No evidence for magnetic alignment in domestic dogs in urban parks

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Abstract

Spontaneous Magnetic Alignment (SMA), or the phenomenon by which animals orientate their bodies non-randomly with respect to a magnetic field, has been demonstrated in many taxa. While a 2013 study could only detect SMA in domestic dogs under calm magnetic field conditions, a more recent study has reported an extremely strong effect of magnetic alignment in individuals observed in urban dog parks. Here, we replicate their methods by measuring the magnetic orientation of dogs during excretion (urination or defecation) in five dog parks in the city of Lyon, France. We report no detectable SMA, though the alignment of the dogs was non-random relative to the orientation of the parks in which they were located. We suggest that urban dog parks present many distractions to dogs, all of which have the potential to influence the orientation of dogs during excretion. We discuss the potential of unconscious observer bias by the volunteer members of the public who collected the data. Though we recognise the benefits of citizen science, we recommend that in such cases caution be exercised and safeguards put into place to minimise observer bias.

Keywords

Spontaneous magnetic alignment, magnetic orientation, domestic dog, magnetoreception, citizen science, replication

Introduction

Many animals have the ability to detect the Earth's magnetic field. For some, this magnetoreception is used as an onboard navigation system (Walker et al., 2002). The most well-known examples of such guided navigation are the long-distance journeys of migratory animals such as birds (Chernetsov, 2016) and sea turtles (Lohmann et al., 2004), though the magnetic sense has also been observed as a navigation tool during shorter-range homing behaviors, in animals such as newts (Fischer et al., 2001) or bats (Holland et al., 2006).

A more surprising finding, however, was that some animals spontaneously orientate non-randomly with respect to the Earth's magnetic field, a phenomenon known as Spontaneous Magnetic Alignment (SMA). Though discussed as early as the 1990s (Wiltschko and Wiltschko, 1995), this phenomenon was further brought to light by a high-profile 2008 study, in which the authors found, by analysing satellite imagery, that resting and grazing cattle have a preference for spatial alignment along the North-South axis (Begall et al., 2008). Since then, many other taxa have been found to align their bodies roughly along the North-South axis, such as fish (Hart et al., 2012), turtles (Landler et al., 2015; Landler et al., 2017), corvids (Pleskac et al., 2017) and lizards (Diego-Rasilla et al., 2017). However, SMA is not restricted to the North-South axis, as newts (Schlegel, 2007) and mole-rats (Oliveriusova et al., 2012) seem to prefer the East-West axis, and cockroaches orientate towards any of the four cardinal points (Vacha et al., 2010).

Though the adaptive significance of SMA remains enigmatic (Begall et al., 2013; Diego-Rasilla et al., 2017; Pleskac et al., 2017), its occurrence has been reported in many taxa and by many studies. However, the effect sizes reported in studies of SMA usually indicate that in a given species, SMA is never evident to such an extent that an overwhelming majority of individuals are oriented in exactly the same direction. Rather, it is most often manifested by a subtle trend in favour of one of the magnetic cardinal axes.

Domestic dogs (*Canis familiaris*) have been reported to be sensitive to the Earth's magnetic field, as they have been found to run along the North-South axis (Benediktova et al., 2020), to be able to detect bar magnets (Martini et al., 2018), and to preferentially choose a food dish placed to the North (Adamkova et al., 2017). Additionally, a behavior of magnetic alignment (SMA) in dogs during excretion (i.e., urination and defecation) was reported in a 2013 study, but could only be statistically detected under calm magnetic field conditions (Hart et al., 2013). This finding led the authors to hypothesise that failing to account for magnetic field conditions in statistical analyses of SMA may lead to highly scattered and non-significant data, and may impede the replicability of some findings. Yet, a 2020 study of SMA in dogs by Yosef et al., which did not account for magnetic field conditions, revealed a surprisingly highly significant North-South alignment in the body axis of excreting dogs (Yosef et al., 2020). The effect size was such that among 1,823 observations, only approximately 4% of individuals showed a body orientation deviating from more than 20° on either side of the magnetic North-South axis. To our knowledge, this is a much stronger effect size that any other SMA study in any species.

Given the surprisingly high effect size obtained in this study and the considerably more mitigated findings of previous similar studies (of dogs and other species), we believe that this study is worth replicating. We therefore measured the spatial orientation of excreting dogs in conditions similar to those of Yosef et al. (2020).

Materials and methods

Data collection

Yosef et al. carried out their observations in various urban dog parks in Israel, centered on Eilat (Yosef et al., 2020). Similarly, we observed excreting dogs in five different dog parks ranging from approximately 300m^2 to 2300m^2 and located in the city of Lyon, France, in May and June 2021. Given that urban dog parks are rectangular zones with relatively small surface areas and are enclosed by fences or walls, we also chose to record the orientation of the longest side of the park, to later account for any potential influence that the orientation of the park may have on the behavior of dogs. This was not done by Yosef et al. (2020).

In each park, every time a dog was seen excreting (i.e., either urinating or defecating), we first assigned this dog a unique ID number, in order to later identify whether one dog was responsible for several behaviors. We also recorded the nature of excretion (urination or defecation). We then measured the orientation of the dog's body axis while excreting, by using a compass aligned with the dog's spine and pointed towards its head. We believe that the act of taking the measurement did not affect the behavior of dogs, as there was already a large human presence in the parks, and the data collector remained at a distance. Measurement error is estimated to be low since the dogs remained stationary and in a characteristic posture during excretion.

Analysis

Similarly to Yosef et al. (2020), we only considered the first behavior from each dog, so as to avoid pseudoreplication and individual bias during the analysis. Although we took this approach for commonality with the previous study, future studies will likely use linear modelling approaches with dog ID as a factor in order to effectively use multiple observations from individual dogs. We performed two different statistical tests of uniformity in R on the pooled data, but also on the urination data and the defecation data separately. The first was Rao's spacing test, also used by Yosef et al. (2020), which detects departure from uniformity in circular datasets. Because SMA can occur in either direction along a specific axis, there can be two peaks of non-uniformity in opposite directions. For example, an animal that spontaneously aligns with the North-South axis can either face North or South, thus yielding a bimodal distribution. The Hermans-Rasson test was recently shown to demonstrate high statistical power in such multimodal distributions, while Rao's spacing test performs more poorly (Landler et al., 2018). We therefore also performed the Hermans-Rasson test on our datasets.

In order to determine the extent of the influence of linear structures on the alignment behavior of dogs in urban settings, we also calculated the angle between the orientation of the dog park and the orientation of the excreting dog. We then performed the two statistical tests mentioned above on this transformed data. Although the data collection performed by Yosef et al. (2020) was also located in enclosed urban dog parks, they did not consider the influence of such structures on the orientation of the dogs.

We calculated the mean deviation of excreting dogs from the North-South axis (possible values ranging from -90° to 90°), as well as their mean deviation from the axis of the longest side of the park. We then obtained the corresponding circular standard deviations (Pewsey et al., 2013) using the circular package in R (Agostinelli and Lund, 2017).

Results

We observed a total of 52 dogs, 33 of which were observed urinating and 19 of which were observed defecating. Among the pooled data, no preference for a particular magnetic direction or axis was detected (Rao’s spacing test: t=145.5, n=52, p>0.05; Hermans-Rasson test: t=2.4, n=52, p=0.67; mean deviation from North-South axis: -1°, circular SD: 51°). No SMA was detected either when considering only urination (Rao’s spacing test: t=107.5, n=33, p>0.05; Hermans-Rasson test: t=1.6, n=33, p=0.89; mean deviation from North-South axis: -4°, circular SD: 54°) or only defecation (Rao’s spacing test: t=124.3, n=19, p>0.05; Hermans-Rasson test: t=2.9, n=19, p=0.52; mean deviation from North-South axis: 3°, circular SD: 45°) (Figure 1A).

When considering the orientation of the dogs relative to the orientation of the dog park, significant non-uniformity was detected by the Hermans-Rasson test in the pooled data (Rao’s spacing test: t=142.6, n=52, p>0.05; Hermans-Rasson test: t=10.6, n=52, p=0.0037; mean deviation from park axis: -8°, circular SD: 40°) as well as in the urination data (Rao’s spacing test: t=138.0, n=33, p>0.05; Hermans-Rasson test: t=10.5, n=33, p=0.0044; mean deviation from park axis: -10°, circular SD: 36°). The defecation data, however, showed no detectable departure from uniformity (Rao’s spacing test: t=125.5, n=19, p>0.05; Hermans-Rasson test: t=3.7, n=19, p=0.36; mean deviation from park axis: -4°, circular SD: 48°) (Figure 1B).

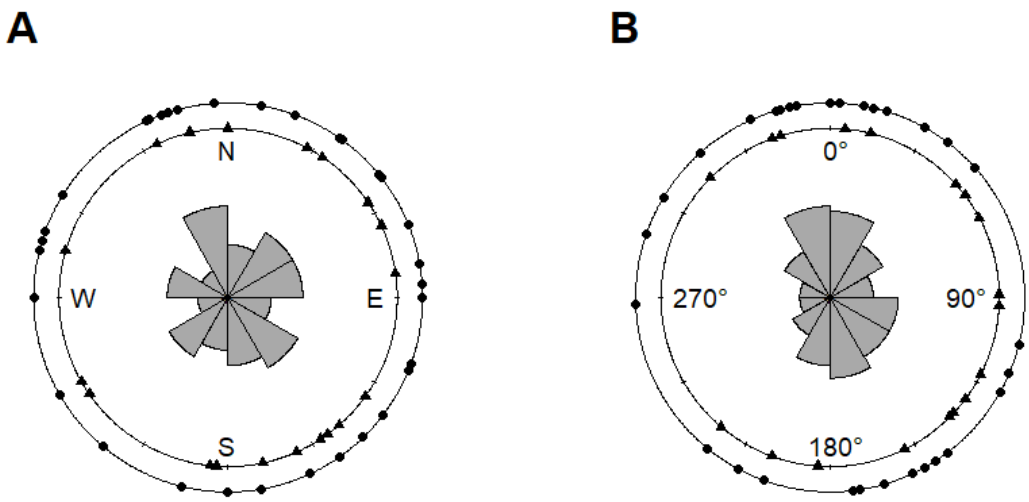

Figure 1. A. Magnetic orientation of the body axis of dogs during urination (circles, n=33) and defecation (triangles, n=19). **B.** Orientation of dogs relative to the orientation of the dog park in which they were located during urination (circles, n=33) and defecation (triangles, n=19).

Discussion

Upon replicating the study by Yosef et al. (2020) in which a strong effect of SMA in excreting dogs was found, we report no such effect. Although their sample size was considerably larger than ours, we do not believe that the non-replicability of their results can be attributed to low statistical power on our part. Indeed, were the true effect size as large as reported by Yosef et al. (2020), the effect would have been detected by our analysis, even with our sample size. Moreover, the statistical tests used in our analysis, especially the Hermans-Rasson test, have high power to detect moderate non-uniformity, even at low sample sizes (Landler et al., 2018; Landler et al., 2020). We could not detect any obvious differences between our methods of data collection and theirs, except for the locality (Israel vs. France).

There are several reasons to expect that studies of SMA in dogs such as ours or the one carried out by Yosef et al. (2020) would not yield strong effect sizes, or even any effect at all. Firstly, the data was collected in urban areas. Although Yosef et al. (2020) state that they were not located in proximity to high-voltage power lines, which are known to disrupt magnetic alignment (Burda et al., 2009), urban areas provide a great many anthropogenic sensory distractions to animals such as domestic dogs, even if the dog parks in which data is collected are not directly adjacent to major areas of passage.

A second implication of collecting this data in an urban area is that the spaces in which the dogs are observed are small and, importantly, enclosed by linear structures such as fences and walls. These structures can provide substantial influence to the direction in which dogs choose to position themselves during excretion, or even other behaviors. This is particularly the case for urination, the location of which is, especially in males, often biased towards prominent structures that rise above ground level. The presence of this confounding factor is supported by our finding that the orientation of urinating dogs was significantly influenced not by the magnetic field, but rather by the orientation of the dog park in which they were located. It is our understanding that Yosef et al. (2020) did not separate urination from defecation in their analysis. On the basis of our own findings and our assumption that they collected data in dog parks with varied orientations, we consider it surprising that the inclusion of the urination data in their analysis would lead to such a clear North-South orientation among the overwhelming majority of the 1,823 dogs studied.

Moreover, urban dog parks often contain, at any one time, several dogs as well as their owners. When collecting our data, we observed that dogs often choose to orientate themselves in a way that allows them to see all other dogs present, or to face their owner. While this is not always the case, it is conceivable that the presence of other dogs or humans in such small enclosed spaces may provide another confounding influence on the orientation of dogs.

The findings of the present study do not, by any means, exclude the possibility that domestic dogs are in fact sensitive to the Earth’s magnetic field, as was reported by the 2013 study carried out by Hart et al.. Our findings rather suggest that domestic dogs are subject to many distractions in urban settings, which renders the detection of any existing SMA very unlikely, and therefore that the strong effect size obtained by Yosef et al. (2020) is a surprising finding. In the Hart et al. (2013) study, which was the first to detect SMA in dogs, the data was collected in large, open rural areas with very little anthropogenic influence, the importance of which was stressed by the authors. Even in such rural conditions, Hart et al. (2013) were only able to detect SMA under calm magnetic field conditions, which contrasts with the very clear North-South magnetic alignment detected by Yosef et al. (2020). Begall et al. (2013) state that a prerequisite for the study of SMA in animals is that the subject should feel unobserved; we do not consider this to be the case in urban dog parks, where anthropogenic distractions can occur in many forms. Therefore, even if dogs do display SMA, as is suggested by Hart et al. (2013), it is not expected that this behavior should be detected in urban settings to the same extent as that which was reported by Yosef et al. (2020).

This type of study inevitably has some degree of subjectivity through reliance on human data collectors. We note that in the Yosef et al. (2020) study, the data was collected exclusively by high school students aged 16. Citizen science, or the contribution of the general public to scientific research, has become increasingly widespread (Strasser et al., 2019). Its advantages are many, in the form of time and budget efficiency, but also in increasing citizen empowerment and scientific understanding (Bonney et al., 2014). However, unconscious biases may easily arise in observers that have not been scientifically trained, especially if the study is not blind, in that the data collectors are made aware of the hypothesis under test before data collection begins. It is possible that this may have been the case in the Yosef et al. study, and that the surprisingly strong effect size may have been at least partly a result of observer bias. In psychological and social research, the concept known as 'demand characteristics' reflects a participant's desire to please the researcher after having been made aware of the latter's research hypothesis, thus leading to a conscious or subconscious change in behavior in the former (Orne, 1962). A similar phenomenon could be expected to occur in the context of citizen science, wherein a data recorder participating in a scientific study for the first time strongly wishes for the experiment to unfold according to the researcher's hypothesis. In such cases, the remedy is to blind the study. Our study was not carried out under blind conditions; however, the data recorder was a trained scientist, which may minimize bias.

A large part of a scientist's training involves the attenuation of one's tendency to be inadvertently influenced by the hypothesised outcome of an experiment, so that the individual can become best equipped to carry out minimally biased scientific studies. Such training is not undertaken by citizen scientists, thus rendering the risk of observer bias inevitably high.

This study not only highlights the importance of replication of scientific studies, but also acts as a reminder to exercise caution when implicating the public in scientific data collection. In particular, keeping the public blind to the scientists’ hypothesis as to the outcome of the research may act as an important safeguard to limit observer bias.

Authorship statement

AR participated in the design of the study, collected field data, carried out the statistical analyses and drafted the manuscript; GR conceived the study, participated in the design of the study and revised the manuscript. Both authors gave final approval for publication.

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Ethical considerations

This work was observational in nature, and consequently did not require any ethical approval.

Competing Interests

We declare we have no competing interests.

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