
STEPS
ECOLOGY
A SITUATE
PROGRAMM
MIND

STEPS TO AN ECOLOGY OF BICYCLES FOR THE MIND

A SITUATED PROGRAMMING MANIFESTO

Robert Levy, February 2018

URL: senters.info/situated-programming

Dedicated to Bristy
my partner in life
and in joint attention

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PREFACE

In the folklore of computing, the turn of phrase "bicycle for the mind"[1] characterizes the aims of intelligence amplification (IA) efforts by way of reference to the well-established scientific fact that bicycles come astonishingly close to making total use of a person's self-generated mechanical power. A bicycle is the most efficient vehicle to harness a human's own power toward locomotive objectives.[2] Can computing technology similarly be used to maximally leverage human powers of perception/action and narrative sense-making?

The metaphor raises an obvious question: why not an electric bicycle, or a self-steering sailboat, or a telepresence drone--for the mind, for that matter? Power tools of thought are ultimately what we want, but there is risk in putting them first. The bicycle model of amplifying human powers highlights the challenge of how to extend agency with technologies closely fit to core human competencies and needs. Skipping this necessary first step seems to lead down a path of not augmenting human capacities, but instead supplanting them in ways that tend to integrate poorly with the actual interests and needs of users. It leads to inscrutable oracles that trade off accountability and expertise for short-sighted convenience.

We do not yet have anything quite analogous to bicycles for the full power of the embodied human mind. But the history of human life is a story of individuals and groups developing practices and tools for scaffolding and extending personhood. I suppose we could think of some of these innovations as wheelbarrows or shovels for the mind, augmenting capacities to participate in the world in specific ways. To measure up to the standards of our analogy from human mechanical power, a bicycle will likely have to extend root human competencies that enable all these specific kinds. But a long time ago humans did begin developing something close to a bicycle for the mind-- language. Language is at base a means (but not the only means) of codifying joint attention and cooperation in a way that enables us to share in advanced content-bearing activities of both direct and abstract construal.[3] The limitations of language are shown by the only partly overlapping power of other workhorses such as music, pictoriality, math notations, etc, but the incredible power of language as a means of scaffolding is why language-aware computing has been a holy grail for the field. Needless to say, conversation has not yet become accessible to tooling except in trivial ways.

All of that said, I do not believe it is correct to say "natural language understanding" is the bicycle for the mind, but rather that NLU is probably only achievable by layering on top of a more fundamental level of tooling: the instrumenting of joint attention. I will make a case here that the bicycle for the mind is likely to be developed in the context of "situated programming", because only by instrumenting and tracking events in processes of motivated attending to environments together, can we scaffold the processes of joint attention that constitute the foundational framework from which the human niche emerges. The aim is to augment action/perception by scaffolding joint attention as the basis for amplifying situation awareness and narrative sense-making, in augmented, virtual, and mixed environments.

I call this work a "manifesto" because I don't consider it an idle theoretical exercise, but instead as advocacy for certain approaches and courses of action that are motivated by real problems in society, technology, and science. Alan Kay once remarked that "the best way to predict to future is to invent it". Likewise the best way to make sense of history is to excavate from it the most sound basis for the direction one is inventing toward. I survey three major trends tracing all the way back to the birth of modern human primates: attending, working, and organizing. Starting with the origins of joint attentional scaffolding and following a thread through changes that have impacted the scale of attention, work, and social organization, I draft a roadmap to an ecology of bicycles for the mind. I have kept references to authors, works, and prior art in the endnotes apart from the main text to simplify presentation.

AGENTS AND THEIR ENVIRONMENTS

Two of the oldest questions in philosophy and science are "what is life?" and "what is mind?". Only a mere 150 years ago[1] did it begin to dawn on pragmatic thinkers that these two questions are actually one question: "what is an agent?". To ask what an agent is is to ask what the difference is between inert mechanisms and living, feeling, self-steering mechanisms. So the question naturally becomes one of feedback and control mechanisms. Agents are systems that act to control parameters of environments that matter to them. To speak of an "environment of" or "mattering to" a system requires a physical explanation, and that explanation is given by natural selection. Mattering is a consequence of evolution because physico-chemical arrangements are either ephemeral or they persist through targeted manufacture, maintenance, acquisition of resources, and so on. To persist requires control of factors bearing on persistence, as biases or preferences. In other words, those things matter to the agent.

An agent, minimally defined, is a system that exercises control over factors ultimately tied to its persistence as an autonomous entity over time. Factors that may be required for the unity of the system to endure but are less directly controllable by the agent are called the environment of an agent. It is important to note that up until here, when we speak of mattering to an agent it is meant strictly in terms of outcomes that can be observed in the functioning of the system by an outside observer. What is called "perception" is an agent's active sensitivity to ecological features called affordances that bear upon control objectives. To say affordances matter to an agent, is to say that the real outcomes matter (both in terms of learning effective habits and in terms of reproduction/survival viability), but also to remark on the first-hand phenomenology of proactive sensitivity to ecological properties. This latter aspect becomes more sophisticated and pronounced in more complex species.

The following three modes or predicaments are definitionally universal to agents.[2] All agents from the most basic kind to human agents must contend with these.

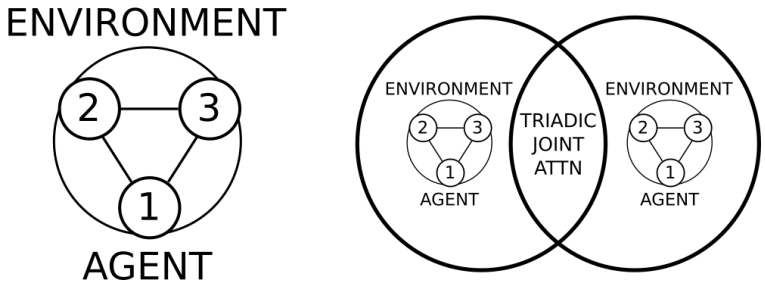
1. ENGAGING: An agent is situated in environments that afford many opportunities and threats demanding awareness and readiness to potentially engage promising ends and mitigate perilous eventualities. Any engagement has opportunity costs, so an agent must budget attention[3] wisely. **The predicament of engaging is that of classifying events as indicative of means to valued ends, in deciding to engage or not.**
2. SUPPORTING: Support, in the sense of contribution of work or effort, refers to relationships that hold between a presently engaged process and one or more potential or ongoing process of an agent. **The predicament for the agent is to what extent does the work of a secondary engagement contribute to (or hinder) the realization of the present enagement's objective, in deciding to include in scope or not.** In economics, the term "disutility of work" captures a key aspect of what agents must optimize in this predicament: ideally only those supporting processes that contribute to realizing valued ends should be involved, and others should be excluded. The phenomenon of concentration or focus is also expressed by optimally excluding/including supporting or subordinate engagement.
3. REALIZING: The third predicament that agents contend with is that of organizing final causes. Final causes are those that motivate the second predicament above and indirectly, the first as well. **The predicament is that of defining ends, in deciding to continue or exit. What defines the unique character or meaning of realized ends is the specific set of options that are available to exit to.** In general, positions that offer more options (giving the agent more autonomy, rather than being at the mercy of circumstance) appear to be favorable, all other things being equal.

JOINT ATTENTION: THE HUMAN NICHE

Human agents are indisputably a unique case among natural agents. What characterizes the "sapience" of humans, as distinct from the more widespread "sentience" of basic acting/perceiving agents more broadly, is our capacity to carry out content-bearing narrative and propositional acts. Such capacities are not deep or intrinsic to intelligence by any means. The rich variety of sentient intelligence in nature manifests as purely pragmatic capacities of agents to steer events toward ends that matter-- solely in terms of direct bearing on positioning or readiness, often to the mutual benefit of agents. The skills supporting sapience are no exception, but they have opened for our species a radically novel niche unlike any other animal's.[1]

This narrative kind of agency is wholly due to a set of evolved capacities constituting a cooperative infrastructure of communication that began with gesture.[2] The function of gesture, including pointing and pantomime is to share, follow, and direct the flow of motivated attending. While other species engage in joint attention[3], only humans are known to be capable of what has been called "triadic joint attention" in which two or more agents attend to a shared focus, and crucially, *coordinate a shared end motivating the focus*.

SENTIENT AGENCY **SAPIENT AGENCY**



Joint attention is important for two reasons. The first reason is that it is directly responsible for human intentionally organized tools and practices. This is because when agents externally coordinate events that bear upon engagement, support, and realization, they are defining and shaping shared processes of narratively organized agency. The second reason, a consequence of the first, is that the practices and tools that arise in service of joint attention become a rich repository of scaffolding that constitutes tacit and explicit common ground supporting the many varieties of social interactions. The accumulation of scaffolding offers potentially endless options for agents to extend the reach of their world-involving activities in socially sharable ways.

The earliest stages of human societies mark the beginnings of a history of tools and practices (such as paintings, masks, signs, speaking, etc) for scaffolding joint attention. Scaffolding is still by and large a highly localized activity between small groups of people, though the coordination of local activities has been significantly broadened by technologies of writing, the printing press, mass media, and the internet. Disseminable graphical practices such as writing and diagramming exemplify how **extensive**[4] sapient agents are: the reach and influence of involvement in the world is amplified by distributed scaffolding practices. Bicycles for the mind aim to *immediatize* these wide feedback loops so as to scale awareness, sense-making, and organizational practices.

THE SCALABILITY OF ATTENTION, WORK, AND SOCIAL ORGANIZATION

In the definition of agency introduced above, three predicaments were identified that any account or specification of basic sentient agents will have to address. I then added a layer on top of this for sapient agents, agents that engage in collaborative narrative sense-making practices: not only do we directly engage the world toward ends, but we engage that subset of our environments that is other agents, developing sensitivity to other agents' states of engaging, supporting, and realizing objectives, in navigating and negotiating the direction of attention. For sapient agents, what arises from the three basic agent predicaments, are three common concerns addressed in diverse ways over the course of history.

1. ATTENTION Any social unit, however temporary or time-extended, and however large or small, is confronted with the need for coordination on what merits attention. Agents develop a shared awareness or common involvement in making sense of events as bearing on shared concerns.
2. WORK Any social unit is confronted with the need for ways of having effects on the world together. Tools and machines have greatly expanded our capacities to work toward objectives. Technologies of attention, such as diagramming and notation, serve to affect agents' processes of realizing specific ends.
3. SOCIAL ORGANIZATION Any social unit is confronted with the need to coordinate on final causes that constitute "what we want to happen". This can include anything from a preference to avoid places with cold temperatures in an outing together, to political causes, legal justice rulings, or the incentive structure of a game.

All evidence suggests that the primary original driver of increasingly advanced cooperation amplified by joint attention in proto-human primates was the stag hunt. Big game hunting required more than one person's help, and the better they coordinated, the better results they got on average. However early human societies did not gather in groups much larger than other primates did, because of the limitations of keeping track of one another and coordinating collective efforts. Humans developed intentional tools for practical purposes (like spears), and tools and practices of attention such as gesture, drama, ritual, painting, language, and an explosion of cultural artifacts as they began to bootstrap their capacities further, scaffolded in this way. It was in this period that people began to tell stories and make sense of nature in the best ways they could find to influence their shared fate positively.

The next major shift in human social organization was driven by agriculture. Permanent settlements inhabited by unprecedented numbers of people led to increasingly hierarchical social organization to manage bottlenecks of attention, work, and governance at scale. In this period the hallmarks of civilization such as trade and money arose to address limitations of personal and collective situation awareness that rendered ineffective older established ways of sharing in common resource pools. Mechanical devices and managerial hierarchies were developed to address the scale of work. Heavy-handed monarchies and religious institutions addressed problems of discovering and coordinating social value at scale.

In the present era we are at the beginning of another major shift in the scale of society, from a hierarchical civilization to a decentralized network society. Near the end of civilization, the human project of industrialization culminated in a generalization of efficient work in the form of information theory, control theory, and the invention of the digital computer. Networked computers have globalized the coordination of mechanical work, enabling ad hoc, easily affordable, planetary-scale machinery. Just as old methods failed us when we formed large settlements, we now need decentralized social organization in order to function at global and interplanetary scale. *The main bottleneck is the need for tools that scale shared awareness and organization.*

SITUATED PROGRAMMING

At the traumatic height of the 20th century, cybernetics emerged as a bold scientific, technological, and societal program that emphasized the engineering of agent mechanisms. Cybernetics was instrumental in the invention and development of computing technology, which it cast as a tool for designing and understanding systems organized by mechanisms resembling the end-directed processes of natural agents. The first high-level programming languages reflected the machine and human sides of this project respectively, with Fortran focused on efficient use of machine resources, and Lisp focused on amplifying human expressive power. As time went on and resources grew more abundant, Lisps and other expressive languages became more practical. Parallel to these developments, user bases were expanding, but at the cost of a growing divide in power between "programmers" and "users". Ever since that trend started, there has been a tension in computing between programming being disconnected with situated use, and use lacking the expressive power of programming. Consequently there have been many efforts to make programming more accessible to wider audiences, and/or to make situated use as powerful as programming. The setbacks such efforts have faced have been both technical (fundamental challenges in interface design, knowledge representation, etc.) and cultural (respectability politics in academia and industry, economic factors).

For a few different reasons, the tide seems close to turning. Mobile and wearable computing is increasingly ubiquitous and we are only a couple of years away from affordable consumer **augmented reality** hardware. That means computing is more frequently applied to activities other than just those ones that are best done sitting at a desk. Some of the original cybernetics ideas, namely neural networks and agent-based learning have become wildly successful, and we are on the cusp of practical **differentiable programming**, a functional, declarative, data-centric approach to programming. Efforts in industry such as **robotic process automation** are aptly proposing agents as an effective user interface model to give users more expressive power. The architecture pattern of **event-driven dataflow** is gaining in popularity at the same time that **decentralized data provenance** infrastructure is maturing. Data provenance is the cornerstone of decentralized network society. As computing scales the labor dimension of collaborative agency, it becomes necessary to scale social accountability with respect to effects and motivations of work. Having auditable records is essential to assessing and correcting faults, and for learning what works and why, in repeatable ways. Only when the systems that extend our agency and act on our behalf are sourced with reliable records, can we make sense of them, take responsibility for them, and employ them with confidence.

All of this points to the viability of developing a software ecosystem in which open data standards and data in the form of private and shared logs of first-class user-instrumented events, replaces application-internal data silos, allowing for composable agent-centered control. Such expression and control can be directly situated in and integrated into agents' lived situations. Because this is an approach of specifying agency and control as data, users will ideally be able to make use of differentiable mechanisms to program or shape systems painlessly *in situ*. While the term **situated programming** does not yet have much currency[1], it is a very fitting one to describe this trend of users gaining more of the power of programming and programmers gaining more situational context, by use-centered, event-driven, world-involving means.

A final major question is the concern of the next chapter: what sort of data specification can adequately capture parameters of joint attention underlying shared agency. In other words how do we build bicycles for the mind? This needs to be a central concern of situated programming, I will argue, because scaling social organization requires expanding our capacities to share common ground, whether passively by means of high-confidence proxy agents or actively influencing events that impact our lives.

THE ART OF BICYCLE MAINTENANCE

The colloquial idea of a bicycle for the mind can be defined more precisely as the hypothetical minimum effective instrumentation of individuals' capacities for joint attention required to effect maximum tandem control of shared situations. What I propose as one approach to constructing bicycles for the mind, within the broader context of situated programming, is a practice I call **narrative process scaffolding** (NPS). My own project of implementing NPS is an open data protocol for coordinating joint attention that I call **senters**. Here I will describe NPS and senters at a high level, but the full specification (a work in progress at the time of this writing) can be found at senters.info.

In NPS, users *instrument* their active involvement in affecting and being affected by their environments. NPS makes use of the kappa architecture of event-driven dataflow programming, but at the user level: events are known to and matter to users. This is because **events** are inextricably tied to **instruments**. Instruments are simple programs that track and emit events.

But instrumenting one's life with streams of events, even as a means of mechanizing chains of reactions in support of useful functions, does not in itself make computing more fluent and meaningful. What distinguishes the approach of NPS is agents' live sculpting of **centers** of bearing on their lives and situations. A center is a recurring or persisting nexus of end-directed feedback. To scaffold a flow of narrative process among centers is to direct it in terms of the three predicaments. This is done using **gestures**.

1. Awareness gestures (engage or refrain): event indicates a center to be aware of to potentially engage or avoid.
2. Composition gestures (follow or voice): event indicates a secondary center to be included as helpful or excluded.
3. Organization gestures (exit or continue): event indicates realization of process calling for exit or continuation.

Gestures and other events are committed to narrative process logs that can be shared with others selectively. Logs that record gestures with respect to instrumented events are recordings of what happened that capture the relevance of the events to varieties of end-directed activity. Not only should this enable more "purposive" specification of systems, but it should make it possible for users to exercise shared and personal agency at larger scales with the help of artificial proxy agents. This is the case to the extent that generic computational processes can be trained to successfully follow these flows, given access to many shared records of experiments. NPS this way facilitates a declarative and legible approach to machine intelligence that serves to closely augment human intelligence rather than developing complex opaque behaviors that elude it.

The shared activity of organizing and repeating flows of end-directed process is the essence of sapience and narrative construal and sense-making. This presents what appears to be the most viable solution to the problem of "knowledge representation" in software. Crucially, shared knowledge emerges from being concerned with others' narrative processes, and attending to signs of others' successes and failures of awareness, composition, and organization in order to provide feedback.

Narrative process scaffolding amplifies social and personal intelligence by augmenting awareness, composition, and organization of end-directed processes. The practice of narrative process scaffolding, to be successful, must generate an extensive field of both widely and more narrowly shared topologies of centers that are sourced from and which make sense of logs of immutable event data: an ecology of bicycles for the mind. Further, knowledge representation as interactive attention-flow replay can be built using software scaffolding of joint attention. Doing so is our best bet in the vital cause of removing the barriers to interplanetary-scale attention, work, and social organization.

A ROADMAP TO BICYCLES FOR THE MIND

The proposed narrative process scaffolding approach to situated programming faces some challenges. There will need to be a **user-level data sharing ecology**[1], more mature consumer-ready **wearable AR hardware**, adoption of **NPS practices**, and learnability of attention-flow by **artificial proxy agents**. The first two are industry-wide trends that are likely to continue to grow. The third concerns potential barriers to adoption of what will admittedly seem to be an unusual approach to computing. Two major shifts in user mindset are required: liberation from applications per se in the "handing over of control" to user-defined narrative pathways, and "turning inside out" of acting inside applications to instead act in a world that one instruments and scaffolds.

Beyond "apps": putting users in control. Narrative process scaffolding has been presented as one answer to the still very new question of how to design software that augments world-involving socially shared activities. While the traditional application model owns and controls what options users have available (without much ability to fit meaningfully into activities owned by other applications), in NPS instruments are simple and controlled by gestures and other events, enabling them to be woven into narrative flows by users. The responsibility for discovery and control of what options are available is turned over to users. Fortunately users are not on their own, having access to process logs shared with them by other users, whose well-trodden paths serve as a guide. Rather than downloading applications, users share references to repository locations of instruments, in the course of sharing the data of narrative processes that call for their use.

Turning user experience inside out. Users are familiar with a model in which an application is visited and entered into to do thing the application makes possible. In NPS, this is turned inside out, with users instrumenting situated engagements in the world, most often in tandem with the contributions of multiple other instrumented sources acting as the basis of centers that are visited in narrative flows. Instruments do not play the role of applications affording information on options for action, rather it is centers that establish ecological information. Centers are supported by instruments in conjunction with actual situations, established by histories of narrative process. Users define processes together as they go, as flows visiting series of centers, each center scaffolding narrative process toward the objective of that center.

Machine-followability via proxy agents is a key aspect of the NPS approach. Users organize (ideally as effortlessly as thoughts are organized) modes of augmented activity by their relevance to circumstance. For proxy agents to helpfully get the attention of their users in the most appropriate circumstances they will have to learn from the data of many users' experiences through the use of instruments that proxy agents are granted capabilities to wield in the context of the center that scaffolds their actions. Followability can likely be achieved by known combinatorial and continuous optimization techniques.

As a closing thought, the idea of narrative process scaffolding differs from traditional computing in that it aspires to a kind of fluency or **intimacy of instrumentation**. When a proxy agent carries out a process for a user as scaffolded, it is typically following a short feedback loop, no different from the kind we come to trust as our own thoughts and feelings. Why do we trust our thoughts and feelings? Mainly because of our active and direct hand in shaping them. And where they go wrong we work to correct them. Our most basic experiences are facilitated by manipulations of embodied instruments to affect and be affected by ecological and social information, and our use of external instruments extends the instrumentation that is part of our bodies.[2] So ultimately narrative process scaffolding aims to flow seamlessly with active perceptual experience, empowering users with heightened involvement in the world.

ENDNOTES

preface: **1.** To the best of my knowledge, the first documented occurrence of the turn of phrase was in a 1980 presentation by Apple Computer co-founder Steve Jobs on using computers to amplify human abilities. In so doing he paid homage to a key theme of the cybernetic movement that gave birth to computers. The title of this manifesto combines this phrase with a reference to "Steps to an Ecology of Mind" by cyberneticist Gregory Bateson, which explored the organization of individuals, societies, and ecosystems in terms feedback and adaptive self-regulation. **2.** In addition to bicycles standing for a close fit between humans and technological extension, bicycles have other fitting associations. Bicycles influence urban planning toward human-centered designs. They have historically stood for liberation and empowerment, playing a significant role in feminism. Susan B. Anthony wrote of the bicycle: "it has done more to emancipate women than anything else in the world. I stand and rejoice every time I see a woman ride by on a wheel." **3.** Spoken language, by any account a crowning achievement of our species (innateness debates aside), is supported by image schematic and metaphorical devices for coordinating construal of abstract domains (Lakoff 1993, Talmy 2000, Goldberg 2003). The use of these devices is so entrenched in cultural practice that our use presents a task of unraveling mysteries for years to come in cognitive linguistics research.

agents: **1.** Roughly 150 years ago a revolution in evolutionary theory occurred, most notably punctuated by Darwin's "On the Origin of Species". In that setting, the "pragmatic turn" in philosophy and science began with Charles Sanders Peirce's project of reconstituting knowledge, meaning, and phenomenology in terms of situated agents calibrating meanings externally in networks of causative consequence. The pragmatic thread can be traced through the work of Uexkull, Vygotsky, later Wittgenstein, Heidegger, Merleau-Ponty and many others. Crucially it led to the 1st and 2nd cybernetics movements, the latter of which in conjunction with James and Eleanor Gibson's pioneering work in ecological psychology has developed into the "e-turn" or "4E" (embodied, ecological, enactive, and extensive) cognitive sciences. The underlying theoretical basis of semiotics (Peircean, not Sassurian), cybernetics, and radical embodied cognitive science is that meaning happens in the world, relative to the predicaments of agents, and as such must be understood in terms of processes of agents' involvement in the world over time. **2.** The assertion that agents are necessarily and sufficiently defined on three dimensions of situated bearing is likely the most controversial (and also the most crucial to the case presented) I have made here. I have arrived at it by meta-analysis of theoretical and empirical work on agents. I believe it is not only a well-motivated scientific hypothesis, but is also a powerful user-level model for scaffolding narrative processes. The table below collects some of the convergent support for a triadic model of control or agency:

	entry	support	exit
Peirce 1867	ground	correlate	interpretant
Stewart 1987	energy	information	imparity
Turvey 1992	opportunity	subact	consequence
Tomasello 1998	sharing attn	following attn	directing attn

3. Eleanor Gibson and Nancy Rader in "Attention: The Perceiver as Performer" (1979) explain that it would be misleading to regard attention as a special mechanism to be studied, and is more appropriately understood to be the activities of the perceiver-actor. Attending is simply the conduct of world-involving, end-directed activity. The word is however useful in pointing out that an agent must prioritize what to engage in, at the cost of engaging in some other activity. The word becomes more of a reference to a distinctive phenomenon in the discussion of joint attention, the phenomenon of agents' states of attending being made targets of attention in their own right, to be influenced and organized.

joint attention: **1.** Alva Noe argues persuasively in "Strange Tools: Art and Human Nature" (p. 65-66) that humans are a class of natural being distinct from animal species. This is more or less the point I am making in distinguishing sapience from the more basic sentience that we share with animals. **2.** Michael Tomasello's research over several decades shows that directing the flow and focus of others' attention in service of cooperative organization is the reason we direct the flow, focus, and organization our own world-involving activities. Basic ecological dynamics cannot be equivocated with the reflective reorganizational process of developing the what, how, and why of activity developed from from skills of joint attention. Some related work that builds this case for a duplex account of sapient intelligence are Hutto and Myin's "Radicalizing Enactivism" and "Evolving Enactivism", Chapman and Agre's "Abstract Reasoning as Emergent from Concrete Activity", Alva Noe's "Strange Tools", Nancy Salay's "Representation: Problems and Solutions", and Sabrina Golonka's "Laws and conventions in language−related behaviors". Importantly, all of this work acknowledges that this duplex account is usage-based, at the level of embodied agents situated in the world together. Representational content is achieved by agents by means of the tools and practices they use to scaffold jointly attending. **3.** Ape gestures include "intention movements" (abbreviated actions that have effects within social contexts) and "attention getters" (actions that call attention, such as slapping the ground). Perhaps surprisingly, dogs (having had some time to adapt to our cognitive niche) have experimentally shown far better understanding of human pro-social intentions and gestures such as pointing than other animals (Kirchhofer, et al). **4.** As Tracy Harms puts it, "mind, as cognitive scientists and philosophers focused on human flexibility are most interested, is characterized by an expanse of reorganizational fluidity." Hutto et al (2014), on the limits of this extent write "limits can be revealed by empirical experiment. Even if one were able to see for miles one might not be able to see for leagues."

situated programming: **1.** William Clancey explored "situated action" in the context of computing in his influential 1997 book "Situated Cognition: On Human Knowledge and Computer Representation". In 2002, Mills and Scholtz published "Situated Computing: The Next Frontier for HCI Research", exploring the reorientation to a data-first, agent-centered approach to computing brought about by mobile and wearable devices. They write, "a future where people will interact with information through a continuously varying array of devices that combine to form ad hoc portals suitable to particular situations. In such a future, people and information will be emancipated." The term "situated programming" was used by Rich Hickey in his keynote lecture at Clojure Conj 2017, emphasizing effective programs, the importance of developing meaning at the systems level rather than fixating on machine-level program abstraction, and the agent-centered design of systems.

roadmap: **1.** Dominic Tarr's secure scuttlebutt protocol (ssb) is an example of the sort of approach I have in mind. It applies the kappa architecture or event-driven dataflow programming at the user level, and for that reason it is a good fit for NPS. Further implementation-level concerns are explored in the senters RFC. **2.** I have repeatedly in this manifesto nodded in the direction of affective and sentic computing (see Rosalind Picard's work as point of reference) which is an area ripe for innovation in the emerging landscape of situated computing. Instrumenting somatic states and scaffolding emotional experiences should be an integral part of our augmented interactions.