

## TIME SENSE OF PIGEONS AND OTHER CREATURES

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### Background

I now have two speculative notes <http://www.3bbb3.net> and <http://www.3aaa3.com> dealing with bird navigation and both of them depend on the bird having an accurate sense of time – a few minutes at most in 24 hours.

Biologists will not accept this, I am sure. My 2005 paper on Line Following (See <http://www.3aaa3.com> ) was sent back by several journals without being refereed, the editors simply stating that there was no evidence that birds could estimate time to this accuracy.

There is a culture clash here :

Birds must be able to have some information about their East West position and from a human navigator point of view it has, up to the present time, proved impossible to get this information other than by a time measurement. Biologists give me the impression that they are looking for some undiscovered physical parameter.

I believe that birds simply must be able to measure time and the problem now is to figure out how.

### The idea of a ticker

One way round this might be to find something that was observable by the bird, and which had a certain fixed period (tick-to-tick, say).

The period need not be a long period such as twenty four hours. It could be (shall we say) 40 minutes. Then the bird's time sense could be (1) count the ticks (2) count the relatively short time between clicks. In a certain range of distances the first step can be ignored.

A ticker might be internal, the result of some biological process, or it might be external.

### An internal ticker

I am not a biologist and my knowledge of physiology is precarious.

As I have said, it seems clear that biologists do not think that birds can count time through some endogenous process or at least they do not think birds can measure time to the accuracy that I calculate must be necessary.

I do not understand how they reconcile this with the idea of the sun-compass which they seem to think is reasonably accurate and requires an internal clock, but I am not knowledgeable enough to dispute the matter.

So, my approach has to be to look for some external ticker that the bird might refer to.

### Options for an external ticker

I think the ticker must be in some sensory range not easily accessed by a human. Were it not so, it might not have been so urgent a task in the eighteenth century to develop the chronometer.

**Although I do not know what exactly constitutes the external ticker (if there is one) but I think it has somehow to be connected with lunar motion.**

Because the moon is close to the earth, it behaves rather differently to most other astronomical bodies and measurements of the moon's position were used in earlier times to augment a navigator's calculations on longitude.

We can easily exclude the motion of stars and the sun as time cues. The essence of longitude determination is to compare the motion of the stars at the unknown longitude with the motion of the stars at the Greenwich Meridian and find out the time difference.

At the earth's surface both the moon and the sun exert forces. The most easily recognisable manifestation is the ocean tides. High tides, for example, in the United Kingdom occur approximately every 12 hours and 25.2 minutes.

The gravitational force at any point on the earth's surface will vary with time and in principle can be a clock. The variation with time at any point is small. The gravitational acceleration at the earth surface is 976 to 983 Gals whereas the observed variation is of the order of 0.15 milliGals. (1 Gal=0.01 m/sec<sup>2</sup>).

Nevertheless, these tiny changes produce very obvious tides in large bodies of water and they might cause some other manifestation that can be detected by birds.

There is a problem with precision : Even sitting by the sea you cannot really be sure when the tide is full without some sort of instrument. Inland the matter is even more obscure.

Looking into this some more, we find that in addition to ocean tides, the same forces cause earth tides and that for some precision construction work these earth tides must be allowed for. Large particle accelerators, formed from long underground tunnels, have to take account of earth tides.

<http://news.stanford.edu/news/2000/march29/linac-329.html>  
<http://accelconf.web.cern.ch/accelconf/e00/PAPERS/MOP5A04.pdf>

More information on earth tides can be seen at

<http://www.okgeosurvey1.gov/tide.html>  
[http://gps.caltech.edu/classes/ge167/file/agnew\\_treat\\_tide.pdf](http://gps.caltech.edu/classes/ge167/file/agnew_treat_tide.pdf)  
<http://www.astro.oma.be/ICET/icetdb/icetindex.html> (An index to other papers)

Recent research shows that the earth rises at least two or three inches, and maybe as much as ten inches. You can't physically see this change because you, the observer, are rising with it.

#### The detection problem

Potentially the lunar contribution to the local gravitational field furnishes us with a clock. On the other hand the actual earth tide, even if it amounts to several centimetres of displacement, is very difficult to detect using instruments. The variation in g is about one part in a million as mentioned above.

These tides have been in existence for millennia so it would not be surprising if nature had somehow reacted to them.

Perhaps we are looking for something that is finely balanced but that is unbalanced by this one part in a million.

I think there must be something acting as a natural amplifier. One thinks of trees and vegetation. The natural amplifier must itself produce something that is detectable.

#### Conclusion

If there is an external ticker I don't yet know what it is.

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#### **Rejected candidates for an external ticker**

*I briefly looked at the following :*

### Cues constructed by humans.

*In principle birds could pick up time clues inadvertently provided by humans. Church clocks striking noon are at least designed to do this at 24 hour intervals and do not coincide with the zenith of the sun's movement. I don't put a lot of weight on this possibility because large clocks are not very accurate; even now, in a city you can hear them striking for a few minutes around the actual hour.*

*Also it seems that pigeons have been homing successfully long before the nationwide synchronisation of clocks which is a relatively recent event.*

*I have noticed in the literature that some experiments have been done in which possible navigation cues (such as visual recognition of the surroundings) have not been excluded. The same might be true for cues constructed by humans.*

### Temperature

*Nothing springs to mind.*

### A scent

*I cannot think that this could work, mainly on the grounds of the necessary accuracy. It would also have to be geographically universal in some sense and be pulsed or somehow variable.*

### Something magnetic

*I cannot come up with anything. What variability there is has a different form from day to day, somehow depends on the sun, and is very small (~20 nanotesla in 40,000)*

### Electrostatic

*I can't come up with anything.*

### Optics

*Something to do with polarisation ? Has to work under clouds and has to have a time element. I find it very difficult to see how polarised light from the sun could be modified on an absolute, rather than solar, time framework.*

### Seismographic sources

*Possible in principle, but would have to be regular. I'm not sure if you can distinguish this from Infrasound.*

### Radioactive sources.

*They surround us all the time at a low level, but I not aware of any periodicity*

### Sound

*A geological source of high frequency or low frequency sound. Ground based low frequency sound probably does not exist. If it did, it would be detected by those stations looking for signs of underground nuclear tests. See <http://www.isla.hawaii.edu/index.php>*

*Infrasound in the air seems to have been much less studied and it should be noted that the idea of low frequency sound playing some role in the homing of pigeons has been examined by Hagstrum :*

*Jonathon Hagstrum in the Journal of Experimental Biology Vol 203 pp1103-1111 (Y2000) has suggested that infrasound somehow plays a role in pigeon navigation and refers to a man called D. R. Griffin as the first person to suggest this. D. R. Griffin "The physiology and geophysics of bird navigation" Quarterly Reviews of Biology Vol 44 pp255-276 (1969). Hagstrum further examines the matter in "Infrasound and the avian navigational map" J Hagstrum J. Navigation Vol 54 pp377-391 (Y2001), and in ION 63<sup>rd</sup> Annual Meeting April 23-25 (Y2007) Cambridge Massachusetts.*

*So far as I understand this, it is being suggested that birds use the infrasound as a sort of directional beacon. Hagstrum has painstakingly indicated points of weakness in his idea.*

*For the present discussion, I wonder if the bird is using infrasound as a time reference. I am not sure what the bird is counting if it is listening to infrasound. Pigeons are said to be able to hear frequencies down to 0.05 Hz so that a wave length is 40 secs peak to peak. It would have to count to quite a large number.*