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Why the islands move

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Abstract Micronesian navigators routinely make voyages across large expanses of open ocean To do this, a navigator must judge both the direction in which he is sailing and the distance he has travelled The rising and setting points of the stars (and other cues) provide instantaneous information about direction, but distance can only be judged by integrating velocity-related information over time Micronesian navigators judge distance in a way that seems odd. When they are out of sight of land, they imagine that the canoe is stationary and that the islands move back past them For each voyage, they 'attend' to an island off to the side of the course which is out of sight over the horizon As they sail, they imagine the island moving back along the horizon changing in bearing until it is imagined to be under the bearing it is known to have from the destination island. Then they know they are near their destination There is good reason for using a frame of reference whose origin is defined by the boat. We show how it finesses a perceptual paradox—the rising and setting points of the stars do not exhibit motion parallax

1 The navigator's world

In the neighborhood of the Caroline Islands, less than two tenths of one percent of the surface of the Earth is land The rest is a vast expanse of water, dotted with about two dozen atolls and low islands Experienced navigators in these waters routinely sail their outrigger canoes as many as 150 miles between islands without the use of any instruments Their reckoning of direction travelled and distance covered is done mentally with the help of some clever ways of thinking about and observing the stars

One of the most widespread notions in tropical archaeoastronomy is the concept of the star path or linear constellation (Aveni 1981). A linear constellation is a group of stars which when observed from any fixed latitude all rise at nearly the same bearing (azimuth) in the east, and all set at about the same bearing as each other in the west. A 'connect the dots' drawing of such a linear constellation is simply an arc across the sky which is anchored at fixed azimuths in the east and in the west While the stars themselves make their nightly journeys across the sky, the arcs of the linear constellations remain stationary Seeing the night sky in terms of linear constellations is a simple representational device that converts the moving field of stars into a fixed frame of reference Caroline Island navigators have assembled thirteen of these linear constellations, plus the North Star and five positions of the Southern Cross, into a sidereal compass which has thirty-two compass points defined by star bearings

Courses between islands are defined in terms of this abstract sidereal compass For every island in a navigator's sailing range, he knows the star point under which he must sail to reach any other island in the vicinity.

The sidereal compass is also involved in judgements of distance travelled on a voyage. For every course from one island to another, the changing star bearing of a third island lying off to the side of the course (and over the horizon so that it is never actually seen on that passage) is taken as a reference for the expression of the distance travelled A curious yet fundamental conception in Caroline Island navigation is that when underway on course between islands, the canoe is stationary and the islands move past the canoe A passage from Gladwin (1970) who worked on Puluwat atoll in the Carolines captures the scene:

> "Picture yourself on a Puluwat canoe at night The weather is clear, the stars are out, but no land is in sight The canoe is a familiar little world Men sit about, talk, perhaps move around a little within their microcosm On either side of the canoe, water streams past, a line of turbulence and bubbles merging into a wake and disappearing into the darkness. Overhead there are stars, immovable, immutable They swing in their paths across and out of the sky but invariably come up again in the same places You may travel for days on the canoe, but the stars will not go away or change their positions aside from their nightly trajectories from horizon to horizon Hours go by, miles of water have flowed past Yet the canoe is still underneath and the stars are still above Back along the wake however, the island you left falls farther and farther behind, while the one toward which you are heading is hopefully drawing closer. You can see neither of them, but you know this is happening You know too that there are islands on either side of you, some near, some far, some ahead, some behind. The ones that are ahead will, in due course, fall behind. Everything passes by the little canoe—everything except the stars by night and the sun in the day" (Gladwin 1970, page 182).

Puluwat islanders impress on researchers that this conception of the islands moving while the canoe remains stationary is a fiction they are aware of, but one that is essential to their way of doing the task.

In the language of Puluwat atoll, this system of expressing distance travelled in terms of the changing bearing of a reference island is called ETAK (Gladwin 1970, page 131) The navigator knows the star bearing of the reference island from his voyage origin Since he knows all inter-island course star bearings in his area, he knows the bearing of the reference island from his goal In the navigator's imagery, this reference island starts out under a particular star (at a particular star bearing) and moves back abeam of the canoe during the voyage through a succession of star bearings along the horizon until the canoe reaches its goal at which time the reference island is under the point which defines the course from the goal island to the reference island The imagery of the star bearings fixed on the horizon thus provides a frame of reference within which the relative movement of the reference island is imagined A technique for performing these computations in mental imagery and for updating the motion of the reference island when the canoe changes speed is described by Hutchins (1983)

The notion of the changing bearing of the reference island can be accommodated by our usual way of thinking in which the canoe is in motion while the islands are still Why then would Micronesian navigators insist on what they know to be a fiction and imagine that the canoe is stationary with the islands in motion about it?

2 Motion parallax

Relative motion between two objects causes a change in the direction of one from the other The rate of change in direction, $d\theta/dt$, depends on the component, v, of the relative velocity that is normal to the line joining the objects, and on the distance between them, d:

$$\frac{d\theta}{dt} = \frac{v}{d}$$

If there is no change in the direction of one object from another, we have: $0 = v/d$ There are two solutions to this equation: $v = 0$ and/or $d = \infty$. As we move about on the face of the planet, celestial bodies do not exhibit motion parallax If our perceptual systems tell us that d is not infinite, we can either believe that $v = 0$ or we can intellectually overrule the perceptual evidence and maintain that $d = \infty$ One way to account for the perception that $d\theta/dt = 0$ is to believe that $v = 0$ by imagining that the object observed has the same velocity as the observer and the islands move past the canoe A passage from Gladwin (1970) who worked on Puluwat atoll in the Carolines captures the scene:

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Figure 1c depicts the Micronesian navigators' solution Here the boat and the star frame are affixed to each other, and the islands move through that reference frame This solution is in complete accord with the perceptual evidence and, furthermore, updating the representation requires moving only one of the three frames

The islands move in the Micronesian method because having them do so accords with the direct perceptual evidence, minimizes the number of moving systems, and organizes the navigator's perception of the world in a way that permits him to answer directly the question "When will the reference island have the same star bearing from my canoe that it has from the goal island?" This technique minimizes the number of moving systems by allowing the two systems that are directly visible during the main part of the voyage (canoe and stars) to have zero linear velocity while requiring the system that is unseen and only imagined for most of the voyage (the islands) to move The Western conception is inappropriate for this task because it has one visible system (canoe) move relative to another visible system (stars) in spite of the fact that there is no perceptible relative motion between them, and holds stationary the system that must be imagined for most of the voyage (islands), in spite of considerable apparent relative motion between fixed islands and fixed stare points

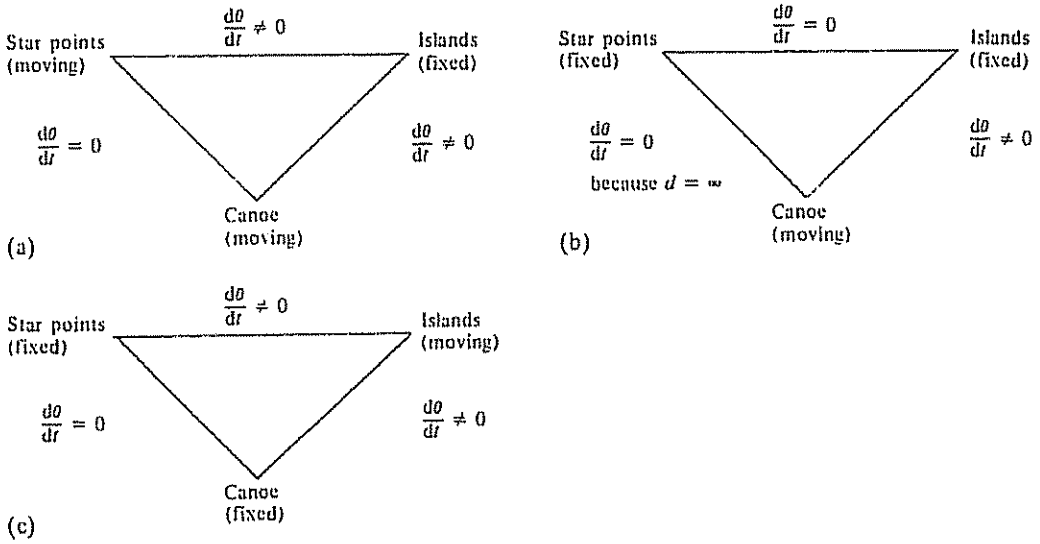

Figure 1 (a) Assignment of velocities favored by the perceptual system in the absence of cognitive intervention; (b) the Western solution; (c) the Micronesian navigators' solution

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