internal states (including goal states) which undergo changes; 2) The agent has internal states that are affected by the environment; 3) Information must be able to pass back and forth between the agent or system's environment and the internal states; and 4), the agent 'must have internal processes that act on or are influenced by the internal states and their changes, among other things' (Markman and Dietrich, 2000, p.144). The batsman's swinging the bat in order to hit the cricket ball would satisfy criterion 1) since the deed (the internal state) undergoes a series of adjustments in accordance with the trajectory of the ball. It also satisfies criterion 2) in that the agent's action (deed) is affected by the environment, namely by the ball's flight path. According to Rowland, information does pass back and forth between the deed and the environment. The ball's path affects the way in which the batsman swings the bat and in doing so, the trajectory of the bat represents the path of the ball. Thus criterion 3) is satisfied. That the deed also meets criterion 4) is not out of the question. For the representational deed, the swinging of the cricket bat would most likely affect and be affected by other states within the agent. For example, the batsman's previous experience as a batter and his established motor programs would also affect the swing of the bat and conversely, the action of swinging the bat could well affect the batsman's subsequent cognitive processes. On the face of it, then, Rowlands' deeds meet Markman and Dietrich's criteria for being representational, or mediating, states.

4.2.2 Objection: Non-trivial causal spread

Theories of embodied representation, such as the two I explain in this chapter, have the potential to show how representational actions are possible, but they are not without their problems. Non-trivial causal spread is a term coined by Wheeler and Clark (1999) to explain an objection to representationalism. Broadly the objection states that if intelligent, flexible behaviour can be explained in part by environmental and non-neural structures and states of affairs then there is no good reason to claim that neural representation use by the agent was the main driver for the behaviour. Thus, the non-trivial causal spread objection is a problem for embodied cognition theorists because while embodied cognition emphasises non-neural bodily aspects it may still be vulnerable to the non- trivial causal spread objection due to the significant role that environmental factors occupy in the production of intelligent, flexible behaviour. Wheeler writes:

> If our best cognitive science picks out factors in the non-neural body as sites of interest then what is to prevent us from treating those factors as codings for intelligent actions with the brain and the environment relegated to the status of a normal ecological backdrop against which that representational function is performed? Similarly if our best cognitive science picks out factors in the environment then what is to prevent us from treating those factors as codings for intelligent actions with the brain and the non-neural body suitably relegated? (Wheeler, 2001, p. 219).

However, Wheeler argues, the non-trivial causal spread argument only obtains if we accept strong instructionism. Strong instructionism is the theory that if a representation drives a behaviour then it is the only driver for the flexible aspects of the action (Wheeler, 2001). Moreover, Andy Clark replies to the non-trivial causal spread argument by highlighting two myths: 1) the myth of the self-contained code. This is the belief that to for something to cause a behaviour the causal factor must act as the whole cause of the behaviour. This however, is not how people (or programs) work. All cognitive processing occurs within a setting – or as Clark calls it – an 'ecological backdrop'. 2) the myth of explanatory symmetry. This is the mistaken belief that we cannot say that one causal factor guides behaviour as the actual workload behind causing the behaviour is shared by multiple factors. As Clark writes, 'Causal equality at one level (the level of work done) may thus co-exist with genuine asymmetry at another level (the level of greatest relevant plasticity)' (Clark, 1998, p. 95-9). In summary, non-trivial causal spread is not a problem for theories of embodied cognition because it does not matter whether behaviour is caused by an array of factors; embodied representations still have a useful part to play in their explanation.

4.2.3 Does Rowlands' theory meet the decoupleability criterion?

Shaun Gallagher argues that it is questionable whether the kinds of pre-intentional actions that we are regarding as representational when they are interacting with environmental events are actions are still representations if they are decoupled:

> Once we do decouple a pre-intentional act [a representational action] from X (the cricket ball, the piano keys, the painting), I suggest that we are no longer talking about action in the same

> sense. Indeed, it is difficult to see how [representational] pre-intentional acts can be decoupled from X (the ball, the piano keys, the painting) or the context without becoming something entirely different from an element of the action at stake or an AOR [action orientated representation] (Gallagher, 2008, p. 356).

Gallagher goes on to write:

> 'Off-line cognition, imagining, remembering, or even re-enacting an action decoupled from its original context and absent X may (or may not) require representation - but this says nothing at all about representation in action' (Gallagher, 2008, p. 357).

Rowlands (2012) replies to this objection with reference to the difference between perceiving something and imagining something. Both are representational, yet differently so. This is because perceptual representation where there is nothing to represent (the absence of X) is no longer perception. It has now become imagination. This is similar, Rowlands thinks, to the argument Gallagher makes about deeds which are representational in the absence of X: they become something entirely different from an action oriented representation.

However, Rowlands argues,

> If we want decoupleability to be a general constraint on representation, and thus a feature of all representations, then all we can reasonably expect from it is a way of typing tokens of

> mental representations independently of their immediate environment […] The immediate environment provides neither a physical nor logical constraint on the occurrence of the relevant representation. It is in this sense that the decoupleability constraint, if understood as a general feature of all representations, collapses into the misrepresentation constraint. But on this way of understanding decoupleability, deeds are indeed decoupleable from their environment (Rowlands, 2012, p. 142).

The main point that Rowlands is making here is that as long as the representational action can misrepresent, it is decouplable from the environment. Thus the decoupleability criterion can be met when the misrepresentation criterion is met. There is also an important distinction to note in Rowlands' theory of representational actions. That is deeds are *representational actions,* rather than *representations*. A *representational action* of a ball in flight could occur in the absence of a ball in flight as in the case of actions which are misrepresenting, or re-enacting. This is contrasted with an action representing, where 'representing' is used as a success term. Note, for example, the difference between saying 1) 'my arm movements are representational of the position of the cup I am about to grasp' and 2) 'my arm movements represent the position of the cup I am about to grasp'. The first phrase speaks of the arm movements as representational actions – representational of the cup's location. The representational actions of my arm may be misrepresenting (I could be wrong about where the cup is and knock it over instead). The second phrase implies that my arm's movements successfully represent the cup (there is no room here for decoupleability or misrepresentation since the phrase is a statement of fact). The first phrase is an example of the way we should read Rowlands' use of 'representation'. On this way of understanding representational actions, Rowlands' deeds do meet the decoupleability criterion.

Moreover, Rowlands remarks that Haugeland's claim (ii) that representations should be able to stand-in for what they represent in the absence of that item, can be read in different ways. One way does, as Gallagher remarks above, preclude actions from being representational. On this reading, it is implicit that what guides behaviour in the absence of the relevant environmental stimulus is not, and cannot be, a form of behaviour.

But this is an assumption that cannot be made, especially given the strong arguments behind the embodied cognition thesis that internal mental states are not the sole guiding forces for behaviour. There is no reason, Rowlands remarks, that a form of behaviour should not guide another form of behaviour when the guiding behaviour and resultant behaviour belongs to the same individual. He asks his reader to consider the role played by rhyme in triggering memories. For example, we may not be able to recall where in the alphabet a letter lies until we have gone through the alphabet rhyme for that portion in our

heads. So we ought not to read Haugeland's second claim as precluding the individual's own behaviour being the sort of thing that can stand in for an absent environmental stimulus.
Rowlands argues that the way we should interpret Haugeland's three criteria is as saying that:

> … (a) the representing vehicle cannot be essentially causally dependent upon what it represents in the sense that the vehicle cannot, as a matter of physical necessity, occur in the absence of what it represents, or (b) what is represented cannot be causally dependent upon the vehicle that represents it in the sense that it cannot, as a matter of physical necessity, occur in the absence of that vehicle (Rowlands, 2006, p. 164).

Therefore, representations are decoupleable if the representations and their represented are not physically causally dependent. This is attributing a much broader meaning to 'decoupleable' than one first might assume when encountering the decoupleability criterion. What Rowlands is saying is that a deed is decoupleable if it is possible that the action might be performed in the absence of the stimulus. An analogy might be that on a short piece of string, one end cannot be said to represent the motion of the other end of the string because the two are physically causally connected. The two ends are influencing each other and neither is representing the other end's trajectory or movement. By Rowlands' wider interpretation of what it means for a vehicle of representation to be decoupled from what it represents, deeds are decoupleable.

There is another way of viewing decoupleability which I will come to in the section below as I explain Clark and Grush's account of minimal representations. As we will see next, Clark and Grush (1999) argue for fully fledged representations which are 'fully' decoupleable and 'minimal representations' which are only partially decoupleable. Minimal representations cannot fully stand in for absent state of affairs, like an abstract mental representation would; instead they are forward emulators of actions about to occur.

In summary, representations can be embodied; found within an agent's body (both neural and non-neural) and her actions. If we accept that an agent's cognitive processes are distributed, then representations are also distributed and not confined to an agent's inner neural structures. These types of representation are still recognisable as representations providing they meet the conditions for being a mediating state and the five general criteria for representationhood set out in the beginning of the chapter. Claiming that non-human animals have embodied representations does not rule out the possibility that they are also capable of possessing neural representations such as modal perceptual representations.[11]

[11] To say that a representation is modal means the representation resides in the same systems as the perceptual states that produced them. In contrast, amodal representations are removed from the perceptual systems. Information from perceptual systems is converted into amodal symbols

For example, perhaps it is the case that some of a dog's cognitive processing relies upon categorising aspects of his environment in accordance with how closely an item matches a stored prototype of a category (as in Prototype Theory). My point here is that representations might exist in other, non-neural forms. Rowlands' theory of representation in action has shown us one way in which this might be the case. Let us now turn to another account of embodied representation which I will argue can be integrated with Rowlands's account of embodied representation.

4.3 The emulation theory of representation

Another theory of embodied representation is the emulation theory, developed by Andy Clark and Rick Grush. Clark and Grush argue for what they call 'minimal robust representations' (1999, p. 7). Their thesis is that there are emulation circuits that help an agent with short-term planning. In addition, emulation circuits may also support mental imagery and form the basis for offline cognition. In human beings, emulator circuits run offline 'if, then' scenarios about bodily actions and their effects on other parts of the agent's body and her environment. Emulation circuits facilitate the prediction of what state of affairs the current actions of the agent are likely to lead to. They are useful because they run their predictions quickly enough for an agent to adjust her movements to maximise the likely

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which are then part of an overarching system of cognition which supports higher functioning (Barsalou, 1999).

success of an action. In their words, an emulator mechanism provides:

> … a quicker kind of feedback for use by the control system. An emulator is just a mechanism (circuitry, software, whatever) that takes as *input* information about the starting (or current) state of a system (e.g., biomass, temperature, etc.) and about the control commands that are being issued (e.g., increase heat by 2 degrees). The emulator then gives as *output* a prediction of the next state of the system. This prediction takes the form of a set of values for the future feedback that the new state of the system should yield. The emulator thus *models* the target system and generates a kind of mock feedback that can be used instead of laggardly feedback from the real system (Clark and Grush, 1999, p.6).

The hypothesis is that emulator mechanisms are at work whenever a person is about to, for example, reach for a cup, catch a ball or jump over a puddle. In support of this hypothesis, it has been shown that damage to the neural emulation systems results in slow, shaky movements that are very likely based on real world feedback as opposed to the hypothetical type of feedback that emulator circuits give to facilitate smooth, effective actions. The conclusion is that the person with neural damage to emulation circuits is unable to simulate an action such as reaching and has to fall back on trial and error learning, using real actions in order to successfully reach out and grasp the cup. The crucial point is that emulator circuits work by emulating, or representing, certain possible states of the agent's body and her environment given the action the agent is about to perform. Clark and Grush remark that emulator circuits provide a 'system of inner states and processes whose adaptive functional role is to stand in for specific extra-neural (bodily) states of affairs' (1999, p.7). Going back to the five general criteria for representationhood[12] emulating systems meet the first criterion set out above, that is, they can carry information about things other than themselves.

Furthermore, Clark and Grush write that emulator circuits break down into component parts. Each component has the job of representing specific states each of which correspond to the components of the possible (future) states of extraneural affairs. In light of this, representations are compositional; they break down into small units. Thus emulation circuits could exist as part of a representational framework, thereby meeting the fifth criterion.

The representations produced by the components of the emulator systems give an account of representations that do not hinder real time cognitive processing and action. Instead these

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[12] 1) The representation can carry information about something other than itself.

2) The representation is teleological – it is directed at a particular goal.

3) The representation can misrepresent X.

4) The representation may be decoupled from the environmental stimulus.

5) The representation can be combined into a more general representational framework

types of representations enhance online cognitive processing, thereby side stepping Brooks' worry that representations (if the agent does indeed use them) would be prone to getting jammed in representational bottlenecks, caused by the time consuming process of converting sensory stimuli into amodal representations and producing subsequent responses.

An emulation system emulates actions before they are performed. This enhances the likelihood that the agent's actions will be successful and it also reduces the need for the agent to have to learn how to perform

certain actions successfully by trial and error. Important to notice is that Clark and Grush think of representations within the emulation system as *minimal* representations. Fully-fledged mental representations may, Clark and Grush suggest, be built upon these minimal 'emulator' representations. But in some agents, minimal representations may be all there is. What distinguishes miminal representations from fully fledged representations is the degree to which they can be decoupled from the environmental stimulus:

> … motor emulation, according to Grush, marks the basic point at which nature, still firmly fixated upon the support of real-time, real-world
>
> action began to use the trick of representing what was not readily at hand. This trick, Grush suggests, marks a real

> boundary between cognitive agency and other forms of adaptive success (Clark, 2008, p.152).

Clark and Grush describe situations that involve a neural emulator. One such situation is when a person reaches for a glass of water. Before the actual movement takes place Clark and Grush hypothesise that a neural emulator circuit runs, which provides hypothetical feedback regarding the success or failure of particular arm and hand movements in relation to the task. The neural emulator is, Clark and Grush write, ‘working just one step ahead of the real-world feedback’ (Clark and Grush, 1999, p.10).

> The emulator represents objects and the environment as things engaged with in certain ways as opposed to how they are considered apart from their role in the organism’s environmental engagements. The perceived environment is the environment as made manifest through the organism’s engagements, because the emulator that supplies the perceptual interpretation is an emulator of the agent/environment interactions. The conceptual significance of this is that it allows us to acknowledge the action/behavioral bias of perception without becoming anti-representationalist about perception (Grush, 2004, p. 393).

It is worth noting again, however, that representations involved in the emulator system are not fully-fledged representations; they are what can be called minimal or weak representations, due the fact that they are not entirely decoupleable, as I will now explain.

4.3.1 Do minimal representations meet the decoupleability criterion?

As I mentioned above, Rowlands argues that motor actions such as catching a cricket ball are decoupleable because they can misrepresent, but for Clark and Grush, emulator circuits are representing context- dependent actions in the future: they are forward emulators. In this sense, emulator circuits are representational of the environment and an agent's actions with it.

Grush writes:

> On the emulation framework, emulators are constructed and maintained in order to be able to stand in for the body/environment. But they don't simply represent the world, but more specifically *they represent the world as interacted with by the organism*. Only those aspects of the body and environment that are manifest in the organism's engagements can be represented by the emulator, and only those that are salient for the organism need be (Grush 2003, p. 88).

Representational emulation states are *not* examples of full-blooded representation, precisely because they are not deployable in a fully offline manner, but rather are located "at the most minimal end of what is surely a rich continuum of possible stand-in invoking strategies" ' (Wheeler, 2005, p. 214- 215). This is what Clark and Grush mean when they talk about partial decoupleability. In one way the representational state of the emulator circuit is decoupleable because it is emulating future interactions with the environment, actions which have yet to happen. On the other hand, they are context-dependent and situation-specific.

Wheeler suggests that 'Clark and Grush's neurally realized emulator may well show that some action-oriented representations may be minimally decouplable' (Wheeler, 2005, p.215). In other words, 'minimally decoupleable' is a term that Wheeler adopts in his quote above to introduce the idea that representations fall along a continuum of decoupleability; some being less so than others. Rather than categorising, for example, saccadic eye movements as either decoupleable or not, it is better to suggest that some representational actions and states may be decoupleable, others definitely are, and some simply are not.

Emulation circuits may also misrepresent. If emulation circuits are at work whenever we reach for a cup or jump over a puddle, it is possible that they are capable of misrepresenting the outcomes of these actions since there are times when we fail to reach the cup or we end up getting wet because we have misjudged the jump over the puddle. Of course, there may be many other reasons why we are sometimes not successful in actions such as these, but it does not seem implausible to suggest that one of the many reasons could be that our emulation circuits are misrepresenting. Furthermore, emulation circuits are teleological. They have a definite goal: to represent the likely outcomes of our actions before we perform them for real. It seems as though emulation circuits meet the five general criteria above that are commonly agreed upon for something to count as a representation. In addition, the emulation system meets Markman and Dietrich's four necessary and sufficient conditions for being a mediating state. Firstly the representational state must undergo changes. When the emulation circuit is activated, there are changes and adjustments made in response to the situation. For example, the emulation circuit will emulate actions differently depending on the situation that the agent is in. This also means that the representational state is affected by the environment. Third, information passes back and forth between the agent's environment and the representational state in that the environment in which the emulation circuit simulates an action will affect how the action is emulated and how the action is emulated will ultimately determine how the action comes to be performed in that environment. Lastly, the agent's representational state must act on or be influenced by other states and their changes (Markman and Dietrich, 2000, p.144). This again seems true since past experience and practice with certain actions will likely affect the way they are emulated and how they are emulated will go on to influence other cognitive processes, the most obvious of which is the manner in which an action is executed.

There are three things that make the account that Clark and Grush give particularly attractive: most notable is the fact that the representors postulated by the emulation theory of representation are distributed across an agent's perceptual capacities and motor skills. In addition, this account of representation does not fall prey to the criticism that representations are unwieldy entities, likely to hinder cognitive processing in times where an agent's cognitive load is raised. Rather, as Clark and Grush (1999) note, the emulation circuit would speed up cognitive performance. Moreover, it is a theory of representation applicable to dogs, as shall be argued in the next chapter.

4.4 Summary

The emulation theory provides an account of minimal representations. Minimal representations are the first step in the evolution of representations that could be decoupled from the environment, yet they are still representations in their own right.

Minimal representations do not represent *that* the world is a particular way; rather, minimal representations represent affordances. They provide the agent with 'knowledge of *how* to negotiate the environment given a particular context of activity' (Wheeler, 2005, p. 198).

4.4.1 What's next?

Above are two theories from within the embodied cognition framework which attempt to explain how an agent might use representations which are not internal brain states. I have brought them together here to demonstrate a way forward for representation in embodied cognition. Although they are not designed to work together, the two theories of representation I have outlined above are compatible as two ways of representing using actions and emulation circuits. I have introduced them both in this chapter to show how we might conceive of representation in non-human animals like the domestic dog. This is the focus of the next chapter.

The main points to take from this chapter are: little is known about the precise neural structures of most non-human animals, so I do not want to rule out the possibility that some non-human animals may use traditional sorts of representation such Prototype Theory. I singled out the Prototype Theory because researchers have begun to investigate whether or not certain non-human animals classify the world in accordance with it, for example. There are reports of pigeons behaving in such a way, under experimental conditions, as to make such a conclusion not unreasonable. But still, the research that tries to discover whether non-human animals are using mental representations such as these are looking for structures that are inner, and originally postulated with humans in mind. Such an approach may be reasonable, but it would be good for research to be done in an embodied representation framework as well. As I wrote in the beginning of this chapter, we should not feel limited as to what we count as representational to neural structures only.

Action-oriented accounts of representation such as the ones that Rowlands and Clark and Grush formulate provide plausible forms of representation that are not purely neural entities. They are compatible theories in that neither precludes the other and they both provide an agent with affordances and environmental states of affairs without entailing an account of inner, mental representations of the sort often attributed to humans.

In fact it seems to me more likely that the sorts of representations that non-human animals use most often are the action-oriented and situation specific ones.

Thus, theories of embodied representation are a good starting point for attributing representations to dogs and other non-human animals. In the next section of this thesis, I focus on the domesticated dog and show how embracing embodied cognition and theories of embodied representation enhances our study of cognition in dogs.

Chapter Five: Embodied representation use in dogs

I argue in this chapter that adopting embodied cognition allows us to formulate a clear hypothesis about representational actions that dogs may use for interacting with the world. The two types of representational actions I will apply to dogs are those explained in the previous chapter: Rowlands' 'deeds' and the representational emulation circuits of Clark and Grush. Many researchers have attempted to study representation in non- human animals, but the notions of representation used are varied and sometimes unclear. Here, I demonstrate that we can find useful accounts of representation in animals by applying Rowlands' theory of representation in action and the emulation theory proposed by Clark and Grush.

Because, as we saw in Chapter One, the communication that dogs engage in revolves around actions, objects themselves play a lesser role in dogs' environments than they do in ours. What delineates most objects in the dog's world is the actions around them, or the affordances they offer the dog: they are food sources, prey, play items, shelter and so on. This is a factor to take into account if we are to construct an account of representation in domesticated dogs: that the vast majority of representations which dogs use will relate to actions, or affordances, rather than objects themselves. While the majority of dogs' representations are of actions related to certain objects rather than the objects themselves, Miklósi writes that ‘this [the lesser role that objects play] is not to say that the dog’s mind operates without utilising representations of objects, but these are very likely different from our own. In addition, perceptual information will differ dramatically’ (Miklósi, 2008, p.156).

5.1 Why investigate representations in dogs?

There are many methodological guidelines we can use to approach the study of domesticated dog cognition and the interpretation of the data that experiments provide. One model is Morgan’s (1894) doctrine of parsimony. Morgan suggested that behaviour is best explained with reference to mental processes that stand lower on the scale of evolution and development. This is the stance that is usually taken by behaviourists. Behaviourists claim that most forms of behaviour can be described and explained in terms of simple associations between an environmental stimulus and a certain response. On this view, the canine mind is a simple device that is adept at making associations between environmental events and behaviours. Such models of behaviour have been labelled ‘low-level’ (Povinelli 2000) and ‘cue-based’ (Call 2001). The wish to avoid positing representations in domesticated dogs is, I believe, based upon the thought that they are inner mental states. However with embodied representations, there is room for representations used to be both low-level and cue based without the need for attributions of inner mental states necessitated by theories of representation which come from traditional cognitive science.

Moreover, I will argue that the attribution of embodied representations can explain cognitive capacities such as short-term planning, forming expectations and making predictions about possible environmental events and the actions of others. For example, a representation can explain how an animal can adapt to a novel situation and successfully interact with his environment in the absence of previous experience with this type of situation.

As we saw in the opening chapter, dogs presented with a novel task in an experimental setting will often look longer at a human than a wolf will in the same setting. The wolf will apply problem solving tactics such as trial and error more than the dog, while the dog's gaze is more frequently upon the human. It has been widely suggested in the literature, and outlined in the opening chapter, that the dog is looking to the handler for cues to problem solving (Byrne, 2003; Topál et al., 1997; Topál et al., 2005). This behaviour can be explained by the dog's representation of the human as a source of information. If a human's actions are representational, as they are according to Rowlands, then the dog can use these actions as a useful information source. For example, if you watch a dog agility competition closely you will notice that the handler directs the dog around the obstacle course, which must be completed in a specific order and direction. The verbal cues that the handler gives the dog are often minimal; what plays the largest role is the position of his or her body in relation to the dog and the next obstacle.

The successful agility dog learns to use the handler's direction of movement, location and speed as representational of the path he is to follow. In the same way, the handler's movements represent the course the dog must take. In situations like these, Rowlands' theory of representational action can come to life and we can begin to see how the dog can use representational actions such as these to guide his successful behaviour in his world. The same thing occurs when the dog is rounding up sheep, the good sheepdog can use the movements of the sheep as a guide to which way they are heading and use this information to prevent their heading off in the wrong direction. The sheep's movements are representational actions which the dog has learned to use.

Another way in which embodied representations can explain and predict behaviour is through the use of the emulation theory of representation - the dog can navigate a novel and demanding terrain successfully by emulating the physical actions required and assessing them based on their likelihood of success. Actions such as making a series of jumps up a steep section of bush are demanding, yet a healthy, fit dog will generally be able to cope with this task possibly through the use of a representational emulation system, which can guide his behaviour moment to moment. Without the use of representations in our toolkit to explain non-human animal cognition, the dog's behaviour can be explained by little other than trial and error and associationist theories of cognition to rely upon which if the situation is genuinely novel cannot explain as easily the adaptive behaviour a dog is capable of.

In what follows I argue that embodied representations can enable a creature to plan, form expectations and make short term predictions about possible environmental events and the actions of others and demonstrate how this might be done. With embodied representations, we are not committed to the view that representations involve elusive intentional mental states within the dog's brain. Rather, representations can be action-based, context-specific and distributed across an agent's body.

5.2 Background to a model of representation in the domesticated dog

The domesticated dog, as a social animal, has developed the cognitive capacity to predict the behaviour of a prey animal based on his own actions. A quite different creature, one that has not evolved to hunt, may not have developed this skill since that skill has no adaptive value for it. Susan Hurley writes: 'animals can occupy islands of instrumental rationality' (Hurley, 2003, p. 252). Her point is that when we are considering the issue of non-human animal conceptual abilities we should consider that the cognitive skills of the dog are likely to have developed surrounding those actions which they have evolved to perform in order to survive.

Therefore, for reasons that I will come to, we ought to also consider that a representation for a dog might usually consist in a representation of affordances, actions associated with an object, rather than abstract categories. Dogs know which objects are items they can play with, chew on, manipulate to gain release from the back garden and so forth. It seems that the sort of knowledge that dogs have about objects involves almost explicitly the types of actions associated with an object. So it seems likely that if dogs use representations, they are action based. Recall the earlier quote from Garbarini et al: In place of abstract representations of formal logic expressed in propositional format, representation proves to be intrinsically linked to the sphere of action and is expressible in the same terms that control it. Therefore representation does not consist in a duplicate of reality, but in the virtual activation of perceptual and motor processes that, when actually executed, allow us to recognise objects and interact with them' (Garbarini et al., 2004, p. 106).

This quote neatly sums up the basis for embodied theories of representation in dogs. The types of representations dogs use will be ones which aid successful dealings with the dog's environment, and are related to the affordances he perceives in his environment. Furthermore, whether something counts as a concept, or representation, depends on its functional role within a system (Clark, 1997). A functional account of representation opens the door to pluralism about representation, for as long as an entity fulfils the functional role, it will count as a representation. Pluralism about mental representation is an attractive possibility; Chemero and Silberstein write that ‘animal behaviour and animal brains are very complex, and we can see no *a priori* reason that all aspects of them or any one aspect of them ought to be explained in *any* one way, whether or not explanations interlock or are complementary’ (2008, p.17). Thus, whilst allowing that there are some aspects of the brain that function on a modal level; perhaps there is other functioning that is amodal. In the domesticated dog’s brain there may not be as much integration as the human brain, but it is possible that there is some. This integrationmay underlie some kind of amodal cognitive processes; perhaps there is an amodal system of representation that coexists with cognition that consists of more modal, brain, body, environment interaction. The focus of this thesis is on the latter, but an amodal theory of mental representation should not be discarded simply because a modular account is also available.

In short, representations, I argue, arise from aspects of the dog’s environment. From the embodied cognition stance, representation, perception and the environment form a dynamic system. Moreover, the dog develops representations in virtue of the bodily actions that are associated with an object. Dogs’ representations will be vastly different to our own because of the differences in their bodies, perceptual apparatus and umwelts. Additionally, we should not assume that each dog’s umwelt is the same. There are great physical differences between dog breeds. Some are very short, some are tall, some have long snouts, and some have short snouts. Obviously, short dogs visually experience the world differently from taller dogs. Similarly, a scent hound's perception of the world will be even more scent orientated than a sight hound (Coren, 1995). So even within the dog species, there will be differences in perception of the environment and differences in the types of interactions an environment affords the dog. Therefore, there will be fundamental differences in what is represented between dogs in the same environment.

Furthermore, if representations are going to aid the dog to survive in his world, they must also be the sort of thing that he can use (Anderson, 2005). Therefore, an integral project of a model of embodied representation for non-human animals will be to account for how the bearer can effectively use features of his representation in his dealings with the world. In short, representations are a valuable tool for the study of non-human animal cognition, especially if we are talking about biological, action oriented, situation-dependent representations. I will argue in the following that these sorts of representations are best characterised as representational actions, or emulations of actions.

5.2.1 General Guidelines for a Theory of Representation

As mentioned above, the primary function of representations in non- human animals is not likely to be the classification of objects as having certain abstract properties. Some theorists do hold this conception of representation in non-human animals (Newen and Bartels, 2007, p. 295). But it is an echo of theories of representation developed predominantly for humans within traditional cognitive science. Contrary to representation being used primarily to categorise the world, it seems far more likely that, first and foremost, an animal represents actions, possibilities for action and likely consequences of actions. This capacity to represent actions, possibilities for actions and potential outcomes of action is more likely to render the non-human animal capable of interacting successfully with his world. That is, representations function mainly to facilitate adaptive and flexible responses to the environment.

As mentioned, there will be some cases where it is unlikely that the domestic dog uses representations in order to interact adaptively with his environment, there will also be some cases where the issue is unclear and some cases where representations are probably behind successful adaptive behaviour. Whether or not representations are needed for successful behaviour will largely depend on the situation. For example, in many situations, the environment is its own model such as in a chase situation, when the animal remains visible the dog may not need to use representations for, wherever it is possible, the dog will use environmental resources to lighten her cognitive load. This makes for faster online cognitive processing which means faster response times to the stimuli.

The situations in which representations are needed are generally those times when relevant stimuli are perceptually absent, or there is a need to simulate actions before performing them to enhance the dog's chance of success in that situation.

The environment plays a large part in the cognitive processing of domestic dogs and other non-human animals. But it is only those features of the environment relevant to a non-human animal which have, from the animal's point of view, impacted on the agent in previous situations that feature on cognitive processing. Therefore, if a non-human animal does possess some mechanism by which a representation is constructed, potential candidates for representation will be those features of the environment that are relevant to the agent and only those features of the environment: 'what this suggests is that what non-human animals actively represent is, primarily or exclusively, affordances' (Millikan, 2006, p.121). In short, non-human animals, unlike humans do not go around collecting what Millikan calls 'dead facts', facts about features of the environment divorced from actions that the agent can associate with those features. This is because the collection of dead facts of this nature does not have immediate relevance to the agent's success in their environment. Collecting dead facts requires a skill which Millikan rightly remarks non- human animals probably don't have the capacity for propositional thought. Millikan is surely right. Therefore, our theory of representation ought to reflect this. Furthermore:

> Pure goals would not be represented torn apart from the perception of affordances directing the animal toward those goals, or at the very least, perception of what will support searching behaviors, designed to raise the probability of encounters with more rewarding affordances. Thus the hungry animal perceives aspects of its environment as for traversing, or for sniffing, or for searching with its eyes, these behaviours being designed to bring it into contact with more direct food-tracking affordances, and so forth (Millikan, 2006, p. 121).

Simply, non-human animals learn to interact successfully with the environment by trying things out. In order to act upon the environment a non-human animal must be able to recognise a feature of their environment as something with a particular type of affordance. For example, our dogs while out tramping have learnt to jump or scramble up things such as large rocks or steep banks. However, steep banks and large rocks come in all shapes and sizes and there are times when we encounter a sharp novel climb.In this situation the dogs may represent the affordances the terrain presents them. The emulation circuit may then emulate some actions to find the action with the best outcome. Finally the action which occurs represents the gradient of the terrain. Because perception and motor skills are intrinsically linked, the representation of the likely consequences of an action will be manifest in the activation of certain motor pathways that become activated when an affordance is perceived. A possible scenario is this. Aspects of the environment that are significant to the non-human animal cause the animal to register on some level when an affordance is available: the non-human animal becomes 'aware' of potentialities for action.[13] Relevant motor programmes are subsequently activated or simulated and the action appropriate to the situation in which the animal agent finds himself is then either carried out or simulated. If it is simulated, the agent has a chance to 'assess' the consequences of his action before carrying it out. Minimal representations come into play by representing the affordances an environment offers. In addition, representational actions from the dog will represent affordances because they are encoded into the action. Recall the example of the agility dog above. The good agility dog can use the human handler's bodily movements as representational of the course he is to take from obstacle to obstacle. In addition, his position as he sails over a jump in midair will represent the direction his handler has shown that he is to go upon landing. Representational actions are readily used by the dog as an information source and his own actions represent aspects of his environment also, which can be used in turn by others.

[13] [18] I have put 'aware' in inverted commas because I do not wish to assume that affordances are known on a personal level. They may register at the sub-personal level, however.

5.2.2 The function of a dog's representation

In the previous section of this chapter I have introduced the notion that representational actions and emulation circuits have a function - that is to represent. This is clear when we consider forward emulator circuits of the sort Clark and Grush speak of. For Rowlands, the functional role of representational actions receives little attention. However, in cases where a dog's actions are used by the individual dog itself and other dogs or humans in a situation to stand in for, or represent a state of affairs, the actions are representational. Ruth Millikan (1993) writes that we must focus on a representation's consumption, or how the representation is used by an agent, to decide whether it is indeed a representation.

This is in accordance with Haugeland's (1995) third claim (mentioned in the previous chapter) because something such as gastric juices or saliva may signal the presence of food but that is not their function. Saliva is mainly used by a creature to assist in the digestion of food. That saliva occurs does not make it a representation of incoming food because saliva is not part of a system of representations; it is part of the digestive system. The function of saliva, therefore, is not to represent food but to assist in the chemical breakdown of it. And, according to Millikan, what determines the function of a representation is how it is used by the animal agent.

The function of a representation, Millikan explains, has been selected for and preserved over time. Recall that for Millikan, a representational system can be divided into two parts: producer and consumer: the part of the system which consumes representations must 'understand' the representations proffered to it. This makes sense. For, if a representational action is to be useful to a dog he must be able to use it as a representation. When a dog is hunting down prey, his movements can represent the path that the prey animal is likely to take. Moreover, other pack mates can use this information, the representational action of the dog, to intercept the prey at another point.

5.2.3 Embodied representations are situation specific

In non-human animals especially cognition is often task and situation- specific. Representations, therefore, are connected to specific situations. As an analogy, consider the cry of the paradise duck. The paradise duck has a loud call which it emits upon noticing a potential threat. This call functions as a warning to other paradise ducks within earshot; it represents danger. In order to function as a representation of danger, the call is located in time and a place: the call represents danger right now, in this place. Representations in other non-human animals likely work in the same way. That is, they are tied to a time and a place just as the paradise duck's call is. Because of this, the representation in the non-human animal is not the sort of thing that can be stored (Millikan, 1993). A representational action, once performed dissipates, as does an emulation circuit activation. This section has discussed the likely features of a representation in the non-human animal. To summarise, here are two main features of a representation in a non-human animal such as the domesticated dog.

1) Representation in dogs is action-based and situation-specific. Representational actions can represent affordances to other dogs and can be used as an information source by dogs to enable successful cooperative behaviour.
2) Emulation circuits emulate responses to a situation in the environment; that is they represent to the dog the affordances provided by the environment and can enable him to produce the most successful behaviour in that situation.

5.3 Scenarios demonstrating dogs' use of embodied representations

In what follows, I give a series of scenarios in which dogs and other non-human animals might use representational actions (deeds), or the emulation circuitry described by Clark and Grush.

5.3.1 Scenario one

It is dusk in a wooded area. The hunting dog has caught a scent of his prey and movement of it in the distance has been visually perceived. The dog begins his chase and the rabbit starts to flee. The dog's visual acuity is good in this light and the moving target in the 300 metre distance that separates them is visible to him when nothing blocks his line of sight. Right now the dog's cognitive load is heavy. He is exerting himself to navigate the forest and his senses are fixed upon his prey. The primary sense in play is olfaction. Every move the rabbit makes can be tracked by the scent cues it leaves. However, there are times when trees obscure the position of the rabbit and although scent cues are readily available the most effective way to catch this target is to gear his movements to the cornering and catching of this rabbit. A simple straightforward chase based on scent and sight will be enough to follow the rabbit but perhaps not enough to catch it. The dog must still anticipate and act in relation to the prey's behaviour and his success lies in the ability to coordinate behaviour by representing the effect of his own actions on the prey's behaviour. In this scenario emulation circuits are triggered. His own actions are simulated in relation to the movement of the rabbit and his actions become representational of the affordances offered to him in that situation. The result is adaptive, flexible hunting behaviour in the domesticated dog.

5.3.2 Scenario two

A Collie has just jumped off the quad bike and been instructed to move out and round up a flock of sheep. Even if he is not conscious of it, there must be a connection for the dog between his actions and what the flock of sheep will do. The dog acts on the basis of what the likely effects of his actions will be. This is integral to the Collie's success in herding sheep. The flock's behaviour is often unpredictable. That is, what the flock of sheep will do in the current situation will depend on many factors such as the contours of the land, what type of flock they are, their previous experiences and so on. Therefore, the flock's behaviour is not always totally predictable. This element of uncertainty in the sheep's behaviour requires the sheepdog to be flexible in his actions. He must be able to adjust his actions on the spur of the moment in accordance to whatever the sheep do. Without this ability there would be little flexibility in his behaviour and his efforts would be in vain. Representations of relationships between events in the non-human animal's world can lead an animal agent to be flexible in her responses to stimuli. That is, representations of the connection between an agent's actions and their likely effects are at the bottom of flexible behaviour (Forkman, 2000). Moreover, the sheepdog has a representational system which can provide real time emulation of what is happening so as to facilitate a rapid real time response.

The Collie uses information provided by emulation circuits to make fast decisions about which action will cause the desired consequence and when the dog is using representations of his actions in this way he can change his responses to the flock in a flexible way. It is now possible for the dog to make functional decisions under novel circumstances.

5.3.3 Scenario three

Representations are needed for anticipatory behaviour: 'anticipatory behaviour is behaviour that is influenced by expectations about the future, such as future states of the environment, future actions or merely anticipations about the way things work in a given situation' (Reznikova, 2007, p. 93). And, as Andy Clark (1997) argues, anticipatory behaviour cannot be adequately explained solely in terms of current interactions between the agent and their environment. Situations that require a degree of future planning that goes beyond actions for immediate consequences are, to use Clark's words, 'representation hungry' situations: 'in this case behaviour consists of regular sequences that are not guided from moment to moment by the ongoing organism-environment couplings (Keijzer, 2002, p. 280). Thus, some form of representation of action remains necessary. For example, when a dog is herding sheep into a small yard, his actions must all be directed at the ultimate future goal (getting the sheep into the yard) even though immediate actions do not satisfy that goal. He is able to take steps to achieve the future goal and for this behaviour, representations are needed for this ability. This is possible using minimal representations within an emulation circuit. The emulation circuits represent the actions available to an agent before they are performed assisting in the success of the action.

5.3.4 Scenario four

You are in a park throwing sticks for your Terrier who loves to fetch sticks. The stick accidentally goes over the fence; a fence which the dog cannot climb through. The Terrier must act upon two things: recognition that he cannot get through the fence and recognition of a possible alternative route to the stick. Moreover the Terrier must be able to find the stick when he has found an access route. This is a complex task, but highly motivated dogs can accomplish it with little difficulty. The dog may first of all try to get through the fence, during the attempt, emulation circuits are firing as possible methods are simulated. The attempt at getting through the fence is quickly abandoned and an alternative action which involves running in the opposite direction of the target stick toward a gate is emulated and then performed. The stick can now be found via scent cues and returned to the human by the same route. In this scenario the ability to simulate the likely success (or failure) of getting through the fence, and then obtaining the stick by following another route is efficient. Trial and error alone would have required much greater effort and more time. If this situation was a hunt for a meal, rather than a game of fetch, use of trial and error alone would not be as effective as the use of a forward emulation circuit. The dog is at an advantage if he can represent affordances that an environment offers and the effects of these possible actions without having to try out many possible actions in every situation.

5.3.5 Scenario five

In an experiment described in the first chapter, Philip, a four year old Tervueren was trained to use different human demonstrated actions to guide his behaviour. First of all, the experimenters trained Philip to repeat a range of human actions to command. When he could do this reliably the humans demonstrated a novel action which involved moving an object from one place to another. On the same command as before, Philip copied the new action more frequently than would be expected by chance. The conclusion of the authors of this study (Topál et al., 2006b) was that Philip 'could have recognized the action sequence, on the basis of observation alone, in terms of the initial state, the means and the goal. This suggests that dogs might acquire abilities by observation that enhances their success in complex socio-behavioural situations' (Topál et al., 2006b, p.355). Emulation may have enabled Philip to learn by imitation. Lots of a dog's early learning is achieved via imitation and emulation circuits seem to have the potential to expedite this type of learning; by simulating another dog's actions a new action can be learned and then tried out. Phillip may also be using the demonstrator's route as representational of the correct response.

5.3.6 Scenario six

A police dog has been deployed by his handler to track an escaped convict. It is 3 am, raining and the convict has had a head start. The handler casts her dog out (gives him a long free line to roam around on) to pick up the scent trail. Once the dog has detected the scent, he then indicates to his handler and begins tracking. The handler follows behind and uses the dog's movements as representational of the route the convict has followed. The dog's actions represent, or stand in for, the route of the convict which is imperceptible to the police dog's handler.

5.4 Dogs' use of embodied representations

In this chapter to the present point, I have sketched some ways in which embodied representations might be used to explain the behaviour of non-human animals such as dogs. The embodied representations to explain the dogs' behaviour may be the representational outputs of the emulation circuits and representational actions such as those described by Rowlands. I hope to have shown how these theories might come to life in our explanation of canine behaviour and how they might be used to facilitate flexible, goal-directed behaviour, enable anticipatory behaviour and reduce the need for trial and error learning.

The overriding influence of embodied cognition on this research is the idea that cognitive capacities, such as the ability to represent affordances, are not confined to an agent's brain. Instead, representations may be found within action and behaviour. In order to apply the emulation theory of representation with certainty to dogs and other non-human agents, we would first need to ascertain whether they have the same neural emulators that studies have suggested humans have. But, given preliminary evidence for emulation circuits in cats (Clark and Chalmers, 2007) it is not unrealistic to suppose they are also at work in dogs and other animals. This might be a fruitful avenue of neurobiological research.

The work that remains of this chapter and the one which follows is to clarify how embodied representations might be used by dogs in certain types of cognitive skills and tasks. I begin by describing how the use of embodied representations might be instrumental in the dogs' ability to learn by imitation. From here, I move to the possible link between anticipatory behaviour and embodied representations. Finally, I suggest that embodied representations could be at work in the dog's ability to make means-ends connections and use social cues.

5.4.1 Learning by imitation

Emulation circuits may facilitate learning by imitation by simulating actions observed being performed by others. When a pup is young much learning takes place through the observation of his litter mates and mother. By observing actions of others in situations of play fighting, navigating the environment and responses to certain stimuli he is learning the affordances that different environments and stimuli provide; these affordances may be represented by the emulation circuits as minimal representations. In addition, actions performed by pack mates can serve as representational actions for dogs observing their behaviour and function as a guide to current and future responding.

5.4.2 Anticipatory behaviour and emulation circuits

Emulation circuits simulate actions open to a dog in a particular context. On this basis, the dog is able (probably on a sub-personal level) to predict the consequences of his actions. For example, say a dog has the task of leaping to catch a ball. Clark and Grush hypothesise that the emulation circuits simulate the action before it is done, thereby fine tuning it and facilitating, say, a successful ball catch. Furthermore, let us go back to the Collie working hard to round up the sheep. Every action he makes would be simulated and perfected before it is performed. The action and its outcome are subconsciously pre-run by the emulation circuits simulating, or representing the action before it occurs. Thus, more successful actions are rendered more likely. In short, it is possible that emulation circuits facilitate smooth, finely tuned motor actions in the domesticated dog, such as leaping to catch a ball or navigating difficult terrain. They do so by representing the actions invited by affordances that the environment presents. In this way, emulation circuits play a part in controlling behaviour such as sheep herding, the pursuit of prey animals and game playing with pack mates and human beings. Being able to represent (even temporarily) the effect of one's actions upon the immediate environment is a great advantage to an agent and one which leads to the dog being capable of anticipating the effect of his own actions on his environment. This type of representation, therefore, is clearly something that a dog could, and possibly does, use in anticipatory behaviour.

5.4.3 Means-ends connections

Similarly, an understanding of the connection between one's action and the environment is also facilitated by the minimal representations provided by emulation circuits. If the dog can emulate the effects of his actions upon the world, via emulation circuits, then emulation circuits could plausibly be the basis for means-end understanding in the domestic dog. As above, this is because the dog has a means by which his actions and their effects can be represented to him. Note that I do not believe it is a requirement that such knowledge is explicit to the dog and this is an intuition shared by Clark and Toribio: ‘in a fairly intuitive sense, it seemed to say of a trained up network, that it could embody knowledge about a domain without explicitly representing the knowledge’ (1994, p.403). Minimal, action-oriented representations also serve the function of avoiding excessive and potentially costly trial and error learning. If emulation circuits are triggered when an affordance, similar to a previously encountered one, is presented by the environment to the dog, then rather than having to learn what to do in this situation all over again, the emulation circuits could run, triggering the same actions that were successful before.[14]

As we saw above, as a hunter, the dog must still anticipate the movements of his prey even at times when he might not be able to see his prey. In these situations, the dog’s success is due to the ability to coordinate his behaviour with the movements of a creature he cannot always see. The dog relies on representing the effect of his own actions on the prey’s behaviour. The emulation theory may

[14]This idea also links with automaticity and proceduralisation of behaviour; new tasks are hard/slow but once practised they become automatic and require no conscious attention or thought (such as driving a car or riding a bike). It also links to schema theory – we build up schema about what we expect to happen given certain circumstances and our response becomes quite automated unless something unexpected happens

explain how this is achievable. If the emulation circuits can simulate the dog's movements and fine tune his success with dealing with the environment then it is possible that this can occur even if the object of prey goes out of sight; enabling the dog to still successfully predict its movements. Thus the dog is able to act successfully in these situations by having something other than the signal directly received from the environment stand in and guide behaviour in its stead. The minimal representations provided by the emulation circuits will represent the dog's own actions and their effect on his prey and facilitates adaptive, flexible hunting behaviour in the domesticated dog.

It is quite possible that different types of representation are involved in different aspects of dog cognition. For example, it may be the case that training and co-evolution with humans has developed the capacity for inner, mental representations as well representational actions.

5.4.4 Representational actions as social cues

Representational actions, as put forward by Rowlands, have many possible uses also. One would be the representing of the dog's trajectory to another dog. Recall, for example, that the cricketer's bodily movements represent the trajectory of the ball as he goes to catch it. In the same way, the dog's bodily movements can represent the route of a prey animal as he is stalking it. The dog's representational actions can, then, be used by others in his pack to help coordinate pack-hunting behaviours.

In addition, the dog can use a human's bodily movements as representational of important aspects of the environment. Recall from the opening chapter that often dogs display the tendency to off-load cognitive work on to his environment. One way in which he does this is by using human cues as an aid to problem solving. Recall the experiment mentioned in the opening chapter which involved trained explosive detection dogs and their handlers (Lit et al., 2011, see page 73). A high number of false alerts were seen by the dogs when the handlers held incorrect beliefs about the locations of target items. The experimenters concluded that dogs are highly sensitive to human social cues, sometimes to the extent that they will use human cues over and above other environmental cues. The handler's cues were given unintentionally via body language. With Rowlands' theory of representational actions in our toolkit, this explanation might be refined by saying that the handler's subtle bodily cues were representational of the (false) target location. That is, the dog was using these representational actions from his handler in an effort to solve the task of detecting explosives in the church.

5.4.5 Embodied representations have explanatory value

The take-home message of this chapter is that minimal representations and representational actions can help explain dog behaviour and certain cognitive skills. Minimal representations provided by the emulation circuits could underlie anticipatory behaviours such as low-level planning and assist the dog in learning by imitation. In addition, they could enable the domestic dog to avoid excessive trial and error learning, by emulating actions before they are performed. Furthermore, they would enhance the dog's cognitive processing. Representational actions can facilitate social behaviours such as the use of a dog's bodily movement by another dog to coordinate pack hunting; or the use of human actions by the dog as representational of a pertinent aspect of the environment.

These types of representations are embodied representations: They are body and action based, situated and occur in real time in response to particular situations. Minimal representations and representational actions can provide the dog with flexible and adaptive behaviour and are entities that are at the very least something that he could use to maximise his chance of being successful in his world.

5.4.6 Representations in the non-human animal represent actions

Emulation circuits simulate and represent actions. As we saw above, emulator circuits run offline 'if, then' scenarios about bodily actions and their effects on other parts of the agent's body and her environment. Emulation circuits facilitate the prediction of what state of affairs the current actions of the agent are likely to lead to. They do this by representing the agent's action and are useful because they run their predictions quickly enough for an agent to adjust her movements to maximise the likely success of an action.

This makes the representation useful in novel situations where fast and effective responding is the key to success. Moreover, representational actions can be used by other agents as a guide to worldly states of affairs. Actions and their likely effects may be represented by their being simulated in emulation circuits. In addition, representational actions can be used by agents to guide responding. Representation in action happens on a sub-personal level, but the agent is still able to use these representations to guide her actions and enhance her chances of a successful interaction with her environment.

5.4.7 Representations are fixed in time and space

Emulation circuits are triggered when an affordance is presented to the dog as he moves about his environment. As a result, the minimal representations are highly context bound and situated in time. Once the action is complete, the circuits stop firing and the dog moves on to another situation where the same will happen all over again, most likely with different representations of different actions. Representational actions are also context-specific; although they can misrepresent, many of the actions by the agent are representational of a current situation.

5.5 Conclusion

Embodied representations such as minimal representations can provide useful ways of thinking about and explaining dog cognition.

The embodied cognition paradigm has opened up a new way of thinking about representations in humans and I have begun to show throughout this chapter how a theory of embodied representation can provide a promising theoretical perspective into the cognition of animals other than us. Minimal representations ought to be studied further, for it seems plausible that they are involved in cognitive processing in a variety of ways. The following chapter aims to further refine the conclusions drawn from the empirical studies on dog cognition through the application of embodied representations and principles from embodied cognition.

Chapter Six: Studying dogs using embodied cognition and embodied representations

This thesis began with a review of empirical literature generated by experimental psychologists and scientists on dogs and their perceptual and cognitive skills. From this beginning, the second chapter introduced the recent embodied cognition framework and, using dogs as a case study, I hypothesised that this philosophical approach might profitably be applied to our explanations and understanding of non- human animal cognition and behaviour. In particular, in Chapter Three, I outlined seven strands of the embodied cognition framework to guide our thinking about canine cognition:

1. Dog cognition is situated
2. Dog cognition is time pressured
3. Dogs off-load cognitive work onto the environment
4. The dog perceives the environment as opportunities to act
5. Dog cognition is for action
6. Dog cognition has evolved
7. Dog cognition is body-based.

From an outline of embodied cognition and the formulation of guiding principles to a study of dog behaviour and cognition, the fourth chapter introduced the idea of embodied representation. Embodied representations are non-neural, situated representational systems which reside in sensori-motor networks and actions. In the explication of embodied representations, I focussed on the two most significant theories of embodied representation: the emulation theory, from Andy Clark and Rick Grush, and Mark Rowlands' theory of representation in action. The fifth chapter sketched an outline of how embodied representations can be used in our understanding and explanation of dog behaviour and cognition.

6.1 Applying embodied representations to the findings of Chapter One

Here, the discussion returns to Chapter One, where we began, to take another look at the experiments conducted upon dog cognition. The aim of this chapter is to consider the empirical data of the opening chapter in the light of the theories of embodied representation and the overarching stipulations of the embodied cognition paradigm. The following discussion groups together cognitive capacities and behaviours that can be seen in a new light from the embodied cognition viewpoint and follows the same basic structure as Chapter One.

6.1.1 Communication

Embodied cognition teaches us that dog cognition is for action. It follows, therefore, that dog communication is also for action. Thus, most communication between dogs, and dogs and humans revolves around actions. Recall Rico, the Border Collie who could fetch 200 toys in response to a verbal command (Kaminski et al., 2004). Then there was Chaser. Pilley and Reid (2012) spent three years training Chaser who, at the end of her training, could fetch 1000 toys on command. But there was doubt over whether Chaser really understood that the noun her trainers used to identify a toy with was a name for the toy. In other words, the worry was whether the dog understood that the word stood for a referent. To test this, recall that the experimenters trained Chaser to respond to the commands ‘nose’ (nudge at an item with her nose), ‘paw’ (pat at an item with a front paw) and ‘fetch’ (go collect an item and bring it to a human). These commands were then paired with words like ‘ball’ which Chaser already responded correctly to. The dog ended up performing well when commanded to ‘paw ball’, she would approach the ball, for example, and begin to paw at it. To this the experimenters conclude ‘Thus, in effect, Chaser treated phrases like “fetch sock” as though the “sock” was a sock and not “fetch sock” - indicting that her nouns referred to objects’ (Pilley and Reid, 2012, p.190).

In contrast to their conclusion, however, the embodied cognition theorist might suggest that the words ‘fetch sock’ still refer to a specific action, inseparable from the toy itself. When we consider the action- orientated nature of cognition, especially non-human animal cognition, it becomes probable that, even when paired with a verb to which the dog will respond correctly, the command ‘fetch ball’ still refers to an action associated with the object (the ball). Therefore ‘ball’ to a dog means something like ‘do something with the ball’. So ‘fetch’ is a modifier of that action, more precisely it is a ‘fetchy’ kind of doing rather than a nosey kind or a ‘pawy’ kind.

Recall Gibson's (1979) thesis that laid the groundwork for embodied cognition. The world around an agent, such as a dog, is not perceived as a collection of objects, instead the dog perceives opportunities for action, or affordances. When a human gives a command, this is another affordance. In the case of the command 'fetch sock' it is an opportunity to act upon a specific item in the world. So we should bear in mind that as dogs are action-orientated creatures, verbal cues more likely refer to affordances, opportunities for action in a specific situation, than to individual objects. Furthermore, we can aid dogs' understanding of our verbal and bodily cues by ensuring that they are clearly representational of the actions we are requesting. For example, we can use representation in action to indicate to a dog a 'sit' command by lowering the hands and arms with the accompanying verbal cue. Similarly, a cue for forward movement may be accompanied by a gesture representational of the request. In this case, it maybe the swift forward swinging of an arm accompanied by a verbal cue.

6.1.2 Embodied representations and dogs' use of human pointing gestures

Outlined in the opening chapter were the findings that dogs demonstrate a significant ability to understand human pointing gestures. A mixture of co-evolution with humans and the individual dog's experience and socialisation determines the skill with which dogs can do this. Moreover, the breed and the age of the dog influences how well the dog will use a human pointing gesture as an aid to problem solving (Passalacquaa et al., 2009; Doréy, Udell and

Wynne, 2010). As we also saw in Chapter One, there are other factors related to the experimental setting which also affect dogs' ability to use human pointing gestures as an aid to problem solving. These include the experimental setting and the proximity and familiarity of the handler. Nevertheless, dogs in general display a remarkable ability to use human pointing cues. The ability to use pointing cues can be seen as the dog using a human's representational actions as information about his environment. The human's pointing gesture is a representational action. For example, it may represent the trajectory of a stick just thrown and the dog's ability to use this representational action as a clue regarding where he should begin his search enhances his likelihood of success in finding it. Interestingly, dogs also understand other dogs' 'pointing' gestures. In fact, English Pointers are bred to do just that. As a hunting dog, Pointers will indicate the direction of a rabbit or hare, with a raised front paw and an angling of the body in the direction of the prey (American Kennel Club, 2013). Other dogs are able to interpret this action as representational of the direction of the prey and the pointer can be used in conjunction with a greyhound in the successful tracking and catching of prey.

6.1.3 Dogs' sensitivity to human cues

As we have seen, dogs have evolved to use humans' cues for problem solving. This skill appears to be more highly developed in dogs than in wolves although data on this is somewhat mixed. Dog cognition is the interweaving of environmental affordances, social cues, individual histories and evolutionarily acquired traits. Therefore, I have suggested that when a dog looks to a human for cues for responding this is not to be seen as a way of avoiding problem solving; it is a problem solving strategy which the dog is disposed to acquire. The dog is using the human for cues by which he can complete the task and is off loading cognitive work on to his environment as he does so. In many situations the dog will do this quite naturally and this skill can threaten the validity of experiments which are not designed to control for the effect of handler cues on the dog's performance. As mentioned above, very subtle handler cues can be detected by the dog, bearing in mind that dogs' superior sense of smell can detect hormonal changes within a human (Kaldenbach, 1998) therefore these must be carefully controlled for.

6.1.4 Reasoning by deductive inference

A point that I have already made, but is worth reiterating, is that we should ensure that our experiments give the dogs tasks that have ethological relevance. This is especially the case when thinking about cognitive skills such as the ability to reason by deductive inference. Several studies have been conducted in the last ten years on dogs' ability to reason by inference (Erdőhegyi et al. 2007; Aust et al., 2008). Aust et al.'s (2008) conclusion was that dogs could make deductive inferences of the kind "If ~P, Q; ~P; therefore Q" in a setting where human cues were controlled for.The evidence for reasoning by exclusion in dogs was mixed in other studies, but one thing was highlighted in all of them: the strong tendency for dogs to use human cues over and above other problem solving strategies.

From the embodied cognition perspective this thesis adopts, dogs' cognitive skills are likely task specific, so when testing their capacity to perform inferences we ought not to give them an abstract problem that involves inferential reasoning in the lab divorced from a real world task that the dog might face. It may often be the case that dogs can learn to reason by deduction in certain experimental settings, yet this skill may not be seen in other contexts. An interesting study would be to examine whether reasoning by deduction is evident in real-world lives of dogs.

6.1.5 Forming expectations about the near future

Postulation of the emulation theory of representation and representational actions may assist the dog in forming expectations about the near future. Forming expectations about the near future is called 'anticipatory planning': 'Anticipatory behaviour is behaviour that is influenced by expectations about the future, such as future states of the environment, future actions or merely anticipations about the way things work in a given situation' (Reznikova, 2007, p. 93). Classical and operant conditioning can explain how an agent can come to anticipate future events in situations he has encountered in the past. For example, most dogs can quickly learn that sitting down when hearing the verbal command 'Sit!' will result in a food reward. In fact, it is often the case that anticipation of future consequences is the driving force for most dog behaviour. However, there will be times in a dog's life where he encounters a novel situation. In these cases being able to simulate certain actions and their outcomes in the face of a new situation is advantageous to him. Novel situations are presented to the dog with more frequency than might be expected. For example, an agility dog is at a competition and her task is to negotiate the obstacles on the course in a specific order and direction. The dog does not have the opportunity to practice the course before the competition begins, although her handler does. Therefore, when the dog enters the ring, her situation is novel. Using bodily movements, her handler uses representational actions to guide the dog around the course in the right order. The dog has been trained to follow these representational actions and much of the success of the handler and dog team depends on how clearly the person can represent the desired direction to the dog and the efficiency with which the dog will respond. The efficiency of the dogs' responding may lie in her use of emulation circuits. These would be deployed to simulate on the spot responses to her handler's cues quickly regarding the best movement to perform over the obstacle which will place her in the best position to tackle the next obstacle. The dog and human are under time pressure and the more quickly the dog can produce the most effective response to her handler's cues, the better. The best way to execute the jump and land facing a certain way will be emulated and performed.

In this way, representational actions from the handler and the representational emulation circuits within the dog can work in tandem to produce fast, effective responses to the task at hand. In the example outlined above the theory of embodied representation and representational actions can work together to anticipate future events in novel situations.

6.1.6 Embodied representations, off-loading cognitive work on to the environment, and means-ends connections

We saw in the beginning that Osthaus, Lea and Slater (2005) tested whether or not dogs were capable of making the connection between means and ends. They conducted four experiments which tested whether dogs would learn that pulling on a piece of string dragged a piece of food previously out of reach into a position where they could consume it. They set up a low, flat box with a transparent top so the dog could both see and smell that there was a reward in the box but out of reach. Attached to the reward was a long piece of string that lay on the floor and poked out through the side of the box nearest to the dog.

Osthaus and her colleagues found that the dogs applied one of two problem-solving strategies: either they would paw close to the food regardless of whether the string was at the site they were pawing; or if the string was in the site that was closest to the food, the dogs would still paw close to the food and paw at the string as well. If the latter of these strategies proved successful, its performance was rapidly perfected; eventually, the string was reliably pulled and the food reward obtained. Thus, Osthaus et al.'s study showed that dogs were able to learn to obtain the food by pulling at the string. However, they concluded, rather than doing so by learning the connection between pulling the string and getting the food, they did so through associative learning, 'in Piagetian terms, the dogs displayed sensori-motor intelligence at stage III (circular reactions), but not at stage IV (means-end understanding)' (Osthaus et al., 2005, p. 45). In short, it was concluded that dogs did not develop a means-ends understanding in relation to the task.

In light of their conclusion, the researchers suggest that perhaps dogs have lost some of their ability to solve problems. They suggested that dogs fail to learn means-ends connections because in their cooperation with humans, it is always the human that carries out problem solving tasks. But, the problem solving ability of dogs may be seen in a different light. Recall that Pepperberg (2004) found that two language trained parrots also demonstrated no means-end understanding when confronted with the same task. The parrots simply asked their human trainers to give them the treat. In contrast, the parrots with no language training solved the problem easily. It could be that dogs' ability to solve problems is not diminished, just redirected: In Osthaus et al.'s study they were employing a problem solving strategy that involved humans. Osthaus et al. are aware of this experiment but conclude that 'it appears that the availability of human-aided solutions to problems can sometimes inhibit the expression of animals' cognitive capacities' (Osthaus et al., 2005, p.46).

Looking at Osthaus et al.'s data through the lens of embodied cognition, however, could lead to an entirely different conclusion. The parrots' performance in Pepperberg's study might not reflect an inhibition of problem solving capacities since it could also be the case that the language trained parrots are simply displaying a different method of problem solving. That is, they are problem solving by off-loading their cognitive load on to an aspect of their environment (the human experimenter). In the same way that we would use a calculator to solve a hard sum, the language trained parrots refer to their human trainer or owner for the solution. This is still problem solving, just as our solving the sum by using a calculator is still problem solving. Dogs also problem solve in this way in certain situations. That they do so does not mean that dog's problem solving abilities are inferior as a result of their association with humans. Rather, when confronted with a problem solving task, the dogs have learnt through evolution and individual learning to off-load the cognitive work onto humans.

Dogs off-load cognitive work on to their environment through the use of human cues. Dogs are able to comprehend human cues toward the best action in a context, thus they use this skill to interact with their environment efficiently. One way in which dogs can comprehend human cues is through the use of the human cue as a representational action. Human cues, even those unintentionally given, can represent for the dog a target's location. Recall for example Lit et al.'s study involving the explosive detection dogs and their handlers (2011). In this study the dogs used unintentionally given handler cues to signal the location of target scents. The handler's actions provided the dog with information regarding the target scent's location, which he acted upon to the extent that he disregarded alternative perceptual cues. In short, the handler's actions are used by the dog to represent the target's location. These are representational actions at work. Moreover, a cognitive skill such as understanding means-ends connections is highly likely to be action-based and situated, as the embodied cognition paradigm suggests. Therefore, it may be difficult to elicit evidence of such an understanding removed from the context in which it would be needed. Emulation circuits may be triggered in a situation requiring a means-end understanding. For example, the Border Collie who is mustering sheep into an enclosed yard operates with an understanding (at least at the sub-personal level) of the effect her actions will have upon the sheep. This means-end connection may be provided by representational emulation circuits which simulate her actions before she performs them to enable the most effective means to achieve her goal in the given situation.

Removed from the context of rounding sheep, and the subsequent trigger of representational emulation circuits, it may be difficult to gain evidence that the same Collie understands a means-end connection.

6.1.7 Studies to test object permanence in dogs

Recent data on the perceptual abilities of the domesticated dog, especially their sense of smell, shows that the degree to which dogs may be able to use olfactory environmental cues as an aid to problem solving should not be underestimated. Experimental data on object permanence in dogs may be due to the confounding variable of dogs using olfactory cues to solve invisible and visible displacement tasks. The effect of scent cues on dogs' responses in experiments cannot be overestimated and is very hard to control for.

However, if dogs were simply relying on olfaction in these instances then surely there would be no learning curve. The dogs would presumably be able to smell their way to the target item right from the outset. This does not appear to be the case, since younger pups (who are born with a keen sense of smell) do not seem able to solve invisible displacement tasks that older pups have sometimes been shown to succeed at. Therefore, it may be that dogs do learn object displacement.

If we take the embodied cognition approach to these tests, however, it seems clear that object permanence is a skill which, if possessed, is context-specific and action based. Moreover, the embodied cognition framework has teaches us to hesitate to consider object permanence in animals as an internal representation of an external state of affairs.

Instead, we should consider the types of situations in which a dog might need to locate a target which is perceptually absent. In hunting situations, for example, this would rarely happen. Even when a prey animal goes out of sight permanently there remains the trail of scent cues which are left behind to follow. Should there be no scent cues to follow for some reason, a search for scent cues will probably commence, but ultimately the hunt would be over. In most situations the dog finds himself in, it seems that the total absence of perceptual cues for a target item would result in search behaviours for scent cues, reference to a human handler (if present) for social cues and eventually the abandonment of the task. It does not seem adaptive for the dog to persist for long with search behaviours for a target which he can no longer perceive or track.

Collier and Baker (2004) suggested that the use of scent cues means that dogs cannot solve invisible displacement tasks. But there is reason to question this assumption. From the embodied cognition perspective, using the environment as an aid to problem solving is still problem solving. Even if dogs are using olfactory cues to find the target item, then they may still be demonstrating an understanding that the object (although it moved out of sight to an unknown location) is still in existence, they know this because they can smell it! A reliance on scent cues to solve invisible displacement tasks is still solving the task when we allow bodily movements and manipulation of the environment into our account of problem solving.

We only draw the opposite conclusion if solving an invisible displacement task is restricted to brain-bound cognitive activity; an assumption which adherents of the embodied cognition hypothesis consider to be false. Moreover, dogs are extraordinarily perceptive of human social cues and we should determine, therefore, whether they might be responding to unintentionally given social cues rather than an understanding of object displacement. Social cues can even be as slight as the detection of adrenaline from an experimenter if the dog begins to respond correctly, or the perception of actions on the part of the experimenter which may represent the location of the target item.

In short, our human understanding of object permanence simply may not be relevant for the dog and different criteria may apply to dogs when we are defining the behaviours we wish to see which demonstrate an understanding of object permanence. Dogs' cognitive skills are situation- specific thus an understanding of object permanence, if it is exists, may only be manifest in the right situation. Additionally, embodied cognition redefines what it means to problem solve. Problem solving in this approach includes the use of social and environmental cues, thus the use of scent and/or human cues to solve invisible displacement tasks still counts as problem solving.

The critic might object that in this case they are not solving the invisible displacement task that was intended by Piaget to demonstrate the requisite cognitive skill. My reply would be that such a definition of what it means to solve an invisible displacement task is human-based. This is highlighted by the human-based implication that because the target item is no longer visible, it is imperceptible: an assumption which may hold for human beings, but certainly not for dogs.

It may even be, therefore, that studying object permanence, while relevant to humans, is not appropriate for dogs given the above considerations and much more research is needed on how to fully control for confounding olfactory cues in present experimental designs for object permanence in dogs.

6.1.8 Counting

Dogs' use of olfaction may be the predominant sense; however, gaze duration is often used as an experimental measure. In West and Young's (2002) experiment on counting, gaze duration was a measure of expectancy in dogs. Gaze duration is a common measure of expectancy in human infants; the idea is that if an outcome violates what the subject is expecting in the trial, gaze duration will be longer than when the outcome is in accord with what is expected. In West and Young's experiment the dogs were shown a different number of biscuits behind a screen than they saw placed there before the screen went up. Their gaze duration in these trials was longer than in the control trials when the number of biscuits revealed behind the screen matched the number they saw placed there. This experiment is problematic because it did not control for olfactory cues. It also is hard to prove that vision is the predominant sense in use during the trial; it may be that a kind of 'sniff duration' measure is a more appropriate measure in this context for dogs. This is especially the case when we consider that vision for dogs plays a secondary role in perception, especially when they perceive attractive smelling stationary objects in brightly lit situations. Embodied cognition emphasises the role of an agent's perceptual apparatus in her cognitive processing. So it is best that experiments into dog cognition are devised especially for dogs, rather than using those designed for humans given the vast differences in our perceptual apparatus. Recall Bonanni et al.'s (2011) conclusion that it is possible that dogs are capable of some assessment of number, but their assessment is based on something quite different from being able to count, in the human sense. For example, the authors note that it is possible that the dogs in their study were basing their assessments of group size not on the number of individuals in the opposing group, but on another variable which is a reliable indicator of the size of the opposing pack. A variable of this kind might be, they write, 'the total surface area occupied by pack members' (Bonanni et al., 2011, p. 113).

An alternative conclusion, from the embodied cognition paradigm is that the total surface area occupied by a group led not to an assessment of number, but a different set of affordances provided by that situation. The emulation circuits would simulate very different actions upon perceiving the affordances provided by a large agonistic group as opposed to a smaller one. There may be no assessment of number at all, just a different perception of affordances. Bonanni et al. (2011) looked for the dogs' ability to count in a natural setting, one which may be encountered by dogs outside of laboratory settings, and this is great. Yet it should be remembered that from an embodied cognition perspective, cognition is for action, and the assessment of number is no different. Therefore, an ability to count may well translate, with regards to dogs, to a different set of actions open to the dog in a setting where there are lots of dogs as opposed to where there are few. Note that the dog need not be able to understand the difference between 'lots' and 'few' rather he just needs to perceive the affordances provided in the different circumstances.

6.2 Summary

Embodied cognition can guide and inform our study of dog cognition. I have endeavoured to show how the conclusions and explanations employed in the experimental studies into dog cognition might be enhanced by adopting embodied cognition as a theoretical background for our study into dog cognition, and this can provide a model for studies of cognition in other non-human animals. Embodied representations provide a clear and applicable way of understanding some of the mechanisms behind flexible behaviour in novel situations. Embodied representations also may underlie basic behavioural processes in times where fast and efficient responding is necessary.

Domesticated dogs have co-evolved with human beings. Therefore, a large part of their cognitive skill-set has evolved within the context of their role in human societies. This can explain the differences in cognitive skills across breeds. This is not to say that some breeds are necessarily 'smarter' than other breeds, just that different breeds will have evolved different cognitive skills according to their role in human society. For example, dogs which have more independent roles such as hunting dogs or retrievers have perhaps evolved more independent problem solving capacities than the dog selectively bred to be a house pet, such as the Cavalier King Charles. Therefore, when looking into the cognitive skills dogs possess in an experimental setting, it would be a good idea to examine each breed of dog separately as it is likely that different breeds will display different cognitive skills. After having done so, we could see whether conclusions which apply to a particular breed of dog also apply to dogs in general.

6.3 Training implications of embodied cognition

The final section of this chapter suggests that an embodied cognition framework could be useful in our approach to training dogs and can help overcome some common training problems.

6.3.1 Training by imitation

Much training relies on the use of verbal commands paired with hand signals. Given the notion that cognition is body-based and our actions can be representational, we ought to ensure that our bodily commands represent the action required of the dog. It is natural to pair a hand signal to a verbal command when training a dog. For example the verbal command 'sit' is often paired with a hand signal. Taking into account that cognitive processing occurs not only in the brain, but also the body, the most effective hand signal we could give is one which mirrors the required action. So accompanying the verbal command 'Sit!' might be a horizontal hand which moves down toward the floor. This is a way of representing with our own bodies the action that is being asked of the dog.

Moreover, more emphasis could be placed on modelling behaviours displayed by other dogs. Recent research has shown that dogs possess a great capacity for imitating behaviour of pack mates and even humans. Dogs that have had the opportunity to watch another dog or a human solving a detour task are more successful than those who have not had a demonstrator (Pongrácz et al., 2001). A detour task might be, for example, a task which requires the dog to move away from the desired location in order to reach it such as when the route to the food bowl on the other side of a fence involves going through a gateway in the opposite direction to the bowl. Moreover, research outlined in the opening chapter suggests that dogs are able to use a human action as a cue for showing functionally similar behaviour (Kubinyi et al., 2003; Topál, et al., 2006a). As I mentioned above, dogs are able to perceive others' actions as representational of environmental states of affairs. When watching the actions of another dog in a detour task, for example, the dogs' actions represent the route to the food bowl and on a sub-personal level the dog can react to this and can repeat the movements with success. Moreover, emulation circuits may be triggered when watching the actions of another dog or human, which enable the dog to simulate more effectively actions which are likely to lead to success. Bearing this in mind, we can approach training in a new light by providing opportunities for dogs to learn from other dogs and human demonstrators.

6.3.2 The slippery floor problem

One example of an area of dog training that has proven problematic is police dogs working on a slippery floor. When the canine division of the police force is required to search a room for, say, drugs and suspects the police dog enters the room first. The canine division arrives at the room and ‘stacks the door’: the officers line up either side of the door frame out of sight and in relative safety from anyone within the room. The dog’s task is to do a circuit of the room and signal the presence of illegal substances if she can detect them before the police officers enter the room. This is safer for both the police and for the suspect (the dog will render less harm than an armed police officer might). If the room has a linoleum surface on the floor which does not provide much traction, the dog must be confident to work as well as he would normally on a floor where he has better grip. However, too often pups that arrive for police force training have excellent retrieval drives, are confident, but they hesitate when asked to work on a slippery floor. This is a major problem for the dog sections of police forces and arises between four and eight months of age (Kennedy, L, 2008). There are possible explanations for why slippery floors pose such a test for trainee police dogs. It could be handler-related. The handler may try and reassure the dog when he first becomes scared of slippery surfaces, thus reinforcing timid behaviour on slippery floors. However, despite attempts at minimising unwanted handler cues, it still remains a big problem. Since learning by imitation is a successful way to teach dogs new skills, it appears that focus should be placed on allowing the dog to watch an older, more experienced dog working on slippery floors. The subtle movements which enable the older dog to work effectively even when the floor is slippery may then be emulated by the young dog's emulation circuits and will hopefully lead to a faster, more successful outcome in which the pup becomes confident on slippery surfaces. This is one example of how adopting an embodied cognition approach to non- human animal cognition is valuable with regards to dog training. From the embodied cognition framework, comes a greater emphasis on cognition which is action-based, body-based and situated. This naturally leads to learning by imitation playing a greater role in dog training. Allowing the dog to watch another dog (or human) demonstrator's actions may facilitate the deployment of emulation circuits within the dog to enable effective simulation of successful actions in that situation. Moreover, the dog's use of another's representational actions will speed the process of learning the correct response in a situation.

6.3.3 Cognition is situated: training and learning are situation specific

When we are training our dogs, the embodied cognition paradigm suggests that we should not expect them to be able to carry skills over from one situation to another. It may be the case that a dog is quite accomplished at performing a certain action in one context, but may have to be re-trained in that same action in a different context. Dog trainers often recognise this, but the reasons behind it are left unclear. The reasons behind this issue are provided by embodied cognition when we accept that cognitive processing is not simply a neural affair, rather cognition employs the agent's body as well in a dynamic interplay with the environment. As we have seen, the dog perceives and represents affordances in his environment, these affordances are unique to his species and I have hypothesised that he represents them through representation emulation circuits which allow him to choose the most successful action for that situation. Given this consideration, the cognitive processing that occurs in this context plus the actions he will perform in a situation will be situation-specific. Many of the dogs' skills are situation specific so we will need to recognise that our dogs have to be trained in the contexts in which those skills will be required. In my experience raising our dogs, we have often found that they needed to be taught the same skill in different settings. For example, our dogs needed to be re- housetrained when we moved house, and then house trained again in our friends' houses. The same happened when training them to come back to call. They mastered the task in the setting of our back garden, but needed re-training in coming back to call at our local park and other busier places. There may be some generalisability of skills if the situations are significantly similar, for instance training them at the park where there are other dogs, people and more distractions in general may be enough for them to perform the same tasks at, say, the beach. This is because the situations are similar enough. My point is the reason why tasks have to be re-trained in different settings lies in the fact that dogs and other non- human animals' cognitive skills are situation specific. It does not mean the dog is misbehaving or did not fully learn the lesson in a previous context. A dog's failure in some task is often attributed to these reasons when he is asked to perform the task in a setting other than that in which he's been initially trained. And this impacts on the welfare of the dog too. If we understand why the dog may seem unable to perform a new task in new settings, because learning is context specific, we are more likely to act with patience and do further training rather than punish.

6.3.4 Cognition has evolved, is situated, action-based and body-based

Tasks such as learning to pull on a string to achieve a goal bear little relation to the problems that dogs face in their natural environments. If we keep in mind that dogs' cognitive capacities are context and action specific, and have evolved over time to aid the dog in his natural environment, then we ought to realise that a means-end understanding is also context and action specific. As I mentioned earlier on, in a dog's natural environment (say the sheep farm of a working Border Collie) a means-end understanding may be present as he carries out his tasks. The means-end connections may be assisted by the dog's use of the sheep's representational actions and his own emulation circuits. However, a means-end understanding may not be elicited in an experimental setting featuring a string-pulling task because learning, as an embodied cognitive skill, is action-orientated. To use the example of a farm dog mustering sheep, a means-end connection may be manifest with the particular movements involved in mustering sheep, and context dependent (inseparable from the mustering situations). In short, because a dog does not show an ability or skill in one setting does not mean that he cannot demonstrate that ability in another setting. Moreover, because tasks can be action specific, a command such as 'stop' may have to be trained going from a walk to a halt, a slow run to a halt and so on. This is because cognition is interlinked with actions so that they cannot be separated and the same action (such as stop) from a different bodily position may be to the dog like a whole new action. A dog trainer spoke with me on this issue (Kira, A, 2013). When clicker training dogs to stop, often an alternative cue will be needed for 'slow down' which it is best to teach the dog first before the cue to stop is introduced. This is because the cues are action-orientated and the cue for 'stop' will continue to mean 'stop' regardless of the pace the dog is travelling at due to the situated nature of cognition.

6.4 Summary

There are many ways in which embodied cognition can influence and inform our training and study of cognition in domesticated dogs. I have focused here upon dog cognition as a case study but the guiding principles of embodied cognition apply equally well to the study of all non- human animal cognition. Recognition of the foundational assertions of embodied cognition provide a sensible approach to ensuring that the conclusions to empirical studies on dog cognition are reliable and that our experimental designs will yield reliable and useful data. Moreover, the adoption of embodied cognition can lead us to formulate theories of embodied representation, such as the emulation theory and representation in action. These theories of embodied representation are special because they are models of representation in animals powerful enough to provide explanations behind certain skills and behaviours that dogs exhibit. Embodied representations can also be hypothesised and tested for without the worry of positing elusive inner mental states to non-human animals. In the next, and final, chapter I argue for one further advantage in adopting embodied cognition. This is that it can enhance our understanding of what it means for dogs to perform actions which are rational.

Chapter Seven: Embodied cognition and dog rationality

7.1 Introduction

Using the domesticated dog as a case study, this chapter argues that our conception of rationality in non-human animals should not depend on the attribution of inner mental states such as propositional attitudes.[15] Instead, I defend the notion that a dog's actions are rational when they enable her to successfully respond to the environment she is in. In short, my theory of rationality is action-based and situation specific and I argue that embodied representations facilitate rational responding at times when relevant environmental information is absent, hard to come by or in a novel situation. Flexible behavioural responses in these latter situations can be generated by the use of representational actions and the deployment of representation emulation circuits.

7.2 What makes behaviour rational?

In the study of non-human animal cognition, this question often arises: 'what makes a non-human animal's behaviour rational?' For strict behaviourists, the non-human animal responds to a stimulus with conditioned responses. For those who wish to explain non-human animal cognition in terms of inner mental states such as propositional attitudes, a non-human animal is said to

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decide on a course of action based on a rational assessment of the beliefs and desires held at the time. The behaviour that this leads to is, on this view, rational behaviour. To meet this criterion a non-human animal must be capable of an assessment of, say, his or her beliefs about a situation and must also be capable of acting upon them. Aside from the fact that it is unlikely that many non-human animals are capable of holding human-like propositional attitudes, I argue that this notion of rationality is too restrictive to adequately characterise rationality in the non-human animal.

In short, this final chapter advocates giving cognitive explanations for behaviour but rejects wholesale the notion that our explanation of rationality should solely rely on internal mental states like beliefs and desires. Such reliance on internal mental states like beliefs are seen in internalist accounts of rationality. From an embodied cognition perspective we can answer the question ‘what makes a non-human animal’s behaviour rational?’ without having to attribute propositional attitudes to the non- human animal. The embodied cognition perspective I have adopted emphasises the idea that the non-human animal is acted upon by the environment and in turn acts upon the environment in continuous feedback loops. Beliefs and desires are not ‘inner’ causes of behaviour. Rather, the environment, brain and non-neural body are one system, each affecting the other to produce adaptive behaviour.I address two questions in the following order.

1) Given our embodied cognition approach, under what conditions are a dog's actions rational (under what conditions can we say it makes sense to perform the actions he does)?

2) What processes enable a dog to fix upon rational courses of action (actions that make sense for him in a given set of circumstances)?

I will argue that the answers to the questions are as follows:

1) A dog's actions are rational (it makes sense to perform them in a particular circumstance) when they enable him to successfully adapt to the environment even at times when relevant environmental information is absent, hard to come by or novel.

2) A dog fixes upon a rational course of action by employing processes that include the use of heuristics and embodied representations.

As my answer to question 2) illustrates, my theory of rationality in the non-human animal is partly reliabilist. That is, an animal's actions are rational if they are based on a reliable source of information First this chapter argues that the non-human animal, such as the domesticated dog, fixes upon a rational course of action by using processes and methods that reliably lead to successful outcomes unless the situation is novel, in which case the rational course of action is one which is adaptive. Second, this account implies externalism about cognitive processes and naturally falls out of the embodied cognition approach in that the environment and an agent's perception and interaction with the environment plays a significant role in cognitive processing. An agent 'decides upon' rational actions by using processes that have in the past worked reliably such as an emulation circuit to emulate the outcomes of potential actions. The second claim, that reliabilism about rationality ties us to externalism about rationality is the claim that the agent (human or non-human) need not be aware of the processes that lead to the rational action. So, for example, a Border Collie need not be aware of how he comes to fix on the best action when faced with a flock of sheep to round up; they must simply be reliable processes that have worked for him in similar past situations. Reliabilism about rationality stands in stark contrast to internalist theories of rationality. Internalist accounts of rationality are often used to assess whether a human's decision is rational or irrational. The assessment of the decision is made on the basis of its relation to her beliefs, desires, and other such mental states (Langham, 2008). In the following, I will show how the account of rationality that I advocate can be formulated and how attributing rationality to non-human animals need not depend on the attribution of propositional attitudes.

7.3 Kacelnik's account of rationality

Zoologist Alex Kacelnik discusses the notion of rationality that depends on the attribution of propositional attitudes. This conception of rationality, he calls PP-rationality. PP-rationality requires beliefs or actions to be adopted based on internal reasoning processes. It is a very human- centred way to conceive of rationality, with a focus on '*process*, not on outcome' (Kacelnik, 2006, p.89). A belief or action is rational depending on the internal reasoning processes behind it. This is a commonly held view of rationality and it depends upon the agent being the bearer of propositional attitudes with conceptual content. Representations within this view are the types of things that can constitute propositional attitudes. They are abstracted from the situation (in most cases) and can be combined and recombined to form different conceptual contents such as thoughts or beliefs. This view of rationality is internalist in the sense that the focus is on internal processes within the agent's head. Whether or not an action or belief is rational depends upon facts that are 'internal' to the agent: the internal mental states that the agent has at a particular time determine what course of action is rational for him at that time. On this view, our assessment of a subject's rationality depends upon which propositional attitudes they based their action on. Which propositional attitudes a subject has based their action upon is a difficult thing to determine with any animal, human or non-human that lacks reasonable language skills with which to express inner thoughts and beliefs. Furthermore, even *with* a reasonable set of language skills, we may not be aware of attitudes such as beliefs and desires that justify our actions. To illustrate Kacelnik gives this example: a chess master is aware of only a fraction of the possible moves available to her at any given point, she does not go through a process of assessing all her relevant beliefs and desires when fixing on the best move for her to make. Consider also driving; many of our actions behind the wheel are not caused by a process whereby we assess all our beliefs about the situation (although some beliefs that we are not aware of may influence our decisions to an extent). Rather, the actions we perform to enable us to drive a car successfully, and the move that chess master makes to her advantage are more likely caused by the use of mental heuristics not an internal assessment of particular propositional attitudes about the current situation.

7.4 Heuristics

Heuristics are strategies for making decisions and solving problems. They allow for fast, efficient, online decision making and are behind much of what we consider to be rational behaviour. Herbert Simon's (1957) research was highly suggestive of the conclusion that humans in general actually have a very limited capacity to weigh up possible courses of action and process information in the face of many possible alternatives. Instead, he remarked that humans 'use simple strategies in decision making that focus on only a few facets of available options' (Herbert, 1957 as cited in Weiten, 2001, p.327). Therefore, it seems much more likely that rather than examining all their beliefs about the next possible move, the chess master and the driver use heuristics to decide on the best course of action. The heuristics used to come to the decision will be ones that have proved reliable in the past in relevantly similar situations. Embodied cognition furnishes the non-human animal such as the dog with two types of heuristics: emulation circuits and representational actions.

7.5 Embodied representational and rationality in dogs

As Clark (2008) and Grush (2004) argue, emulation circuits fire to allow the dog to simulate opportunities for action presented to him in any given situation. These are fast and effective ways to enable the dog to respond adaptively even in situations which are novel or challenging. Thus emulation circuits can enable the dog to respond rationally to the situation he faces. Moreover, dogs can use the representational actions of others as an information source regarding the best way to respond. A large part of learning by imitation, I have argued in the previous chapter, is the ability to understand that another's actions are representational of a possible course of action. The dog that has watched another dog successfully navigate his way to a desired consequence is more likely to repeat the demonstrator's actions to receive the same reward. The dog's rational behaviour in this example is underpinned by the use of representational actions.

Thus, PP-rationality alone doesn't seem to furnish us with the best account of the rational processes behind an agent's course of action when interacting with the environment. But can we claim that using heuristics such as the use of representational actions and the emulation circuit is a rational process? In fact, we can. The actions which are produced by heuristics count as rational processes since their use reliably facilitates the agent's success and/or survival in the right situations.

This point applies to rationality in non-human animals as well as humans. If reasoning by the evaluation of propositional attitudes is 'too restrictive as a conception of process rationality in the human case, then it shouldn't be required for process rationality in animals either' (Hurley, 2006, p.13). At the heart of Hurley's remark is the idea that rational processes are those cognitive processes which reliably result in behaviour that contributes to an agent's success in his or her environment. This conception of rationality is better suited to explanations of human and non- human rationality. What Kacelnik terms PP-rationality (the formulation of rational processes that traditional cognitive science tends to leave us with) is too restrictive to be applicable to human beings let alone non-human animals, so we are better off adopting an embodied view of rational processes.

Of course, by adopting a more liberal embodied account of rational processes I am not suggesting that there is no place whatsoever for an internalist account of rationality, akin to Kacelnik's PP-rationality. With human beings, we can incorporate both in some situations. Clearly, there may be times when an agent is both acting upon processes that have been successfully applied to a similar situation in the past, and upon assessments of her beliefs about the situation at hand. My argument is that we ought not to restrict our notion of rationality to an internalist, propositional attitude based account of rationality for it is too restrictive when discussing rationality in humans and non-humans.

On a terminological note, sometimes the focus in discussions of rationality is on what makes an agent's behaviour rational. At other times, the focus is on what makes the processes behind behaviour rational (See, for example, Dennett, 1981). In the former dialogues rationality can be classed as behavioural rationality. In the latter, rationality can be classed as process rationality. Hurley above couches her remarks about rationality in terms of process rationality.

An example of behavioural rationality is often adopted by economists. On this approach an agent engages in rational behaviour when he or she behaves in such a way that her actions lead to the accomplishment of a desired goal. That is, an action is rational whenever it is characterised by patterns of behaviour that result in those outcomes most beneficial to the agent. This is classical behavioural rationality. Game Theory is based on this conception: rationality as behaviour patterns which maximise utility for the agent. The focus in classical behavioural rationality is on the outcomes of behaviour rather than the processes behind them

In his chapter in *Rational Animals*, Kacelnik discusses this version of behavioural rationality under the heading E-rationality. E-rationality claims that patterns of actions are rational when they maximise the expected utility for the agent.

An alternative example of behavioural rationality is Kacelnik's notion of B-rationality. B-rational behaviour maximises fitness 'across a set of evolutionarily relevant circumstances' (Hurley, 2006, p.22). The focus in B- rationality, as with E-rationality, is on the outcome of behaviour rather than the processes behind behaviour. What makes an agent's behaviour rational is, for Kacelnik, determined by the outcomes of the behaviour (whether the behaviour maximises fitness) not the processes that guide it.

Recall that process rationality is concerned not so much with outcomes of behaviour but with how an agent comes to select the method by which she will achieve her goal. Rational processes must be reliable in order to count as rational. That is, they must lead to the right results reliably. It cannot be mere coincidence that the method used to achieve a goal worked. Therefore, any theory of rationality that couches rationality in terms of process rationality must also be reliabilist. In the literature surrounding process rationality, there are two types of process rationality: theoretical and practical (process) rationality. In practical process rationality, rational processes reliably lead to the agent choosing an action which will achieve his or her goals. Theoretical process rationality stipulates that the rational process reliably leads to true beliefs. In summary, rational processes are those which reliably lead to the selection of an action which will achieve the agent's ends. The behaviours that the processes lead to are rational precisely because they stem from a rational process.

To recap, the previous discussion highlights a distinction between rational behaviour and rational processes. Rational processes are those processes that reliably lead to rational behaviour. A rational process is a process that has reliably worked in the past to produce actions which maximise an agent's adaptive fitness. A rational action is one which enables the agent to successfully adapt to the environment at times even when relevant environmental information is hard to come by or costly. Thus, there is a distinction between behavioural rationality (rational actions) and process rationality (rational processes). When Kacelnik discusses PP-rationality, he is talking about a type of process rationality: that is, he is discussing traditional cognitive science's answer to 'how does an agent come to perform rational actions?' When Hurley talks about heuristics, she is also talking about process rationality: how the agent comes to, or fixes on rational actions.

As mentioned above, I will not argue either for adopting a process rationality approach, or a behavioural rationality approach. This is because the two are not mutually exclusive. Both behavioural and process rationality can work together for a formulation of rationality in the human and non-human animal. In the following, I explain why this is the case.

In Kacelnik's account of B-rationality, there is the thought that it is evolution which furnishes the agent with a repertoire of rational behaviours, behaviours that maximise fitness for the animal agent. This, however, is problematic because evolution can only do so much for an animal agent faced with environmental and social challenges. For example, evolution has provided the dog with a fixed set of epistemic capacities, but over the course of the dog's life, there will be novel tasks or situations that require him to flexibly adapt: circumstances that evolution has not kitted him out for. The degree to which a dog must possess cognitive plasticity (be adaptive and flexible in his behaviour) depends on the varieties of challenges that he is likely to encounter in his environment.

On this point, Kim Sterelny writes 'animal agents would be rational [by Kacelnik's B-rationality theory] to the extent that their capacity to choose the optimal action in their situation was not subverted by constraints on their capacity to access and use the information. So understood, rationality would be an aspect of optimal design' (Sterelny, 2006, p.302). And I agree, because Kacelnik's conception of rationality does not take into account the times when an animal must adapt to circumstances on the fly; his theory of B-rationality is limited and only applicable to those encounters with the environment which his ancestors have encountered frequently and where relevant information is not hidden from the animal. Thus, there will be times when behaviours which have in the past been successful, will not be applicable to the situation at hand. In these cases, the rational course of action is one which is adaptive in this novel situation and can be facilitated by the use of embodied representations.

7.6 Summary

In summary, rationality, I argue, ought to be grounded not just in processes that have in the past been successful for a non-human animal, but also within the plasticity of an agent's cognitive processes that enable him to successfully adapt to the environment even at times when crucial information is difficult to obtain and an agent must, if he is to be successful, think on his feet. In other words, we ought to partly tie our conception of rationality to the idea that rationality is grounded in the flexibility of an agent's cognitive processes that enable him to successfully adapt to the environment even at times when relevant environmental information is hard to come by or costly. Rational behaviour can result from these flexible cognitive processes when it maximises his adaptive fitness. Embodied representations, as I have argued already in this thesis, can underpin flexible cognitive processing. They can enable a non-human animal such as a dog to respond quickly and effectively to his environment. In short, embodied representations assist the formulation of rational behaviour in dogs and other non-human animals.

Rationality for the non-human animal is behaviour which maximises the non-human animal agent's chances of success in his or her environment. This behaviour can be the result of flexible cognitive processes or the result of reliable processes which have in the past been successful. For those, like me, who adopt embodied cognition, the environment plays an active role in shaping an agent's cognitive processes. On Hurley and Kacelnik's account, cognitive processes that reliably lead to fitness maximising behaviour are rational processes and are predetermined by evolution. But as argued in the previous section, this conception of rational processes is as limited as if we were to accept only the internalist version (I.e. Kacelnik's PP-rationality).

The environment, the non-neural body and the brain all interact to produce reliable cognitive processes that inform rational action. Constantly, relevant aspects of the environment affect the agent's behaviour and brain and vice versa in a continuous feedback loop. Because of these interactions with the environment, there is also a great degree of plasticity in an agent's cognitive processes. Once we recognise the large part that the environment plays in shaping an agent's cognitive processes we can recognise that there is some degree of cognitive flexibility available to every agent interacting in the world. It is this cognitive flexibility that facilitates successful (fitness maximising) behaviour even in novel and/or hostile environments for which evolution cannot have kitted out the agent. Thus rational behaviour in novel situations can arise from these flexible cognitive processes. This thought is at the heart of embodied cognition theorist John Haugeland's remark:

> A sophisticated system (organism) designed (evolved) to maximise some end (such as survival) must in general adjust its behaviour to specific features, structures, or configurations of its environment in ways that could not have been fully prearranged in its design (Haugeland as cited in Clark, 2008, p.150).

Thus, taking an embodied approach to the study of non-human animal cognition allows us to see more clearly how rationality might be more liberally characterised to include the notions that rational behaviours result from reliable processes and that rationality can also be grounded in the flexibility of an agent's cognitive processes which enable him to successfully adapt to the environment even at times when relevant environmental information is hard to come by or costly. Such reliable processes include the mechanisms which involve embodied representations such as we have seen in Clark and Grush's emulation theory of representation and in Rowlands' representational actions.

I began this chapter with two questions:

1) Given our embodied cognition approach, under what conditions are the dog's actions rational?

2) And how does the dog fix upon rational course of action?

I then stated that I would answer them this way:

1) A dog's actions are rational (it makes sense to perform them in a particular circumstance) when they enable him to successfully adapt to the environment even at times when relevant environmental information is absent or hard to come by, or when the situation is novel.

2) The dog decides upon a rational course of action by employing processes that have in the past proved reliable in leading to successful and/or fitness maximising) behaviours in the current situation. Or, if processes that have in the past reliably lead to fitness maximising actions fail in a novel situation, a rational course of action is one which is adaptive in this novel situation.

Answer 1) gives an account of behavioural rationality. That is, it states under what conditions a dog's behaviours are rational. Answer 2) then claims that rational processes are those that reliably produce successful behaviour in the current situation, or are those adaptive behaviours which arise from flexible cognitive processing in novel situations. Moreover, embodied representations enable the dog to produce successful responses to his environment and are foundational to rational behaviour in dogs.

The conception of rationality which I have argued for above applies to both human and non-human animals. One of its strongest features is that it can cope with situation specific types of rationality that dogs and other non-human animals display. For example, a primate might behave in particular ways in certain contexts that she cannot generalize to logically similar contexts. Hurley asks us to suppose a monkey observes that another fellow monkey ‘a’ is dominant over monkey ‘b’. She also recognises that ‘b’ is dominant over ‘c’. Although she has never observed ‘a’ and ‘c’ together, she can realise that ‘a’ is dominant over ‘c’ and is able to use this information toward various ends (Hurley, 2006). ‘The ability to reason in this way in such a situation is not generalisable, however. For the monkey, while able to make transitive inferences in this context may not be able to in a foraging situation’ (Hurley, 2006, p.150). In other words, practical knowledge of how to complete tasks may be tied to specific situations. It is likely that the domestic dog occupies islands of practical rationality, and it is important that our notion of non-human animal rationality incorporates this.

We should expect rational actions and the rational processes by which the dog fixes upon the rational action to be tied to specific situations and not generalisable. For example, the processes that reliably lead to a dog’s success in a training task (such as coming back to a call) may not work when the situation is altered but the task has remained the same.

In conclusion, I have argued that we ought to be more liberal in our accounts of rationality and accept that rational processes are flexible and adaptive cognitive processes. They can also be those that reliably lead to rational behaviour in the agent's environment.

In short, rational behaviour in the non-human animal is behaviour that maximises fitness or is successful in achieving the agent's goals and embodied representations play a large role in the production of such behaviour.

Conclusion

This dissertation applied the embodied cognition framework to the study of domesticated dogs. I have argued that embodied cognition may be particularly valuable in the postulation of representation use in dogs. Embodied representations can help us to explain and understand certain behaviours and cognitive skills that we see in domesticated dogs. As mentioned at the outset, representation use by non-human animals is much discussed, but a clear and useful formulation of the nature of these representations was needed. I have outlined two main accounts of representation from within embodied cognition and argued that their application to the study of dogs is worthwhile. Their value lies in the provision of guiding principles which can positively impact on how we understand, study, and train dogs in their various walks of life.

The application of embodied cognition and embodied representations to behaviour and cognition in dogs can also shed new light on some of the conclusions drawn in the experimental studies. When applied to empirical research, the embodied cognition paradigm can also guide the formulation of the questions we ought to be asking. For example, rather than ask ‘can dogs count?’ we might instead examine situations in which an assessment of number may be advantageous to the dog and ask ‘what are the affordances open to the dog in situations where he faces, for example, a larger group versus a small one'? Then, 'What guides his rational behaviour in each situation?' Embodied representations can facilitate the flexible use of information enabling the dog to produce successful, adaptive and rational behaviours even at times when the dog is facing a novel challenge and is under significant time pressure.

Final comments

This dissertation hopefully provides a useful resource for researchers in dog cognition to focus on the dynamic interplay between the dog, his peers, environment and human counterparts. In addition, the findings of this study can enhance experimental design and inform the conclusions that we draw from empirical data regarding dogs' cognitive capacities and behaviour. I support studies with an ethological focus, designed for dogs rather than humans. I also make the case for a greater emphasis on the role of actions and the environment in the study dog cognition.

Moreover, I have argued that the adoption of two models of embodied representation can enlighten future research into dog cognition. In contrast to abstract theories of representation, we can see embodied representations come to life in dogs' daily interactions with their surroundings. Embodied representations can also underpin an account of rationality for non-human animals such as dogs.

As rational beings, dogs are ends in themselves, with intrinsic value that deserve respect and kindness on this basis. This thesis has opened up a new alternative to the idea that dog behaviour is the outcome of sub- personal conditioned responses. Instead their responses can be seen as the rational actions of an agent adapting to her environment.

In conclusion, this dissertation sprang from the need for a fresh approach to the study of dog cognition. Recent years have seen an increase in the number of studies on dogs, and this is a worthwhile endeavour. Dogs occupy a unique position in the animal kingdom and their long-standing close association with humans makes this species a fascinating and ideal subject to which we can apply the principles of embodied cognition in our efforts to understand them further.

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