

Sub Space: Describing Distant Psychological Space

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Submarine navigation proceeds without the benefit of windows. Instead, experienced submarine Officers develop complex skills for mentally turning acoustic information conveyed in displays and in the alphanumerics of passive sonar into spatial representations of other vessels, their paths, intentions, and the high uncertainty of the undersea world (Kirschenbaum, Gray, & Ehret, 1997). We lack data about the psychological space of experts as they reason about distant space in such areas.

Gesture analysis is a promising methodology for observing and understanding the spatial representations that people build to solve difficult problems. It has been used to examine how astronomers reason about the movement of objects when only static representations are visually available (Schunn, Trickett, & Trafton, 1999) and to examine representations of abstractions such as rates of change in algebra word problems (Alibali et al., 1999).

In the current study, we videotaped and analyzed the speech and spontaneous hand gestures of submarine Officers who were instructors in the Submarine Officers Basic Course. Four instructors participated in hour-long, interviews designed to prompt explanations about basic issues in submarining. We transcribed the speech, and then we transcribed the physical aspects of gesture such as the hand or finger shapes, motion, or location in the speaker's personal space.

We found a small set of common gestures that all Officers use similarly (e.g., "bearing" is usually a straight arm/hand, fingers close together pointing not just a direction but a path). We also found a number of topics that Officers convey in gesture.

Our data show that when Officers' gestures convey **perspective** these are more likely to represent an egocentric, as opposed to a removed, exocentric, view. One example is a gesture about sound propagation from the perspective solely of a sensor that is receiving a signal. In other examples, Officers gestured phenomena as relative to themselves physically, as if they were standing in own-ship.

Officers' speech and gesture both convey **uncertainty**, or hedging/estimation. This is important because less experienced Officers are over-certain at times. Often, the only hint that an Officer is hedging or expressing uncertainty will come through one modality

only (hands alternate in box-shape up and down; hands circling). About 20 percent of speech and 20 percent of gesture were coded as reflecting uncertainty.

It is common for Officers to gesture complex **spatial dimensions** of the relative positions and motion of the target of interest and own-ship. Officers also gesture complex spatial representations about the shape and degree of angle of conical beams and the effects on signal processing of effects such as the position of the towed array (an array of sensors towed behind the ship) when the ship turns, etc.

Spatial features commonly represented in gesture were shapes (e.g., conical beam, hyperbolic wave front) relative distance and position, direction (bearing, course), and motion (e.g., across or in the line of sight).

Many of the iconic gestures represented or replicated pieces of **common displays** or figures that Officers use. However, other iconic gestures seemed more physical, as if the Officer were relying on an internal, **visual analogy** to describe an idea. In a gesture about beam forming, one hand played the part of the towed array and the other was a vessel being tracked. Each hand moved through the "water," suggesting not only a world-view/bird's-eye view of the contact and own-ship, but the gesture superimposed relative motion on that view, in a way we think is different from other displays and figures.

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