# Embodied Cognition in Observational Amateur Astronomy

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**Abstract:** We investigate the embodied cognitive practices of amateur astronomers, as they engage in observational routines in the field. In particular, we take an "interactionist" perspective to the problem and address the question: How is the body used as a resource for practical, conceptual, and communicative purposes in the process of planning, searching for, and sighting celestial objects? The basis for our analysis is a set of ethnographic video and field note records collected over several years of fieldwork. We scrutinize the moment-by-moment interactions among practitioners for episodes in which different modalities of embodied action are recruited and coordinated to produce and communicate complex meanings in the practice. As a whole, therefore, we seek to empower learners—as the ICLS 2016 calls for—by bringing insight into foundational aspects of knowing and learning.

**Keywords**: embodied cognition, amateur astronomy, hobbies, out-of-school learning

## Introduction
Responding to ICLS 2016's call for research "… to provide [renewed] insight into how people learn," in this paper we investigate the embodied cognitive practices of amateur astronomers, as they engage in observational routines in the field. By and large, the human body has been relegated to a secondary role in accounts of reasoning and learning (Hall & Nemirovsky, 2012; Stevens & Hall, 1998). By contributing to approaches that work to re-inscribe the body into cognitive processes (e.g., Goodwin, 2011, 2013; Nemirovsky, Rasmussen, Sweeney, & Wawro, 2012), our goal is to add to basic theorizing on knowing and learning in STEM practices and to fine-grained analyses of the situated, context-dependent nature of these processes. We thus seek to empower learners—as the Conference calls for—by bringing insight into foundational aspects of learning.

We pursue this inquiry from a perspective known as "interactionist" (Jordan & Henderson, 1995). As such, we seek to document how the body is used as a resource for action and resoning, *in situ*, on a moment-to-moment basis, in interaction with other bodies, material infrastructures (e.g., tools and instruments) and other parameters of practice, such as communities' norms and values, divisions of labor, histories of participation, and so on (e.g., Hall & Stevens, 1995; Stevens, 2000). Specifically, we ask the question: How is the body used as a resource for practical, conceptual, and communicative purposes in the process of planning, searching for, and confirming sight of a celestial object?

As we will see, this question becomes particularly interesting and complex when we consider the conditions of practice of observational amateur astronomy and the specifics of the "task" of finding any single celestial target. For good seeing, astronomers practice under the darkest possible conditions and only red-screened light sources (e.g., flashlights and computer screens) were allowed on site. Because the practice is densely populated with tools and various artifacts—including telescopes, tripods, binoculars, computers, books and various star charts and notebooks, tables and chairs, among others—and observations are often carried out in small groups, these conditions created some important practical challenges, such as coordinating joint activities and communicating information on celestial scenes to peers and visitors.

Finding a celestial target clearly involves conceptual complexity as well. The process typically unfolds as follows. First, the astronomer picks a target, frequently one missing from a pre-made, themed list of observational targets (or similar). Then, he/she may read some about the object, say, in search of information regarding its shape, general look, location, and relationship to nearby celestial bodies. To do so, the astronomer may resort to a number of sources, from handwritten notes (taken at home), to printed books and other reference materials, to computers (and other electronic, handheld equipment), and others. Following that, he/she will chart a "star hopping" path through visible objects in the vicinity of, and towards the target, and finally attempt to sight it through the scope. In all, this makes for an iterative and relatively extended pursuit in which practitioners continuously assemble to one another representations and descriptions of a target scene, and coordinate their understandings of it. Bodies take center stage in these processes, as we will see.

## Theoretical framework
The interactionist perspective that we adopt insists on a socio-cultural, activity-systemic perspective in which knowing and learning are actively produced in the transactions among elements of such a system—including the

 

organization of the activity (or practice), the distribution of roles and attributions within the activity, the material and historical conditions under which participants work, etc. (e.g., Gibson, 1979; Jordan & Henderson, 1995; Saxe, 1991; Hutchins 1995; Cole, 1996; Engeström, 1999). For our inquiry into embodied cognition, this means that we see "human thinking and learning [as] intimately tied not only to the body, but to a body that interacts with others and is active in social and cultural settings already rich with mediating artifacts that afford particular kinds of joint activity" (Hall & Nemirovsky, 2012, pp. 213-214). We take it that multiple modalities of embodied action are engaged in these processes—including gestures, talk, touch, prosody, gaze, body posture and orientation, and tool use (Goodwin, 2011; Hall, 1996; Nemirovsky et al., 2012; Stevens, 2012)—and our work is aimed at documenting how these modalities are manifested in observational amateur astronomy practice.

Further, as Goodwin (2011) illustrates, multiple modalities of embodied action are coordinated in activity, each mutually elaborating on one another as means of articulating and expressing complex meaning. In addition, because the oft-collaborative character of the task of finding a celestial object, coordinations and alignments between participants' bodies should also be expected (Stevens & Hall, 1998; Hall, 1996). These should be further intertwined with the immediate conditions of practice, as we will see in the analysis.

Finally, we note that—as in other techno-scientific practices (Latour, 1987; Lynch & Woolgar, 1990)—observational amateur astronomy is heavily mediated by technical representations (e.g., star charts, maps, and pictures), tools (telescopes, binoculars, and others), and various artifacts. In action, these serve to structure and extend the active body and are critical for an account of how people create meaning within the collective, naturally occurring exchanges in the field.

## Methods

The data we analyze here are ethnographic video records and field notes (Hammersley & Atkinson, 1995) produced during two distinct research studies. In the first study, which took place between 2002 and 2003, the *f*irst *a*uthor (FA) documented the individual and collective practices of amateur astronomers with the goal of explaining structures and processes of extended, interest-based participation (Azevedo, 2013). In the second—which spanned the full year of 2014—we returned to the field with the explicit goal of documenting the embodied practices that permeates amateur astronomy field practice and which the first study had hinted at. In all, we collected 8 hours and 55 minutes of video in study one and 6 hours and 11 minutes in study two, and several pages of field notes, theoretical and analytical memos across both studies.

Studies one and two were carried out on different settings as well. Study one in fact included two settings—Mt Hillview and Lake Countryside, both located in Northern California—each of which was frequented by different communities of astronomers. (All names are pseudonyms.) Study two took place within a single community of astronomers that met at the High Meadows observation site in the Texas hill country. In all cases, astronomy clubs and communities held a variety of events and we focused on the most common and recurrent ones, namely the public "star parties" (i.e., outreach efforts) and members-only nights held at that site.

Of particular importance, based on observations in study one, in study two we sought to address the challenges of data collection under the dark conditions characteristic of astronomy field practice. This was especially crucial in light of the goal of documenting, at a fine grain of detail, the interactions between participants and the bodily practices involved, the use of star charts, telescopes and other tools, and how these were coordinated and elaborated upon throughout the "task" of seeing an object.

To tackle this problem, we used an infrared (IR) camera fitted with an infrared lens. Because the camera shed light undetectable to the human eye, we were able to illuminate and record participants' interactions and long-term work without disturbing the original conditions under which they carried out their practice. Had we used a regular camera and illuminated the scene with red-screened flashlights, we would have circumvented the technical problem, but fundamentally altered the constraints and affordances that practitioners regularly encounter and thus the very character of the embodied practices we sought to study.

## Analysis and results

We scrutinized the full set of ethnographic records for moments in which participants' (astronomers and visitors) bodies seemed to take an active role in the ongoing observational activity. We then bracketed these moments for further analysis and watched the corresponding videotape segments several times, all along transcribing parts that required clarification or elaboration (for whatever reason). With episodes of embodied cognitive practices catalogued and described, we classified them into categories that reflect either a modality of embodied action and reasoning or their functional role in the activity. We organize the presentation of results around these categories.

## Averted vision

Averted vision is a technique that is crucial to observing deep sky, and therefore faint, celestial objects. The technique works by exploiting the basic structure of the human eye. Briefly, the eye has two distinct types of receptor cells—i.e., cones and rods. Cones are found mostly in the central area of the retina and their function is to make out details and colors in a scene. However, cones are not very sensitive to light. Rods, on the other hand, populate the periphery of the eye and they are very sensitive to light, though they cannot make out object details or colors.

When applied to amateur astronomy practice, the technique posits one should look at a faint object at an angle—rather than directly, straight on—thereby exposing the most sensitive part of the eye to the scene (say, in a telescope or binoculars). The exact angle of off-center looking varies across individuals, but usually it falls between 8 and 16 degrees. Both specialized books and amateur astronomers report that it takes time to learn the technique, but the gains in "seeing objects" are recognizably high (Dickinson & Dyer, 2008).

Because averted vision requires training a body part itself to perform in unusual ways, the technique perhaps best exemplifies how deeply embodied cognitive processes can be in a STEM practice, and astronomy in particular. The technique is perhaps also a prototypical example of learning-by-doing across STEM disciplines; no matter how much one might hear explanations of averted vision, mastering the technique takes extended individual practice.

## The body as medium of communication

The unique conditions of practice that characterize observational amateur astronomy create practical demands that seem quite specific to the hobby. In particular, the severe constraints imposed on the visual channel create challenges for effective communicative practices, especially given the potentially complex nature of finding a specific object among many plausible candidates. Apparently to compensate for this "loss," amateur astronomers rely on various alternative ways of communicating information relevant to the ongoing task and the body is frequently a protagonist in these processes.

Particularly noteworthy, we have observed that bodies may be used literally as inscription surfaces to communicate and explicate details of celestial scenes (say, as seen through a telescope's eyepiece). As an example, in an episode during the Mt Hillview event of 9/7/2002, Sally was searching for the M103 open star cluster in the constellation of Cassiopeia. Upon finding it, Sally offered to share the view with FA. FA then sat next to the telescope and Sally stood to his side. She then rested her left hand on his left shoulder and proceeded to use her right indicator finger to inscribe the telescope scene on FA's back! To do so, she first traced a circle, starting halfway up FA's back and moving clockwise down and up. Such a circle was to represent the circular field of view offered by the scope's eyepiece. Sally then moved on to mark star hopping points on FA's back, always within the limits of the circle and always discursively elaborating on her actions, checking on FA's understanding as she went along.

In a similar manner, in our most recent study in the High Meadows site (5/3/2014), we documented an event in which a senior astronomer inscribed the Big Dipper asterism on the palm of a visitor's (a young girl) hand. The goal was to explain to the girl how to find the star Polaris by following an imaginary straight line extending from two of Big Dipper's stars—a commonly known strategy.

In all, these events show how seeing a celestial object is literally an interactional achievement in that it requires touching bodies as a way to convey technical and observational information. Simultaneously, the episodes illustrate how modalities of embodied action are coordinated in activity, one elaborating on the other so as to achieve complex meaning that neither modality could individually convey (Goodwin, 2000, 2011).

## Gesturing

Gestures (Kita, 2000; Roth, 2000) permeate all aspects of observational amateur astronomy, from planning an observation to carrying it out and explaining one's "seeing" to others. We organize our narrative around the functional uses of gestures throughout the collaborative problem solving process of seeing an object, folding into it an account of how gestures appeared in conjunction with other modalities of embodied action.

### Highlighting

Highlighting refers to a set of practices that "divide a domain of scrutiny into a figure and a ground, so that events relevant to the activity of the moment stand out" (Goodwin, 1994, pp. 610). In an archeological excavation, for example, an experienced researcher may highlight to an assistant the conceptually relevant marks on a patch of dirt by gesturing with a dowel to selectively single out aspects of the dirt and elaborating verbally on what constitutes foreground and background in a "scene" (Goodwin, 2000, 2003). In amateur astronomy, highlighting takes on various forms and they are particularly ubiquitous when astronomers communicate to one another specific information relevant to a star hopping sequence.

To exemplify, consider an episode in which two astronomers (Guy and Bob) set out to observe the Sombrero galaxy. Guy was the more experienced of the two and he took the lead in charting a path to their common target. After some studying of a few charts, Guy then proceeded to explain to Bob his star hopping sequence. Switching his gaze back and forth between the night sky and the star chart he held with his left hand, Guy traced a “C” pattern connecting objects in the vicinity of the target (Figure 1), all along narratively elaborating on aspects of the pattern to which he was pointing. By doing so, he highlighted to Bob (and others) an emergent, relevant pattern among many other possibilities and this pattern could be used to anchor the path to the target.

As a whole, highlighting practices of amateur astronomers almost always picked either emergent features of sets of celestial objects (as above) or well known, landmark object or configurations (e.g., the Big Dipper). As a rule, the gestures making up these practices were performed over various media, including the sky, star charts, computer screens, picture books, and others.

Figure 1. Four snapshots showing Guy’s tracing of a “C” shape to highlight a set of adjacent objects. For about one minute, he repeated the gesture 3 times, tracing the “C” back and forth (7/26/2014, High Meadows).

## Measuring and way finding

Again as part of communicative and coordination needs, participants use gestures to create relational, on-the-fly measures that can aid in locating objects in a star hopping sequence. To illustrate with a single case, consider an episode in which Jack and Brian had just finished confirming sight of a particular celestial target. Jack passed the telescope seat to Brian and proceeded to describe what he (Jack) had seen. The following interaction ensued.

| | |
|---|---|
| Jack: | ((to Brian)) Okay, if you notice you can… when you look at the Telrad ((scope viewfinder)) you can use your averted ((vision)) a little bit and move… it is a little above… see the three stars ((points with left indicator finger to the sky and gestures a line through three adjacent stars)) and the one that is directly above it ((gestures up and down on a line)), it is about half again above it… when I went that far that’s what I got. |
| Brian: | [((inaudible)) |
| FA: | [Half what? It’s about half what? |
| Jack: | ((to FA)) Uhh, when you go three stars ((points with left indicator finger to third star in the sequence)) and then there’s a star above it ((“holds” two points with left indicator and thumb, Figure 2.a)). You go half that distance up ((points with right indicator to a region above the points fixed by the left hand, Figure 2.b))… or half again. |
| FA: | Okay. |

a. b.

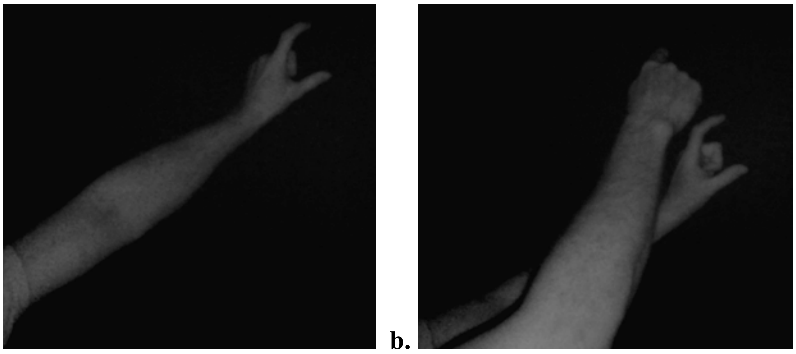

Figure 2. (a) Jack "holds" two points (stars) that were key in his star hopping procedure—his left thumb pointing to one and left indicator pointing to another. The distance between the two fingers then emerges as a measuring stick in the star hopping sequence; (b) Jack points with his right indicator to the direction of the hopping sequence, stating that target is to be found half a measuring stick distance added to last star in the hopping sequence (10/26/2014, High Meadows).

Beginning in turn 1, Jack went briefly through the star hopping procedure that they had previously worked out, in the process using an improvised measure of distance to locate the position of the target celestial object. Such a distance was a gestural yardstick (Figure 2.a) that had just emerged as an artifact of the pointing to stars in the hopping sequence. As Jack elaborated in turn 3, *half* of that measure was now to be added atop of the last star in the hopping sequence—thereby flexibly reusing the emergent yardstick to communicate object location. As with highlighting practices, gestures used in measuring always appeared in coordination with other modalities of embodiment (tool use and speech) and it too occurred always across various media that formed the infrastructure to the practice.

## Conclusions and implications

We have begun documenting the embodied cognitive practices of observational amateur astronomy with the goal of contributing to our general understanding of knowing and learning in STEM practices. The human body has been conspicuously absent from accounts of knowing and learning and our work here is meant to help ameliorate this gap.

In all, we have found many results that align with the extant literature, including tool use and gestures as essential forms of embodiment for knowing and communicating in action (Goodwin, 2011). We have also uncovered some novel forms of embodied activity, such as the use of averted vision (as a way of improving one's seeing of faint celestial objects) or inscribing the body with astronomical scenes, which we showed to reflect both the core disciplinary aspects of astronomy but also the conditions of observational amateur astronomy practice. As we extend our investigations within and beyond amateur astronomy, we expect to continue uncovering a variety of new forms of embodied action and reasoning in STEM disciplines and to shed further light on processes of knowing and learning.

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