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MYSTERIOUS WAYS: THE RIDDLE OF THE HOMING ABILITY IN DOGS AND OTHER VERTEBRATES

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ABSTRACT

The homing ability of animals has fascinated many laymen and scientists for some time. Despite considerable efforts by researchers to elucidate its underpinnings, however, it is still not known exactly how a bird, for example, can determine its longitudinal position on the globe and find its home from an unknown location to which it has been displaced. The same seems valid for terrestrial animals such as dogs. To bring this problem to renewed attention and to stimulate further research into this topic, this paper introduces two largely unknown sources dealing with the homing ability in dogs. Both contain remarkable instances of dogs that repeatedly returned to their homes or keepers from unknown locations. The first source concerns the work of Edwin H. Richardson with messenger dogs in World War I; the second source concerns the systematic homing experiments that Bernhard Müller performed between 1953 and 1962 with 75 dogs. Both authors maintained that the homing success of the dogs could not be explained in terms of the use of their usual senses alone. I go on to review currently available explanatory hypotheses for animal navigation with a focus on bird and mammal homing, and also touch upon orientation abilities in humans. This review shows that there is no consensus among leading experts with regard to the most suited model, and many admit that a conclusive explanation for homing is still lacking. Hence, an additional governing factor such as ESP might well come into play. Drawing on the training methods for dogs applied by Richardson, I suggest testing this hypothesis by training dogs to find their keepers at an unknown location.

INTRODUCTION

The ability of many animal species to find their way home across large distances, as well as from unknown locations to which they had been displaced, has intrigued many laymen and scientists for some time. And, although parapsychology classically centres on experiences of people (Irwin & Watt, 2007, p. 2), this subject has also been discussed by a few members of the parapsychological community, and, in fact, seems to have stimulated academic psi research in animals. In the middle of the 20th century, Joseph B. Rhine (1951) and Gaither Pratt (1953) were among the early authors who explicitly highlighted the potential connection between the homing ability of animals and extrasensory perception (ESP), and who pointed to the demand for clarifying studies.

In the meantime, scientists in the mainstream setting have created an enormous body of knowledge on the biophysical cues involved in animal orientation. Among vertebrates, the most extensive research has been performed with birds (Akesson, 2003; Bertold, 2012; Newton, 2008; Thorup & Holland, 2009), but terrestrial animals (Bovet, 1992; Linnell, Aanes, Swenson, Odden & Smith, 1997; Rogers, 1988) and aquatic species (Lohmann, Lohmann & Endres, 2008, Lohmann, Lohmann, Brothers & Putman, 2013) have also been monitored and subjected to numerous experiments. As a consequence of these results, it has seemed likely that psi would most probably not be involved in governing typical homing behaviour (e.g. Morris, 1977). But interestingly, although several

hypotheses have been put forward to explain especially the birds' homing success after displacements, there is still no certainty and consensus among scientists regarding the factors that guide these animals on their journeys (e.g. Bertold, 2012; Gagliardo, 2013; Newton, 2008; Thorup & Holland, 2009; Wallraff, 2005; Wiltschko, 1996). The homing ability of terrestrial animals seems equally unexplained and perhaps even more puzzling, given their comparably limited field of vision and relatively slow mode of motion.

Nevertheless, in contrast to researchers from the mainstream setting, parapsychologists typically have deemed the accounts about animals who found their owners at an unknown location to be of greatest significance in the context of the potential involvement of psi in animal navigation, because these animals would not be able to rely on biophysical cues to find their owners across considerable distances, some of which were more than several hundred kilometres (Gaddis & Gaddis, 1970; Rhine, 1951; Rhine & Feather, 1962; Sheldrake, 2011). Should this reported ability of many animal species, including birds, dogs and cats, be established experimentally, this might contribute significantly to elucidating the as yet unknown factors that govern 'normal' homing success, especially after displacement. However, with the exception of work conducted by Rupert Sheldrake (2002, 2011), practical experiments addressing this specific aspect of animal homing have not been conducted.[1] Taking into account the fact that animals appear able in principle to display psi abilities (for a review, see Dutton & Williams, 2009), it remains possible that ESP could play a role in governing the mysterious home-finding process of animals.

In the light of this perspective, the aims of this article are (1) to bring this possibility to renewed attention, (2) to stimulate further research into this topic, and (3) to introduce two largely unknown sources concerned with the homing ability in dogs. The first source reports the work of Edwin H. Richardson with messenger dogs in World War I, the second the systematic homing experiments that Bernhard Müller performed between 1953 and 1962 with 75 different dogs. These sources have not been cited in the literature on homing and animal psi up to today (e.g. Rhine, 1951; Rhine & Feather, 1962; Gaddis & Gaddis, 1970; Schwertner, 1984; Nahm, 2007; Sheldrake, 2002, 2011), and seem absent also from the mainstream literature with the exception of Bovet (1992), who mentioned Müller's study in passing. Both Richardson and Müller support the view of others who have maintained that the dog's homing success

[1] Sheldrake (2002, 2011) has also drawn attention to the phenomenon that some animals, in particular dogs, seem to be able to know in advance when their owners are coming home. His practical experiments strongly supported this appraisal. It seems little known that Schwertner (1984) had already conducted similar experiments. He stated that it would be fairly well known among dog and cat owners that some of their pets know when their owners return home. Schwertner briefly described experiments he performed with two dogs that lived in the same house, and with their keepers or unknown persons, respectively. A keeper or an unknown person would return to the home of the dogs in a car, either in their own car or in a car unknown to the dogs, while the dogs stayed at home, not being able to see the arriving car. One of the keepers stayed at home with the dogs. From the possible combinations, the following situation called most explicitly for an extra-sensory explanation: a beloved keeper was driven home in a car and by a driver unknown to the dogs. The dogs still reacted in a manner that strongly implied that they anticipated that a loved one would return home. The reactions of one dog were more reliable than the reactions of the other dog (Schwertner, 1984, pp. 59–63).

cannot be fully explained in terms of the use of the 'normal' senses alone.

In the first two parts of the present article, I present summaries of these two sources. In the subsequent parts, I present brief reviews of currently available explanatory hypotheses for bird and mammal homing, and explain why—in contrast to the prevailing 'common' opinion typically spread via public media — they are regarded as unsatisfactory even by experts in this field. The last part before the Concluding Remarks section also includes a short discussion of the homing ability in humans.

The Work of Edwin H. Richardson with Dogs in World War I

Colonel Edwin Hautonville Richardson spent many years training dogs of various kinds (Richardson, 1910; Richardson & Richardson, n.d. [presumably 1951]), and established the British War Dog School in Shoeburyness in 1917 (Richardson, n.d. [presumably 1920], 1921). In this school, hundreds of dogs were trained to act as messenger dogs and sentries close to the front line in World War I. Here, I focus on the ability of the messenger dogs to return to their keepers through unknown terrain. Richardson's interest in the homing ability of dogs was first raised when his first dog found its way home from the centre of Brighton, where it had got lost in crowded streets. It was the dog's first visit to Brighton, and he was taken there in a carriage on a winding and "not at all direct" route. Richardson's house lay "several miles" behind Brighton, but the dog was seen heading towards the house in the evening, apparently travelling "over land he had never seen before, and in a totally different way of travel from that on which he had set out in the carriage that morning" (Richardson & Richardson, n.d., p. 24). In the following, I cite excerpts from an article that Richardson (1921) had published in a little-known journal named *Psyche: A Quarterly Review of Psychology*. The paragraphs below summarize Richardson's main thoughts and findings regarding the subject in question (pp. 52–53):–

> The subject of homing instinct is one which leads into many interesting fields of investigation, and is certainly of peculiar attraction to those whose perception is awakened to the fact of causation in mind . . . My own actual experiences connected with this form of intelligence have been almost entirely with dogs, in whom this instinct is very highly developed. The intensity, however, differs in individual dogs, and also in various breeds. During the war several hundred dogs were trained as messengers and dispatch carriers. The training for this work was based on the homing instinct, but I found it necessary at the training school to study the psychology of each dog as the bent was much more highly developed in some dogs than in others. Dogs of wise and affectionate natures were the only ones of any use in the strenuous work they had to perform in the field, and the great lever by which the homing instinct was initiated, was that of devotion to the man who was deputed to be the dog's keeper. A dog could be taught the duties of messenger service mechanically, but when it came to maintaining this effort in the field only some very powerful emotion could enable it to overcome the obstacles in its way. In briefly describing these obstacles, I will explain that the messenger dogs for the British Army were concentrated in units behind the line and were dispatched in groups to those parts on the line where particularly strenuous fighting was expected. They went up in the charge of their keepers, each man having three dogs. Having arrived at Brigade headquarters the keepers remained there and the dogs were taken from them by troops occupying the front line . . . They were frequently taken up to their posts at night, over ground utterly unknown to them previously, and were released some hours afterwards with their messages. Sometimes

> they returned by the way they had been taken up, but more often chose a more direct route straight across the country . . . It will be remembered that this would lead them over trackless ground, or along trenches and roads crowded with every sort of traffic, through villages full of troops and every sort of obstruction and temptation. That these dogs accomplished this work is one of the wonders of the war. *How* they did it cannot be fully explained, for the reason that we do not fully understand the influences which control the animals when under an overpowering desire to return to the place from whence they came. Suffice it to say that it was the determination to return to a beloved master, as represented by his keeper, and that as a result of this emotion, portents and signs indistinguishable to man were waymarks on the journey.

In a preceding book, Richardson described the methods applied in the training and the use of messenger dogs in more detail. He also dwelt more extensively on the 'homing instinct' of these dogs (Richardson, n.d., pp. 163–182). Again, he maintained that their homing ability could not be explained by means of the dogs' usual senses, such as sight, hearing or smell. The sense of sight could be ruled out because the dogs found their way back to their keepers in full darkness or thick mist through trackless country unknown to them. In fact, it seemed as if

> trained dogs, and even half-trained ones, work better under these conditions than in daylight. And this was also borne out in the field. The keepers have related to me that on certain nights, when the conditions were so bad, the night so dark and thick, the ground so water-logged and shell-marked, and on certain occasions quite new to the dogs, that they were fearful that these would prove too much even for their faithful followers. But the curious point was brought out, that the dogs seem to work much better than usual, at such times. As one man said: "It seemed as though 'Jock' divined my fears, and put out an extra effort to show they were needless" [pp. 172f]

According to Richardson, hearing and smell could likewise be ruled out because the dogs often chose different routes for their return, across unknown country without trail (p. 163). Richardson also related cases from "civilian canine life" in which dogs were said to have got home across considerable distances (p. 164). Hence, he concluded "that the causative guiding source of the homing faculty has its origin in the realm of metaphysics, rather than in external phenomena, and if any explanation is sought, it is here that investigation should be made" (p. 174).

When Richardson began the training of dogs, he first used a fixed base, then a movable base, and he carried the dogs to the place of their release on a roundabout route. In general, he recommended leaving the dog one or two days with the keeper at the Brigade headquarters before sending it to the front. However, dogs were also able to find their keeper when they were removed from him immediately after their arrival at the headquarters (pp. 105–108). Typical distances that the dogs had to cross were from 3–6 km, but Richardson also lists examples of the dogs returning to their keepers from distances of 10, 14, 17, 17 and 22 km. With regard to the training and the development of the homing ability, he reasoned

> that observations seem to point to the fact that the intense desire to reach a given place impels the dog forward; that as it yields to this impulse, that a certain guiding sense, which is in itself quite independent of any assistance from external phenomena, comes to its aid, and the sense of direction is, in this very sense—that the dog desires to be there, and follows this desire, rather than troubling about the aspect of the surroundings in getting there. The more it becomes accustomed to throw all its effort

> into this intuitive prompting, the more it discards any temporary assistance it may be tempted to use, in the first place, such as noting turns in the road, and other external aids, and also the more it improves in its way-finding duties. The deduction, in fact, seems to be plain, that the desire itself brings its own lesson, and a world of intelligence is opened up to the dog, and to all animals, under stress of this governing force, of which we human beings are quite unconscious, because we have not yet exercised this particular mental effort along the same lines as the animals. It will therefore be seen, that those promptings which have their origin in what we call instinct, are due to an intelligence quite apart from, and infinitely above, any guidance from the senses.
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> [p. 179]

Comments on Richardson's Work

With regard to this claim, it is of interest that, as mentioned, the dogs were even able to find their keepers at locations where the keepers simply stayed behind while the dogs were moved onward. In these cases, the dogs had no opportunity to become acquainted with the place the keeper would remain in. Such observations highlight the possibility that the homing ability of dogs might indeed not be restricted to a given geographical location, but that the keeper himself might be the target of location—irrespective of his whereabouts. In fact, the ability to find a beloved keeper at an entirely unknown location after displacement of the dog to another location would be much more difficult to explain than a dog's returning to a known location from an unknown place. The supposition that some animals are in principle capable of finding their attachment figure at locations entirely unknown to them is supported by anecdotal reports (Gaddis & Gaddis, 1970; Rhine & Feather, 1962; Sheldrake, 2011). This, however, was not the case with Richardson's dogs. They had always spent some time with their keepers at the location where the keepers remained, even if only a very short time. Thus, suggestive as the reports of Richardson are, it is unfortunate that he did not conduct the *experimentum crucis* that, in case of success, would have removed doubts in this respect: after sufficient training in the usual way, he could have reversed the task, leaving the dogs at their base and hiding their keepers at continually increasing distances. If some at least of the dogs had successfully located their keepers, this would have had considerable impact on current explanatory models for goal orientation in animals (see below).[2] Moreover, remarkable as Richardson's findings are, his descriptions are not as detailed as one would wish them to be from a critical perspective. It is apparent that his observations regarding the peculiar homing ability of his war dogs were only a sideline of his comprehensive work with them. Systematic experiments with a scientific background are described in the next section.

The Work of Bernhard Müller on the Homing Ability of Dogs

Before I review the work of Swiss researcher Bernhard Müller (1965), I will briefly sketch a conceptually similar approach that was applied earlier by

[2] In fact, the German army had trained messenger dogs not only to return to their base from the front line, but also to go back again from the base to a second keeper at the front line (Richardson, n d., pp. 74f, 256f). This two-way system, however, relied on familiarity with the terrain and the routes to choose, and was not exclusively founded on the emotional bond with the dogs' keepers. Richardson abstained from training for this two-way approach because it was more difficult and time-consuming to train, and fraught with several difficulties, especially in times of war.

behavioural scientist Bastian Schmid. Apparently unaware of the abilities of messenger dogs, it seems that he performed the first systematic experiments to explicitly assess the homing ability of dogs (Schmid, 1932, 1936; for a summary of Schmid's work, see Sheldrake, 2011). In these experiments, the behaviour of three dogs that were displaced to an unknown location 4–5 km distant as the crow flies was continuously observed by Schmid and several helpers. Two dogs found home successfully on all trials performed with them (three and two trials, respectively). One dog was tested in a rural area, the other in the centre of a major city, namely Munich. The latter's success is especially remarkable because being displaced to an unknown location in 4.5 km air-line distance in the centre of a large city with street canyons on plain ground effectively rules out orientation by sight, and it would likewise be very difficult to detect salient familiar odours. The third dog failed on three occasions to find home in a rural area, even when he had full view of a location very familiar to him. Curiously, the successful dogs didn't seem to use their noses on their way home; they didn't sniff for cues close to the ground, or in the air. After an initial phase of orientation, they simply trotted in a homeward direction with raised heads. Tentatively, Schmid attributed their success to a hitherto unknown sense, an "absolute sense of orientation" (Schmid, 1932, p. 156).[3]

Whilst Schmid's exploratory study is regularly cited (e.g. Rhine, 1951; Sheldrake, 2011), the largely unknown experiments performed by Müller (1965) represent the most extensive and systematic study on homing dogs ever performed. Between 1953 and 1962, Müller experimented in Switzerland and Nepal with 75 dogs. The ideal test series for a single dog consisted of four runs from the same release site at a distance of 2.5 to 3.0 km from the home territory, four runs from a different release site at 5 to 7 km distance and shifted clockwise through an approximate angle of 120°, and four runs from a distance of 10 to 89 km, shifted another 120°. Hence, a complete test series consisted of 12 runs that started at three different locations.

Of these 75 dogs, 19 completed the entire series successfully, seven started successfully but didn't complete the series for different reasons, and 49 didn't find home in the first runs and were not studied further. In total, Müller recorded 249 successful homing tests. The dogs were carried to the release sites in closed baskets by a variety of forms of transport, usually via complicated detours. Experiments were carried out in all weather conditions including rain, snowfall and fog, by day and night. To document as many details of the dogs' behaviour as possible, Müller used stationary and mobile observers along the potential tracks they might take, and he tried to follow the dogs at a safe distance. In no case did the dogs follow the route they had been taken to the release site.

Prior to the tests, Müller determined the dogs' social status by a number of selected behaviour characteristics, and classified them into three categories:

[3] Another early series of systematic displacement experiments was performed by Francis H. Herrick (1922). He performed eight tests with a cat that didn't return after the last trial. Herrick stated that its homing success could not be attributed to vision, hearing or smell. But because his cat seemed to have difficulty finding home after it had once been displaced during anaesthesia, he tentatively attributed its homing ability to the kinesthetic sense.

dominant alpha-animals, submissive omega-animals, and dogs that belonged to an intermediate group. He assumed that with increasingly higher rank, the 'value' or the importance of the home territory for the dogs would increase, and would thus result in a greater homing impulse and success. Müller's results strongly confirmed this assumption. All 22 dogs classified as alpha-dogs belonged to the 26 dogs that completed the entire test series successfully or that started successfully; the remaining four dogs belonged to the upper midfield. Of the 27 dogs classified as omega-dog, none returned home. Usually, these dogs would look for human settlements, no matter in which direction, and try to associate with humans, or in the case of Nepalese street dogs, other dogs, and stay there. The homing impulse seemed to be absent.

The alpha-dogs, on the other hand, would spend a typical adaption phase in the surroundings of the opened basket (Müller divided this phase into three stages), and then leave the release site, determined to go home. On their way, they would avoid any contact with people. A very characteristic bearing of a dog on its way home after the initial orientation phase was to hold its head high and in a peculiarly stiff manner when trotting, its eyes appearing somewhat "veiled". Often, and seemingly untypical of the dogs' normal behaviour, they would stumble when the soil was uneven, or even collide with low wire fences. Müller figuratively described this behaviour as if the dogs were "ridden by an alien force". In general, orientation by vision seemed to play a negligible role in their journeys. During the repetition tests on the same release sites, the dogs displayed all three stages of the agitated initial adaption phase again and typically commenced their homing phase from a different spot of the release area. Similarly, even when they reached the same bottleneck such as a ridge or a pass on each repetition test, they would again take different routes thereafter. Should they have recognized characteristic topographical features of these places, they didn't seem to utilize this knowledge. Rather, they used new and typically shorter routes on each repetition, which sometimes led them over different mountains and through different valleys. Hence, the dogs seemed to have learned how to choose the correct direction in a general sense, and were able to adjust their routes accordingly.

However, despite the many details that Müller's experiments with homing dogs brought forth, he remained at a loss to explain its underpinnings. Müller postulated a "polarized sense of direction" that would extrapolate the intra-territorial orientation of dogs also to remote places, but he could not explain its *modus operandi*. Moreover, he discarded as insufficient the existing models that were promoted to explain the homing success especially of birds, and postulated that if the ability found in bird species to use "absolute reference systems" analogous to the sun compass were to be detected in dogs, the problem would again be solved only in part. It would still remain unclear how the animal could determine its geographical position and the direction to choose at the release site.

Apparently, this problem is still unsolved. Because one may think that the dogs' ability to find home might be related to the same ability known from birds (especially pigeons), and that both feats might even rely on similar cues for orientation, I will introduce unsolved enigmas of bird migration research in the following section of this paper. The current hypotheses about homing

birds will be followed by those for mammal homing, and I will also touch upon aspects of spontaneous spatial orientation in humans.

Explanatory Hypotheses for Bird Homing

In the academic literature on migration, scientists distinguish between normal *orientation* and *navigation*: orientation (or compass orientation) refers to the ability of animals to align their movement direction to external stimuli such as the sun or the earth's magnetic field; navigation (or goal orientation) refers to the ability of animals to find their way to a defined location from another, often unknown, location to which they had been displaced, and it comprises the orientation towards the defined location at the release site (Berthold, 2012; Thorup & Holland, 2009). The homing success of dogs is an excellent example of animal navigation. To understand what is currently known about animal navigation, it is recommended that we look first at research performed with birds, because the largest series of experiments have been performed with these animals. As a result, it is now known that perhaps all birds—migrating and also non-migrating bird species—possess the ability of navigation. Hence, it should suffice here to cite Peter Berthold, a leading authority in the field of bird migration research, who summarized the state of knowledge in the scientific German standard handbook on bird migration as follows:–

> According to the results of thousands of displacement experiments . . . we must assume theoretically, or as a working hypothesis, the following: after a displacement to an unknown location, every bird can (1) determine its geographical position at the release site in relation to the starting point, and (2) return to this starting point—provided that the bird is healthy and is tested within the scope of its bodily spectrum of performance . . . Frequently, the spontaneous and rapidly performed initial orientation at the release site already points towards the target place; and direct observations, retrieved rings, calculations of flying times, and telemetry studies prove that frequent essentially direct return flights are made by the shortest way.
>
> [Berthold, 2012, p. 182, my translation]

Many different cues that seem to govern orientation are discussed by ornithologists, such as a sun and star compass, a geomagnetic compass, wind directions that are integrated in terms of angles to compass references, atmospheric chemosignals, and visual landscape features. But because these cues only guide orientation but don't explain navigation, it is often thought that birds are somehow able to align these cues with an internal map of the earth's surface, of supposedly characteristic features of the earth's magnetic field, or even with an olfactory map, and thus find their way home (Akesson, 2003; Berthold, 2012; Gagliardo, 2013; Newton, 2008; Wallraff, 2005). Yet, it is difficult to imagine how and why birds, even non-migratory species, should possess an internal map of the earth's surface that includes geomagnetic and/or olfactory features for long-distance homing from locations they have never been to, and topographic features for shorter distances, as it is often assumed. Thus the concept of an internal map still needs to be regarded as a hypothesis that has not so far been well established (Thorup & Holland, 2009; Berthold, 2012). Consequently, scientists seem at a loss to explain how bird navigation works. In the words of Berthold:–

> It needs to be stated explicitly at the outset that, up to the present, it is entirely

> unknown how determination of their geographical positions and destinations is performed by birds. This is the last big riddle of animal migration. There exist neither explanations nor fully satisfying hypotheses. [Berthold, 2012, p.167, my translation]

Many other authors advance similar concerns, although in less drastic terminology. For example, Wallraff (2005, p.189) states that "even the basic features of pigeon homing are not yet understood in full detail". Newton (2008, p.265) concludes that in addition to compass orientation systems, "birds also have a map sense that enables them to find familiar places again, often by direct flight. Exactly how they achieve this remains a mystery, despite our knowledge of the directional cues involved", and Thorup and Holland (2009) assert that it is still unknown how birds determine their geographical position on the globe, especially with regard to longitude. In fact, tests of the different possible cues that guide orientation have usually led to inconsistent or contradictory results. At present, the most intensely discussed cues that may govern bird navigation are geomagnetism and airborne odours. In the sections that follow, I provide a very brief overview of these two subjects.

Geomagnetism as Potential Factor Guiding Navigation

Regarding geomagnetism, it is established that the homing success and the straightness of homing routes taken were not impeded in experiments when birds were fitted with magnets or electric coils that disturbed the perception of geomagnetic cues (e. g., Bonadonna, Benhamou & Jouventin, 2003; for other references see Wallraff, 2005). Besides, geomagnetic cues rarely contain three-dimensional information that would allow a bird to determine its geographical position at the release site after it was transported there without having access to any kind of useful cues. Magnetic patterns may also be largely distorted in areas with geomagnetic anomalies, and geomagnetic parameters at a given location may change considerably during the timespan of a long-lived bird; even the positions of the magnetic poles move over the centuries. Furthermore, the geomagnetic field is prone to disturbances from solar flares (Sheldrake, 2002; Newton, 2008). Consequently, proponents of the olfactory approach stress that the geomagnetic sense might play only a minor role in bird orientation, and perhaps none in navigation (e.g. Wallraff, 2005; Gagliardo, 2013).

Volatile Chemosignals as Potential Factors Guiding Navigation

In fact, and surprising as it may be, the experimental evidence in favour of the olfactory hypothesis appears to be more convincing (Gagliardo, 2013; Papi, 1991; Wallraff, 2005). Nevertheless, it is still regarded with great scepticism in the ornithological community — some authors don't even seem to consider it worthy of explicit discussion (Newton, 2008; Wiltschko & Wiltschko, 1999). Indeed, conceptual difficulties make it problematic to imagine how exactly the olfactory system would govern the pigeon's flight (Berthold, 1996, 2012; Gould, 2009; Gould & Gould, 2012; Rozhok, 2008; Sheldrake, 2002; Thorup & Holland, 2009; Wiltschko, 1996). To find home using olfactory cues, pigeons must detect a gradient of familiar molecules in the atmosphere, or stable ratios of different volatile compounds. Yet, the air above a given geographical region is rarely in a stable condition. Sometimes, masses of air displaced in their entirety, some are divided into different layers, or are mixed with other layers.

It remains to be established whether the postulated molecular gradients are detectable under these conditions over distances of hundreds or thousands of kilometres, and whether these kinds of distinct atmospheric gradients exist above the uniform surface of oceans, as suggested by some (e.g. Bonadonna, Benhamou & Jouventin, 2003), and what the nature of these compounds might be. Furthermore, especially in certain regions of the earth, the wind direction changes frequently, and thus will make it difficult to detect and follow a stable gradient of osmophorous molecules. Müller (1965) stated that the direction of the wind did not affect the dog's homing success, and excluded an olfactory mechanism for dog homing.

Conclusions about Bird Navigation

Given such practical and theoretical difficulties that surround each of the proposed guiding cues, ornithologists postulate that orientation, and most likely also navigation, is mediated by a complex redundant system that integrates different cues, which themselves include different sub-systems (Berthold, 1996, 2012; Newton, 2008). Nevertheless, it remains unclear how exactly this is supposed to work. The unsolved question about how birds can possess an "internal map" of whatever kind, even for regions unknown to them, adds additional weight to these difficulties. Hence, ornithologists are still engaged in controversial debates. Some simply seem to hope that one or more of the possible methods of navigation would work somehow without going into details (e.g. Rappole, 2013), and proponents of a certain approach neglect references to contradictory or problematic findings (Gagliardo, 2013; Wiltschko & Wiltschko, 1999, 2010). Still, all are in principle unwilling to take potential unorthodox cues such as extra-sensory perception (ESP) or 'morphic fields' in the sense of Sheldrake (2002, 2011) as a plausible governing factor into account. If ESP or morphic fields are mentioned at all, they are rejected with utter conviction (e.g. Wallraff, 2005).

Explanatory Hypotheses for Mammal Homing

The homing ability of mammals is fascinating in its own right and might even contribute to a better understanding of the homing ability in birds, although it is not clear how far cues governing mammal homing are relevant for bird navigation. In a more practical sense, mammal homing is of importance in the context of the removal of 'nuisance' animals (large carnivores, bears, or elephants, and in the context of (re-)introducing individuals of endangered species into a new territory (for reviews, see Rogers, 1988; Linnell et al., 1997). Some animals that have been displaced in these contexts have successfully found home across large distances. For example, a white-tailed deer travelled 560 km, a polar bear returned from 470 km away, a bat from 320 km (Rogers, 1988), two cougars found home from distances of 465 and 490 km (Ruth, Logan, Sweanor, Hornocker & Temple, 1998), and a bear returned home from 389 km (Landriault, Hall, Hamr, & Mallory, 2006). Among reptiles, a crocodile that was flown across Cape York in Australia (air-line distance 126 km) followed the coast line of Cape York for 411 km until it reached its home again, thereby continuously increasing the distance to its home territory during the first half of its travel (Read, Grigg, Irwin, Shanahan & Franklin, 2007). Sheldrake (2011)

lists several anecdotal reports in which dogs and cats, but also horses, sheep and a pig, found their way home after being displaced to distant locations unknown to them. Yet experimental research that has addressed potential underpinnings of the homing abilities in terrestrial mammals in the wild is clearly under-developed.

Research into Mammal Navigation

Many experiments have, however, been performed to assess the *initial orientation* of mammals after their release at an unknown location. Sometimes the animals, often small rodents, were released from a cage in the field, but these experiments are difficult to interpret because the agitated animals might look for shelter in the first place instead of identifying their homeward direction (Bovet, 1992). In other experiments, animals were put into symmetrical labyrinths or orientation arenas in a laboratory. A classical test series was performed by Precht and Lindenlaub (1954) with several dozen cats. They used a labyrinth with a radial symmetrical base area, and transported it to different locations unknown to these animals. The cats themselves were transported in sacks that prevented them from seeing their surroundings. By observing through which of 24 exits the cats were leaving the labyrinth, the authors intended to determine the initial orientation of the displaced animals. In two experimental series, the cats left the labyrinth in the direction of their home with a statistically highly significant frequency—at least, if the displacement distances were not greater than 5 km. At a distance of 12 km, the results were distributed more or less evenly. Lindenlaub (1955, 1960) repeated these experiments successfully with mice. They even preferred their home direction when the labyrinth was placed under a Faraday cage, thus excluding the possibility that they made use of electromagnetic cues (Lindenlaub, 1960). Bovet (1971) pointed out that the best results had been obtained by Lindenlaub and by himself, and also by another experimenter (Fisler, 1967) when all visual clues were removed from the mice. Karlsson's (1984) results obtained with bank voles support this finding, but only with adult and sub-adult individuals that already possessed a home range. These observations seem in line with Richardson's assertion that his dogs often found their keepers better on black nights or in mist than in daylight with several stimuli affecting their usual senses, or after explicit training to disregard these stimuli. Karlsson's observations also seem convergent with Müller's finding that the homing ability was most pronounced in alpha-animals for whom the possession of a home territory seemed most important.

Explanations for Mammal Navigation

In general, it is thought that mammal navigation functions along similar lines as bird navigation, with a geomagnetic sense playing the most important role. In fact, there is a growing body of evidence that shows that mammals are able to perceive geomagnetic cues (Begall, Burda & Malkemper, 2014; Begall, Malkemper, Červený, Němec, & Burda, 2013). Also, dogs seem to be sensitive to the earth's magnetic field, even to small variations of it (Hart et al., 2013). But again, it remains unclear to what extent this (subconscious?) ability to perceive geomagnetic stimuli might help them to navigate home, especially

if animals such as dogs change their alignment and thus their orientation, according to small geomagnetic alterations and variations, as reported in Hart et al. (2013). Obviously, a cue that would allow for proper navigation should be as stable as possible to avoid the choice of wrong directions because of cue fluctuations.

As for humans, most attempts to find a geomagnetic sense for orientation were unsuccessful, and the few positive results need to be regarded with caution (Begall et al., 2013, 2014; Bovet, 1992; Finney, 1995).[4] However, anthropologist Ben Rudolph Finney (1995) described two instances of persons who successfully determined directions in small sailing canoes when they were sailing without technical aid across the open sea. When no cues for orientation were available, one of them concentrated intensely and slowly rotated his body until he felt that a certain direction felt different, correctly assuming that this was South—a typical example for orientation. The other, a Hawaiian named Nainoa, Finney's navigator with whom he sailed thousands of nautical miles across the Pacific Ocean, was apparently even able to perform proper navigation. Once, Nainoa relaxed after a prolonged and desperate struggle to find a visual cue in a black night on the ocean with shifting winds. Suddenly, he felt a strange calmness, and "knew" where the moon was. Nainoa described it as if "there was something that allowed me to understand where the direction was without seeing it. And it was almost like I would just give up fighting to try to find something with my eyes" (Finney, 1995, p. 503). On later voyages, Nainoa has allegedly had similar experiences, and he started to cultivate them. Finney reports that he strived "to keep his mind blank and avoids straining to detect direction from the wind, swells, or glimpses of celestial bodies through the overcast. Then, when he gets a directional feeling, he tries to accept it without question, for 'if you doubt your feelings you are lost'" (p. 503). Sometimes, Nainoa would even see a mental image of the location and the distance of islands he was approaching. Finney speculated that these individuals were able to apply correctly a usually unconscious sense of direction that would be based on geomagnetism. But again, I find it hard to imagine how one can detect the position of the moon or an island out of sight with a sense of direction that relies on magnetism.

Concluding Remarks on the Homing Ability of Dogs and Other Vertebrates

Although many hypotheses have been put forward to explain bird and mammal navigation, and even though some are obviously relevant for animal orientation, there is at present no conclusive theory for navigation, and also no consensus among scientists with regard to the most suitable model. This is especially valid for the most intriguing cases, such as Müller's dogs or Nainoa. Apart from that, what may be learned from the literature reviewed in this article is the following:–

[4] It seems that most humans are not even able to sense a strong magnetic field. This has already been tested frequently in the context of *Animal Magnetism* and the researches on the odic force postulated by Karl von Reichenbach (for a review, see Nahm, 2012). Only some 'sensitives' were found to be able to detect the presence of a strong magnet in the dark.

- Dogs, but also other terrestrial vertebrate species and humans, seem to have access to an as yet unexplained ability to locate their home.
- Not all animals of a given species display the impulse and/or the ability for homing. One factor that determines whether animals make use of their homing ability appears to be the social ranking of the individual and the emotional bond with its home.
- This ability appears to work most reliably under conditions when no distinctive external cues are available, and possibly after entering a special state of mind. Finally, homing dogs seem to assume a characteristic posture, trotting home with raised heads and without sniffing, once they have successfully orientated themselves towards their goals.
- The 'sense of direction' can apparently be trained in individuals receptive to it.

As mentioned already, there are numerous anecdotes in which an animal found a beloved person, rather than a definite location, from another location (Gaddis & Gaddis, 1970; Rhine & Feather, 1962; Sheldrake, 2011). Given the truth of these anecdotes, they would fit easily into the deductions just presented, and they would clearly demonstrate that the usual hypotheses to explain navigation need to be supplemented by an important factor akin to ESP. Indeed, Richardson also thought along these lines; in his last book (Richardson & Richardson, n.d.), he stressed again that the homing ability of dogs could not be explained with the use of the normal senses, and likened it to clairvoyance (p. 164). In addition, he included several anecdotes that in his opinion demonstrated telepathic interactions between dogs and their keepers, and other dogs.[5]

The hypothesis concerning the proposed additional factor aiding navigation can be tested experimentally. A promising approach would consist of training animals to find a beloved person, or a beloved mobile home. Sheldrake (2002) has already attempted to train pigeons to locate displaced pigeon lofts. These attempts failed for various reasons, and the implementation of the required training and tests was time consuming and far from being trivial. Training dogs along the lines described by Richardson (n.d., 1921) might in principle be cheaper and easier, although many dog owners might be reluctant to offer their dogs for experiments. Hence, the final stages of these tests especially should be performed over sufficiently large and safe terrain. Moreover, it is not necessary any more to employ teams of observers to follow the dogs on their

[5] Some of the reports Richardson cited related to crisis experiences, and they were taken from the *Journal of the Society for Psychical Research*, the *Revue Spirite*, the *Annales des Sciences Psychiques*, and *Light*. Apparently, he showed interest in psychical research. Richardson also mentioned in passing that he once lived in a haunted house, one wing being disturbed by "unaccountable noises and happenings". The dog he lived with at that time was afraid of this part of the house and never went there (Richardson & Richardson, n.d., p. 23). Moreover, he reported an example of a mother who was searching for the spot where her son died on the battlefield (Richardson, 1921, p. 54). She was accompanied by two officers with a map of the site. While the officers searched the location with the help of their maps, she waited, and had the distinct feeling that they were searching in the wrong places. After several fruitless attempts, they followed the mother to where she would have gone to from the start, and she was right. She told Richardson that she "just knew" where the place was. Readers familiar with the literature on psychical research and crisis experiences in particular might not be surprised by such accounts, but their possible relation to animal navigation is intriguing.

routes, as it was the case in the experiments of Schmid (1932) and Müller (1965). A convenient way to monitor the whereabouts of the dogs constantly consists in fitting them with tracking devices such as are used in telemetry studies. The signals emitted would enable a dog to be retrieved if it got lost, and allow their routes to be studied in far more detail than previously possible. Considering the apparent impasse of current research into animal navigation, and the enormous efforts, financial budgets, technical equipment, and intricate experimental designs that have already been employed in researching animal homing over the last century, such experiments appear comparatively cheap and realizable. They might result in intriguing findings that would complement and advance the presently available hypotheses on animal navigation in important respects.

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