Centers of Attention: How Joint Attention Solves the Hard Problem of Content

[WORK IN PROGRESS]

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Abstract

Psychology is on course to becoming a hard science (which is to say a general explanatory framwork consistent with physics and biology, rather than a patchwork of popular models that each have some utility in some domain) but has met with the Hard Problem of Content (Hutto & Myin 2013) as one of its most pressing concerns. Another relatively newer field that has at various times been called computer science, cybernetics, or informatics has been stymied by the same problem of meaningfully operating on information content, in its quest to move from more narrow and literal to more generic and flexibly expressive machinery. Physical agents are unproblematically sensitive to pragmatic information (tracking causal effects and exploiting causative possibilities), but the hard problem is how do some kinds of agents (perhaps only humans as of yet) acquire the capacity to traffic in information **about** the situations they find themselves in? In this paper I make the case for an ecological-semiotic approach that enriches the traditonal Gibsonian approach with a Peircean biosemiotic model of convention-based use of ecological information. A case is made for the ecological task as semiotic self-control even in the basic case, which joint attention surfaces into a coordinative enterprise of publicly iterating and generalizing tasks into practices. This process is identified as the source of public symbol-use and content. A formal model of basic and joint agency is presented, along with some proposed constructive tests of the hypothesis.

Outline of Thesis

- **Ecological Information Basics**

  - **Why ecological psychology?** The Gibsonian ecological approach is the the most well-developed and explanatory theory of pragmatic information and therefore the most promising avenue for offering a coherent and veridical account of information and its applications.

  - **Law-based ecological information.** A review of Gibsons's theory of perception and ecological information as since developed by Turvey and others.

  - **Convention-based use of ecological information.** A review of Golonka & Wilson's work on convention-base use of ecological information as an explanation of cognition that goes beyond strictly direct and perceivable information.

- **An Ecological-Semiotic Approach to Perception and Information**
  Proposal to merge Biosemiotics and Ecological Psychology.

  - **Gibsonian information theory needs Peircean biosemiotics.**
    Gibsonian ecological psychology is enriched by a biosemiotic understanding of the convention-based uses of ecological information To complete the account of the convention-based aspects of pragmatic information-use (semiosis). Peirce's model is highly explanatory of convention-based processes. Biosemiotics has found great utility in applying this approach to understanding teleological mechanisms in the "wet cybernetics" of life.

    The value of semiotics is to produce, given the resources of "convention-based use of ecological information" alone, an account of prospective control tasks as semiosis, and then given the additional resources of joint attentional skills, an account of content as coordinated scaffolded abstraction of intentional practices.

  - **Peircean Biosemiotics needs a Gibsonian foundation**. It tries to build up from sensations, which doesn't work. this is borderline mysticism (in some of the same ways enactivism is as well). Gibson's approach solves this.

  - **Semiotic Scaffolding**. A review of Hoffmeyer's biosemiotic work on semiotic scaffolding, and Stjernfelt's work on the evolution of semioic self-control.

  - **The Prospective Control Task as Semiotic Self-control**

    * The fact that organisms innately depend on detecting convention-based information for their basic self-maintenant functions reveals that perception-action cycles are couched in convention-based semiotic control at the task level.

    * Turvey's ontology of task performance in the 1992 paper appears to have independentally identified task performance as having a triadic structure

    * Peirce's symbol/semiosis, while intended to be an abstract and broadly applicable mathematical fact, is clarified greatly if taken to paradigmatically begin as the case of an agent attending to a task such that the vehicle is the context of it being possible and advisable to engaging the task, the intepretant is a context of focus where the relevant subtasks are solicited in support of the the task, others excluded from focus as not helpful or relevant, and the symbol's object or target is the context of having realized the task's purpose. This Gibsonian task interpretation of Peircean symbol and vice versa is what I have termed a "center of attention".

- **The Hard Problem of Content**
  - **The problem.** brief overview of Hutto & Myin's argument
  - **Proposed solutions.** no need to rehash the litany of approaches that fail as these are mostly covered by Hutto & Myin. But I will explore some solutions that fail to solve it as way of making the clear the problem we're trying to solve and why it's a real problem.
    * Korbak: Skyrms signaling networks solve the hard problem. It does not solve it because it only trains agents behaviors into alignment with facts of the evironment, it does not not inform agents of these facts such they might attend to the relevant factors for accessing them.
    * Bickhard: TODO, I have a working suspicion, but I need to better understand Bickhard's work in order to be certain.
  - **Joint attention as a solution to the hard problem of content** Review prior art, and what it so far does not explain
    * Tomasello: Framework of Cooperative Communication
    * Ramstead et al: Cultural Affordances
    * Stjernfelt: Joint Attention and Semiotic Self-control
- **An Ecological-Semiotic Approach to Joint Attention**
  - **Clues from empirical research.** Tomasello's research on joint attention offers a revealing piece of evidence: the human-unique skill set developed in infancy (sharing, following into, and directing attention) corresponding to the triadic structure of task attention. I make sense of Tomasello's finding as evidence that humans necessarily develop a keen awareness and influence upon of observable behaviors in contexts together comprising centers of attention, enabling us to achieve the distinctively human feat of open-ended joint agency by coordinating these parameters specifying centers of attention governing their respective processes of semiotic self-control.
  - **The collaborative constitution of agency hypothesis.** I propose based on confluences of convergent evidence that the origin of humans explicitly using abstract symbols to scaffold joint attention is directly derived from coordinating and generalizing task structure. Tacitly in basic agency and explicitly in joint agency, it is the compression of focus into subtasks that produces generality. Further, the use of manifest public sign vehicles to invoke centers of attention makes joint agency significantly more capable than basic agency, as it allows for developing explicit and particular strategies of attention to structuring of the focus of centers.

- **Joint agency solves the hard problem of content.** In agreement with Hutto & Myin's proposal with respect to the function of public symbol systems, I claim that joint attention, by making symbolic abstraction and the collaborative development of symbol creating joint agency, solves the hard problem of content.

- **Human semiotic task abstraction appears is Turing complete** whereas solo animal task abstraction is not, which agrees with the plainly obvious fact of the enormous generative variety of the human niche vs that of other animals. Importantly, this Turing completeness is a symptom of content-curating practices owing to capacities for meta-level use of symbol in constituting symbol, not its cause.

- **FoCo & CoFoCo: a Formal Ecological-Semiotic Model of Agency and Joint Agency** Formally explicate the notion of focus compression (FoCo) for basic agency and of coordinated focus compression (CoFoCo) for joint agency.

- **Testing the Hypothesis**

  - **FoCo should improve unsupervised artificial agent performance on standard benchmarks.** These conclusions apply to the hard problem of content in computing, suggesting a constructive test of the hypothesis, that artificial agents should benefit from implementing a FoCo strategy for acquiring compressed attention to centers as modeled in the way proposed here.

  - **CoFoCo should create greater improvements than FoCo alone.** Following up on the promising results of Lee et al (2021), a second constructive test of the hypothesis is proposed that artifical agents trained using a CoFoCo strategy of coordinated attention to centers as modeled here, will considerably improve performance on tasks.

  - **CoFoCo should enable augmentation of human agency by aligning agents with human centers**. A third constructive test of the hypothesis is proposed that bears on the human and the machine case in tandem: human decisions in contexts of engagement, focus, and support which together describe centers of attention can be instrumented enabling data collection and training using the CoFoCo strategy such that machine agents can offer some degree of awareness and support in shared contexts of scaffolding human practice.

Ecological Information Basics

Why ecological psychology?

In the second half of the 20th century, James and Eleanor Gibson began the project of developing a phenomenology of perception as prospective biological

control guided by affordances of the physical environment. Rejecting the Cartesian view of perception being the result of enriching raw sensory input, they arrived at a theory of perceptual development consistent with the biological understanding of development as differentiation, and of perceptual control systems rather than sensations. This work produced a comprehensive theory of information in terms of the direct fit between agents and law-based dispositions of the environment.

TODO, make case for eco psych over other approaches

Law-based ecological information

The ecological approach has developed a powerfully explanatory account of information pick-up as a fit between organisms and their environments. Invariant physical patterns, such as regularities in the array of light reflecting upon surfaces over perspectival movement at the relevant scale, can specify affordances. Affordances, such as a walkable ground, or a climbable tree, specify reliable options to be realized by agents that are able to use them. Effectivities, which are the dispositional properties of agents that complement affordances, can be innately evolved to fit affordances or require differentiation in the course of development to realize the affordances they fit. In ecological psychology the term "task" refers to instances of prospective control-oriented behavior, which is understood to characterize the teleological nature of agents' behavior in general. When an agent actively engaged in a task uses affordances to guide itself toward a preferable state, it is picking up on ecological information. Embodiment of ecological information is the calibration of body and environment in a kind of measured adjustment guided by affordance. To acquire the information supporting perception-action in this way is to measure affordances by the effectivities that fit them.

Convention-based ecological information

Affordances have the unique property of supporting direct perception by specifying reliable action opportunities for compatible and prepared agents, but direct perception is not the only way for agents to acquire ecological information. Agents also come to embody ecological information by indirect, convention-based means as well (Golonka 2015). Convention-based information, unlike law-based information, does not guide action, but rather selects, or tips the balance between attending among available affordances of the environment. An example that serves well to elucidate why is that the exterior of a can of beer does not specify the information for getting to the outcome of drinking beer in the same way that the reflectivity of a paved surface specifies the information for slipping and sliding on ice, or the way that the can affords opening by lifting its lever. Instead what the labeling of the can offers is a way of selecting the beer drinking experience, which is then engaged via direct affordances of the can and the liquid. This account of the use of conventions to selectively attend to the direct affordances that must be realized in order to achieve the indicated outcome illustrates that

some actionable/perceivable event or feature (eg. a stop sign as object in the layout of the environment) is always needed as a means of selecting some other (eg. controlling one's vehicle in relation to the expected behavior of other cars.)

As Golonka's examples illustrate, the convention-based/law-based distinction is a cross-cutting one, orthogonal to distinctions such as natural versus human-made or social versus nonsocial. The most widely popularized examples of law-based information tend to be natural, non-social examples (such as the affordances of climbable trees to animals that can climb them), but this is mainly for pedagogical reasons due to their relative simplicity. There are human-made, non-social affordances such as steps, ramps, doorways, walkways, and shelters, and natural social affordances such as infant crying and facial expressions, and pointing gestures, which we will explore in more detail. Most social information is however convention-based, both among humans and animal species. Golonka gives the example of the honeybee waggle dance, which might seem to be a social affordance supporting an ecological law relationship between honeybees and food sources, but is recognized instead as convention-based natural social information because the conditions it is sensitive to may blink in and out of existence. Human gaze-following in contrast is a natural social affordance, because gaze is used in cooperative communication, and it always follows linearly to the immediate location of its target. For comparison, the human deictic convention of composing phrases such as "the room we are in" is conventional, because it can't be used to continuously guide action as a mathematically expressible ecological law the way that gaze can. And finally, it should be clarified that despite the wealth of socially-oriented examples, convention-based information need not be social, as demonstrated by examples such as a domestic cat relying (often unsuccessfully) on the sound of a can-opener to pursue an opportunity for food, or a person deciding between two courses of action based on the outcome of a coin flip.

An Ecological-Semiotic Approach to Perception and Information

Gibsonian information theory needs Peircean biosemiotics

Peircean biosemiotics needs a Gibsonian foundation

Semiotic scaffolding

The prospective control task as semiotic self-control

The Hard Problem of Content

The problem

Proposed solutions

Joint attention as a solution to the hard problem of content

1. Tomasello's theory of cooperative commmunication

Research on joint attention in primates and human infants has uncovered a framework of cooperative communication unique to humans: at around 9 months of age, we begin to use gestural signals to share, follow into, and direct what adults attend to (Carpenter, Nagell, Tomasello 1998, Tomasello 2008). These skills suggest an innate disposition to assist others by guiding attentional focus as an effective means toward shared objectives. These behaviors, especially when augmented by tools and repeatable practices for motivating and guiding attention, are referred to as scaffolding. This framework of cooperative communication has received wide attention as an explanation of the origin and present source of the unique human niche, characterized by the ubiquitous exchange of shared intentional practices and narratively curated content.

An Ecological-Semiotic Approach to Joint Attention

Clues from empirical research

The collaborative constitution of agency hypothesis

Joint agency solves the hard problem of content

Human semiotic task abstraction is Turing complete

FoCo & CoFoCo: a Formal Ecological-Semiotic Model of Agency and Joint Agency

Testing the Hypothesis

FoCo should improve unsupervised artificial agent performance on standard benchmarks

CoFoCo should create greater improvements than FoCo alone

CoFoCo should enable augmentation of human agency by aligning agents with human centers

References

- "Philosophical Investigations" Wittgenstein 1953 https://static1. squarespace.com/static/54889e73e4b0a2c1f9891289/t/564b61a4e4b04eca59c4d232/1447780772744/Ludwig.Wittgenstein.-.Philosophical.Investigations.pdf
- "Man-Computer Symbiosis" Licklider 1960 http://worrydream.com/refs/Licklider%20-%20Man-Computer%20Symbiosis.pdf
- "Augmenting Human Intellect: A Conceptual Framework" Engelbart 1962 http://dougengelbart.org/content/view/138
- "Perception of Another Person's Looking Behavior" J. J. Gibson & Pick 1963 https://www.jstor.org/stable/1419779
- "The Senses Considered as Perceptual Systems" J. J. Gibson 1966 https://b-ok.cc/book/3554998/9b8962

- "Attention: the Perceiver as Performer" E. J. Gibson & Rader 1979 https://www.researchgate.net/publication/291344991_Attention_The_Perceiver_as_Performer
- "The Ecological Approach to Visual Perception" J. J. Gibson 1979 http://b-ok.cc/book/864226/e0dd92
- "Affordances and Prospective Control: An Outline of the Ontology" Turvey 1992 https://canvas.brown.edu/courses/755816/files/20990546/download?wrap=1
- "Social cognition, joint attention, and communicative competence from 9 to 15 months of age." Carpenter, Nagell, Tomasello 1998 https://www.jstor.org/stable/1166214
- "An Ecological Approach to Perceptual Learning and Development" E. J. Gibson & Pick 2000 https://b-ok.cc/book/879525/7d1f69
- "Origins of Human Communication" Tomasello 2008 http://b-ok.cc/book/541274/39859f
- "Empowerment: A Universal Agent-Centric Measure of Control" Klyubin, Polani, Nehaniv 2005 https://www.researchgate.net/publication/4201381_Empowerment_A_Universal_Agent-Centric_Measure_of_Control
- "A free energy principle for the brain" Friston, Kilner, Harrison 2006 https://www.fil.ion.ucl.ac.uk/~karl/A%20free%20energy%20principle%20for%20the%20brain.pdf
- "On Intelligence From First Principles: Guidelines for Inquiry Into the Hypothesis of Physical Intelligence (PI)" Turvey & Carello 2012 https://booksc.xyz/book/42939095/6bac90
- "The Evolution of Semiotic Self-Control" Frederik Stjernfelt 2012 https://www.researchgate.net/profile/Frederik-Stjernfelt-2
- "Radicalizing Enactivism" Hutto & Myin 2013 http://b-ok.cc/book/2554656/1b7ea8
- "Natural Propositions" Frederik Stjernfelt 2014 https://books.google.com/books/about/Natural_Propositions.html?id=X37ioQEACAAJ
- "A Rich Landscape of Affordances" Rietveld & Kiverstein 2014 https://www.tandfonline.com/doi/full/10.1080/10407413.2014.958035?scroll=top&needAccess=true
- "Self-organization, free energy minimization, and optimal grip on a field of affordances" Bruineberg & Rietveld 2014 https://www.frontiersin.org/articles/10.3389/fnhum.2014.00599/full
- "Laws and Conventions in Language-Related Behaviors" Golonka 2015 https://www.tandfonline.com/doi/abs/10.1080/10407413.2015.1068654
- "Strange Tools: Art and Human Nature" Noë 2015 http://b-ok.cc/book/2640649/b1b44d
- "Cultural Affordances: Scaffolding Local Worlds Through Shared Intentionality and Regimes of Attention" Ramstead, Veissière, Kirmayer 2016 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4960915/
- "Evolving Enactivism" Hutto & Myin 2017 http://b-ok.cc/book/2947353/09d772
- "Attentional actions – an ecological-enactive account of utterances of

concrete words" Jasper C. Van Den Herik 2018 https://sciendo.com/article/10.2478/plc-2018-0005

- "Free energy, empowerment, and predictive information compared" Biehl, Guckelsberger, Salge, Smith, Polani 2018 https://www.mis.mpg.de/fileadmin/pdf/abstract_gso18_3300.pdf
- "Getting into predictive processing's great guessing game: Bootstrap heaven or hell?" Hutto 2018 https://philpapers.org/rec/HUTGIP
- "Steps to an Ecology of Bicycles for the Mind: A Situated Programming Manifesto" Levy 2018 http://senters.info/situated-programming
- "Unsupervised learning and the natural origins of content" Korbak 2019 http://philsci-archive.pitt.edu/16429/
- "Joint Attention for Multi-Agent Coordination and Social Learning" Dennis Lee, Natasha Jaques, Chase Kew, Douglas Eck, Dale Schuurmans, Aleksandra Faust 2021 https://arxiv.org/abs/2104.07750?context=cs.MA