

A Teleology- based Activity Architecture for Artificial Organisms

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Abstract

The proper context of teleology, the study of goal-directed action, is biological. Humans, foxes, sea anemones and pine trees act for the sake of achieving certain ends, while iron filings, rainfall, ocean currents and quartz crystals do not. But in this paper I describe a teleology-based architecture for defining and generating appropriate action, direction, tendencies and ends that can be used by artificial organisms. The architecture shows how an organism will employ projected final causes, how they are stored, how they can be modified, adapted to new stimuli, and how certain actions are reinforced while others suffer a reduced efficaciousness through the success or failure to achieve certain ends.⁹⁹ [This is a final cause in the Aristotelian sense, *to hou heneka*, which is literally, "the for-what", but is sometimes translated as "that for the sake of which." In Greek you can prepend an article to a phrase and make it somewhat substantive. Working two and a half millennia ago with an impoverished vocabulary Aristotle was forced to coin many of his own terms. He did not use "final cause," which is a term out of the Medieval Aristotelian tradition. Instead he used "the for-what" to designate the purpose for which an action was started.]

Introduction

The concept teleology has a long history of misuse. It has been furiously rejected and advocated by both sides and every facet of the vitalism/mechanism feud. It has been used to support anthropomorphism in nature and the Argument from Design. It has been rejected on the grounds that it necessitates contradictions like future causation and predetermination. Its use and definition have been abused by philosophers of every sort, and its study is ornamented like a rococo palace with a wide variety of useless and confusing neologisms, most of which were coined to make use of goal-directedness without using the word teleology.⁹⁹ [As J. B. S. Haldane once quipped, "Teleology is like a mistress to a biologist: he cannot live without her but he is unwilling to be seen with her in public." Quoted from *Measurement of Evolutionary Activity, Teleology and Life*, M.A. Bedau, N.H. Packard. (In C. Langton, C. Taylor, D. Farmer, and S. Rasmussen, eds., *Artificial Life II*, Santa Fe Institute Studies in the Sciences of Complexity, Vol. X, (Redwood City, CA: Addison-Wesley, 1992, pp.431-461)]

My purpose is not to argue the validity of a biological teleology [99] [See Hanover's thesis for a sustained argument] but to offer a foundation of the concept and how I will use it to drive artificial organisms. I will briefly cover the fact that there is an inextricable connection between life and teleology. A living organism depends on every action to sustain its life to

some extent. Every action requires an answer to the question: what does the organism have to lose in the case of failure and what does the organism have to gain in the case of success? There is only one ultimate answer: its life. There can be a whole chain of lesser values to gain or lose but all of these must eventually lead to the ultimate value for every organism. Any concept of teleology requires life, and in applying teleology to an artificial organism there must be some dependent process, substance, or power source without which it would collapse and die. Teleology requires the alternative of life and death in order to be meaningful.

If a fox fails to catch a hare the immediate effect may be exhaustion. It rests for a while and then continues to hunt. If the fox fails to catch any prey for weeks the short term result is suffering, the pain of hunger, while the lack of energy reduces his ability to hunt. Exhaustion comes quicker during a chase. Eventually getting to his feet may take any remaining strength left to him, and without sustenance his organs will fail. The health of every cell in his body is intricately connected in a complex chain of dependence. The fox dies and finally disintegrates.

The purpose of this poignant description is to show the unbreakable tie between successful action and life, and unsuccessful action and death, and that any man-made device that attempts to imitate living things must also implement a similar chain of values based on the nature of the device.⁹⁹ [I do not in any way attempt to validate or distinguish living organisms from artificial organisms, although a description of "artificial organism" is in order. Strictly speaking an artificial organism would be an organism created by man (artificial being the differentia), but I am not going to distinguish plants and perceptual level animals like dogs and chimpanzees from AL "organisms" generated with software, machines inspired by B.E.A.M. robotics or any other device that is designed to imitate the goal-directed behavior exhibited by all life.

I offer no justification for including machines and animate things in the same class. I also do not address other philosophical conflicts with determinism or theories of consciousness. But I should point out that although we are self-aware volitional beings and the conceptual level is necessarily non-deterministic, even in humans the perceptual level is deterministic and therefore on this narrow position what I am presenting does not seem to contradict most valid objections to materialism.

Strictly speaking applying "goal directedness" to non-living things like a software driven device is incorrect on an epistemological basis. I notice that many AL and AI advocates attempt to justify their study on the grounds that the functionality of a specific piece of software satisfies a particular concept's definition without realizing that the purpose of a definition is not "to serve as the absolute criterion of class-inclusion." [?] This is an inversion of the purpose of definition, which is exclusionary. You have the genus and then what makes the thing different.

But as I said at the start of this note I am going to set aside the potentially valid objections to the application of life to non-living things (perhaps in error) and continue to use the concept, organism, to refer to any organism, even artificially generated organism-like devices. Nor am I going to enter the quarrels over the character of consciousness. From the fact that the popular speculations on the nature of consciousness such as ephenomenalism or the identity theory are self refuting it

does not necessarily follow that the processes of a perceptual level consciousness cannot be imitated to some degree by a deterministic machine.]

It is not enough to observe phototropism in nature and then say, "I will construct a machine that seeks light. It will exhibit life-like properties." You must also ask why should the machine move or position itself toward light? For what end? Is it to recharge capacitors or batteries? Why does it need to do that? Does it require stored energy for some deeper purpose? Eventually you should reach a point where your only answer is, "because the device will shutdown--in effect die--without it."

Note the following concepts from the previous paragraph: seek, move, end, require, purpose and die. These reveal the goal-directedness in an organism and the relationship between action and value, which is based on two necessary functional abilities that all living and artificial organisms must possess, self-generated action and the association of value-significance to an end state.

Self-generated Action

One of the many differences between a living and non-living thing is goal directed action. Both animate and inanimate things can act. The action of a hurricane is based on many factors, including the temperature and current flow in the ocean and the air, but as is the case with all non-living things these are outside forces interacting and producing the effect, a large storm system. (Not self generated for the purpose of sustaining the hurricane's existence) [?] In contradistinction, the action of living things can be self-generated, and ultimately all biological action whether conscious or not is teleological. Inanimate objects do not act in the same way living things do.

Phototropism in plants is the result of the regulated distribution of the hormone auxin that weighs down the stems and leaves on the side opposite the sun, bending the plant in order to maximize the reception of incident light. [99] [The auxin mechanism controls the asymmetric rate of growth on plants] Higher animals such as dogs possess complex and even modifiable behavior. A dog that has been raised with cats may simply ignore them or even play with them as it might another dog, but the sight of an unfamiliar cat may cause the dog to chase it. This is an example of a learned exception to the innate (stereotyped) behavioral trigger in the dog's consciousness that classifies cats as prey.

Self generation is a necessary condition for both purposeful and vegetative action. Both purposeful and vegetative actions are self-generated in that the cause is internal to the organism. It is the source of energy that

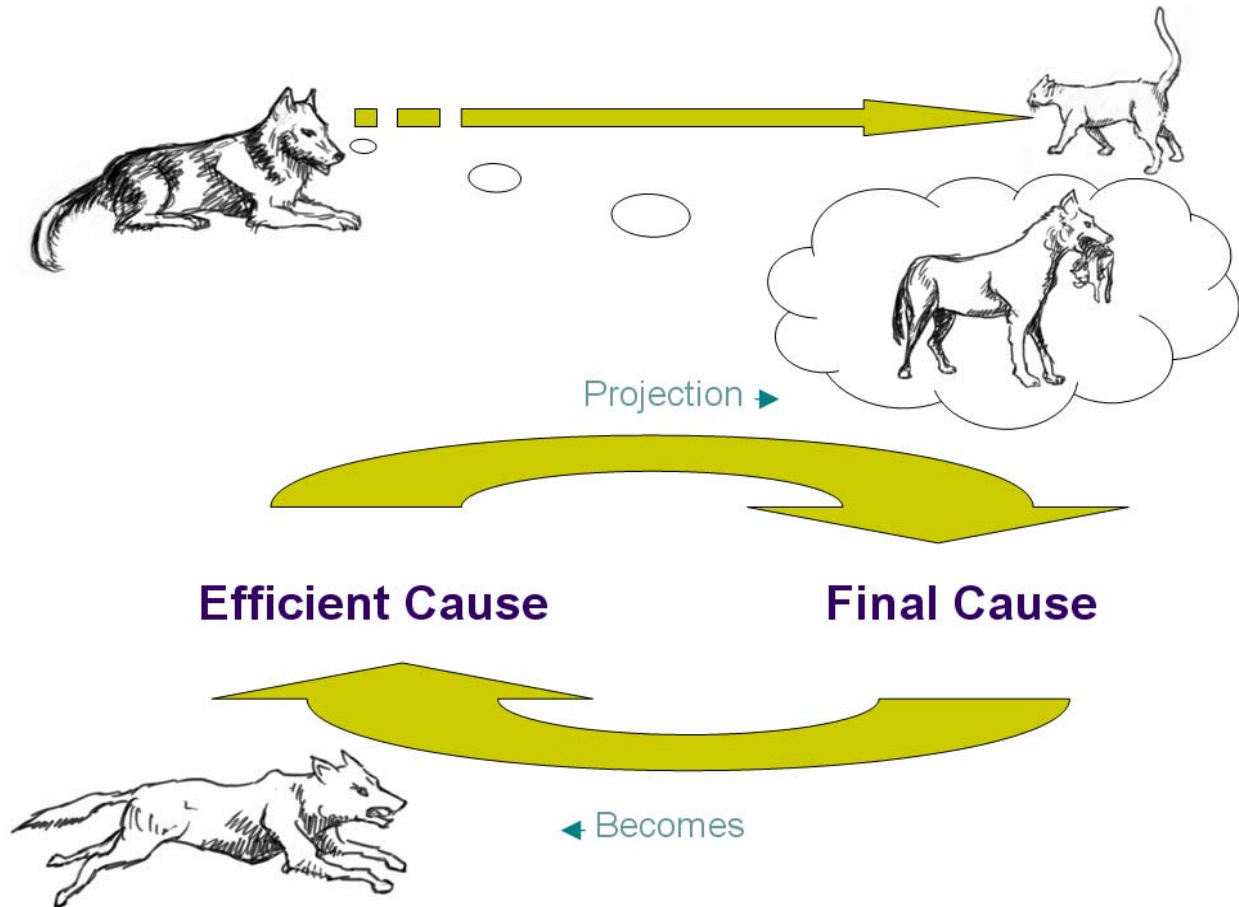
distinguishes self-generated action from non-self-generated action. A living organism supplies its own energy for the actions it undertakes. The fox gets to his feet, climbs a hill, and crouches in hiding as a larger predator passes. All of his actions are internally generated and sustained by an internal supply of energy that he must continually replenish by catching prey, eating it and processing it as food. Snow falls, dead leaves glide on the breeze, waves crash against the beach, but none of these act in the way a fox acts. A stone rolling down a hill is passively moved by outside forces like wind or gravity, but the fox moves himself through the internal generation and expenditure of energy that he himself must act to gain and process.

Value Significance

Self generated action is a necessary condition of teleology but not a sufficient condition. For teleology, self-generated action is the genus of which seeking a value is the differentia. There are many self-generated actions that are not value-seeking, or are simply the effects of value seeking like the sound of your heartbeat.

Goal Causation

Self-generated action for the sake of something the organism values leads to the concept that unites them, goal-causation.



A Simple Example

To concretize the previous ideas let me step through the process of creating an extremely simple artificial organism at a fairly high level. What I have in mind is a creature limited to a one sense modality, temperature. Let us call this example creature biotemp.

Biotemp's sensory mechanism is made up of a single input apparatus, a temperature probe, and based on the data fed to the perceptual level the organism will act a certain way.

There is no difference on the sensation level. Everything is an undifferentiated stream of data for each modality. The perceptual level's first task is to select and group sensations that differ from one another (per modality--e.g., for audio, if the volume and frequency of the hum of a fan is continuous it soon drops out of awareness). The perceptual level requires differentiation to operate. In the somatosensory modality if

pressure or temperature gradually increase but are between a high and low threshold the slightness of the graduation reduces or prevents the organism's likelihood of becoming aware of these. However below or above the threshold causes the sensory mechanisms to send data at rapidly oscillating values, in effect drowning out other sensory input for this modality. This is what pain is for the organism, a repeated bombardment on the perceptual level from the sensory level. As the temperature rises above the max threshold the sense mechanism increases the frequency of the messages and oscillations widen.

[graph]

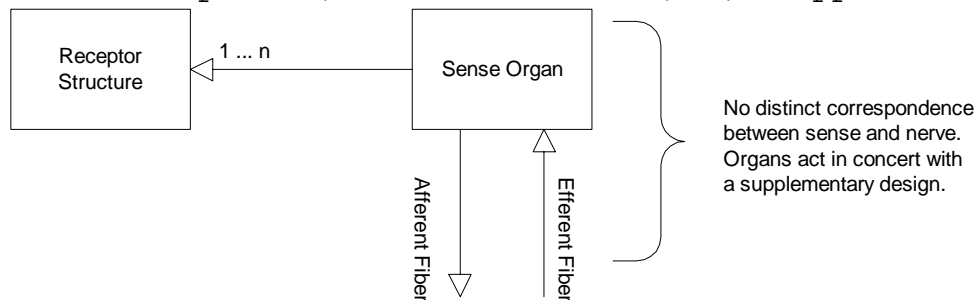
As t increases f and o increase proportionately.

Stimulus response

- imposed on subject
- action produced input
- feedback (SR loop)
- re-afferent, contingent upon efferent output)
- "continuous flow of activity rather than a chain of distinct reflexes" [Gibson, 31]
- looks at something, sniffs odor, seeks stimulus, not just impassively waiting for them to stimulate.

Two kinds of movement, performatory or executive movement and exploratory or investigatory movement (seeking stimuli).

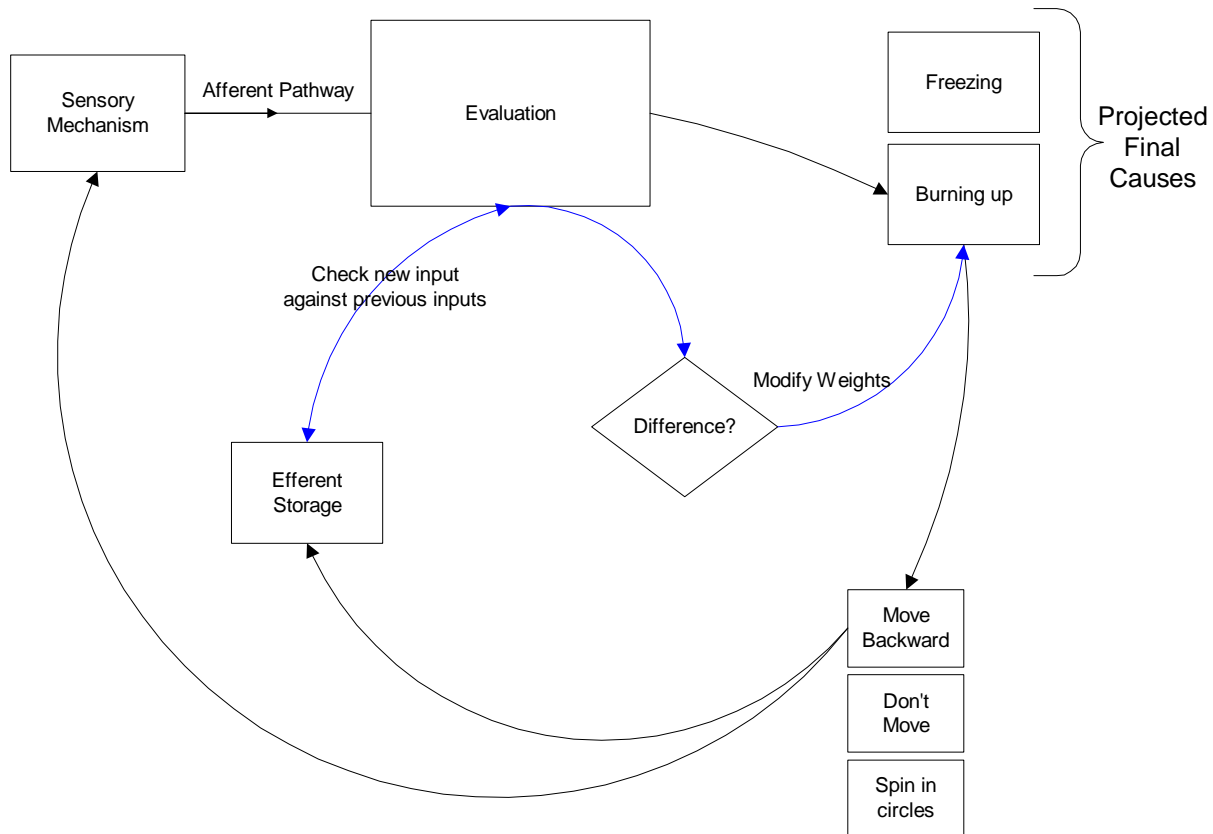
Thermoreceptor (< lower threshold) (> upper threshold)



Imposed stimulation -- passive	Imposed proprioception
	Imposed perception
Obtained stimulation -- active	Obtained proprioception
	Obtained perception

Sense data

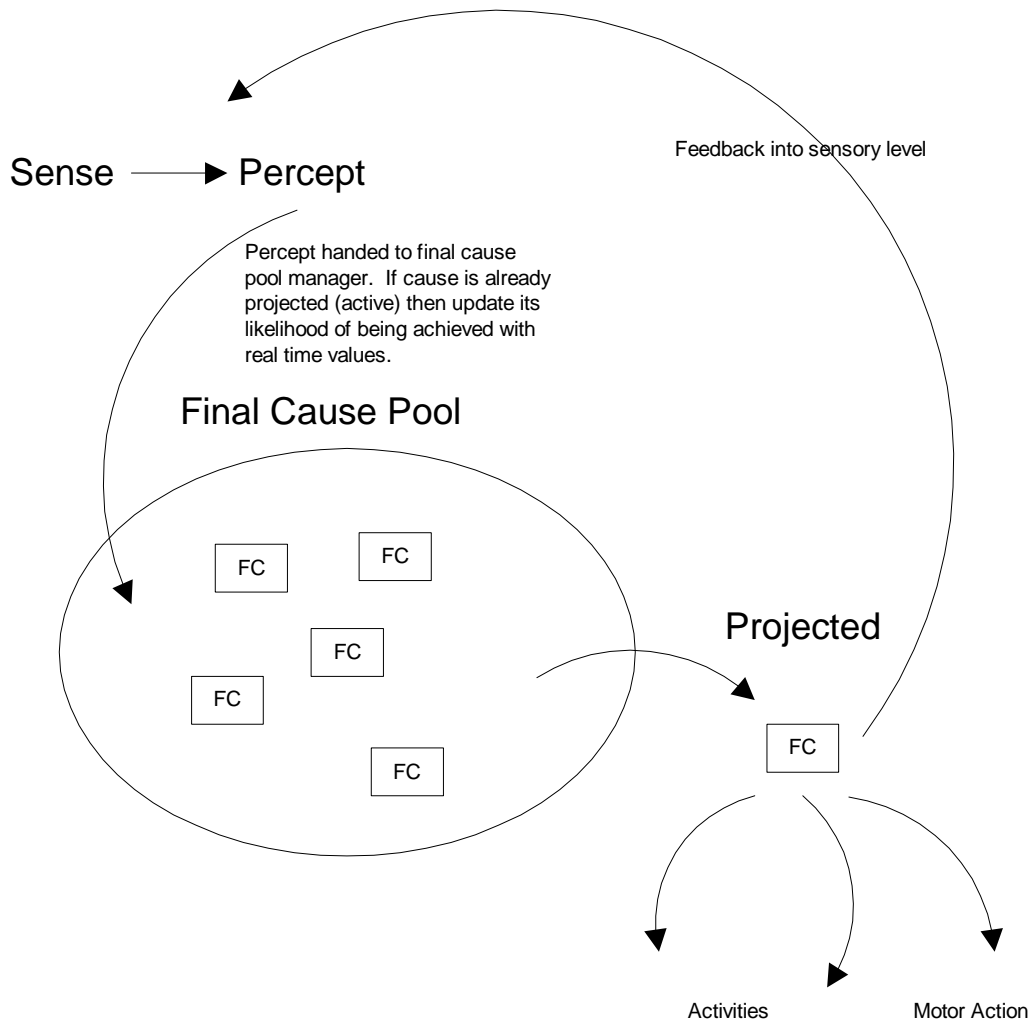
1. Sense data is typed by the sense object
2. The strength of the sensation is gauged by the quantity and difference
3. Sense perceptions are effects of the objects that act on your sense organs. "The cause of perceiving is the object perceived."
- 4.



An Example from Nature

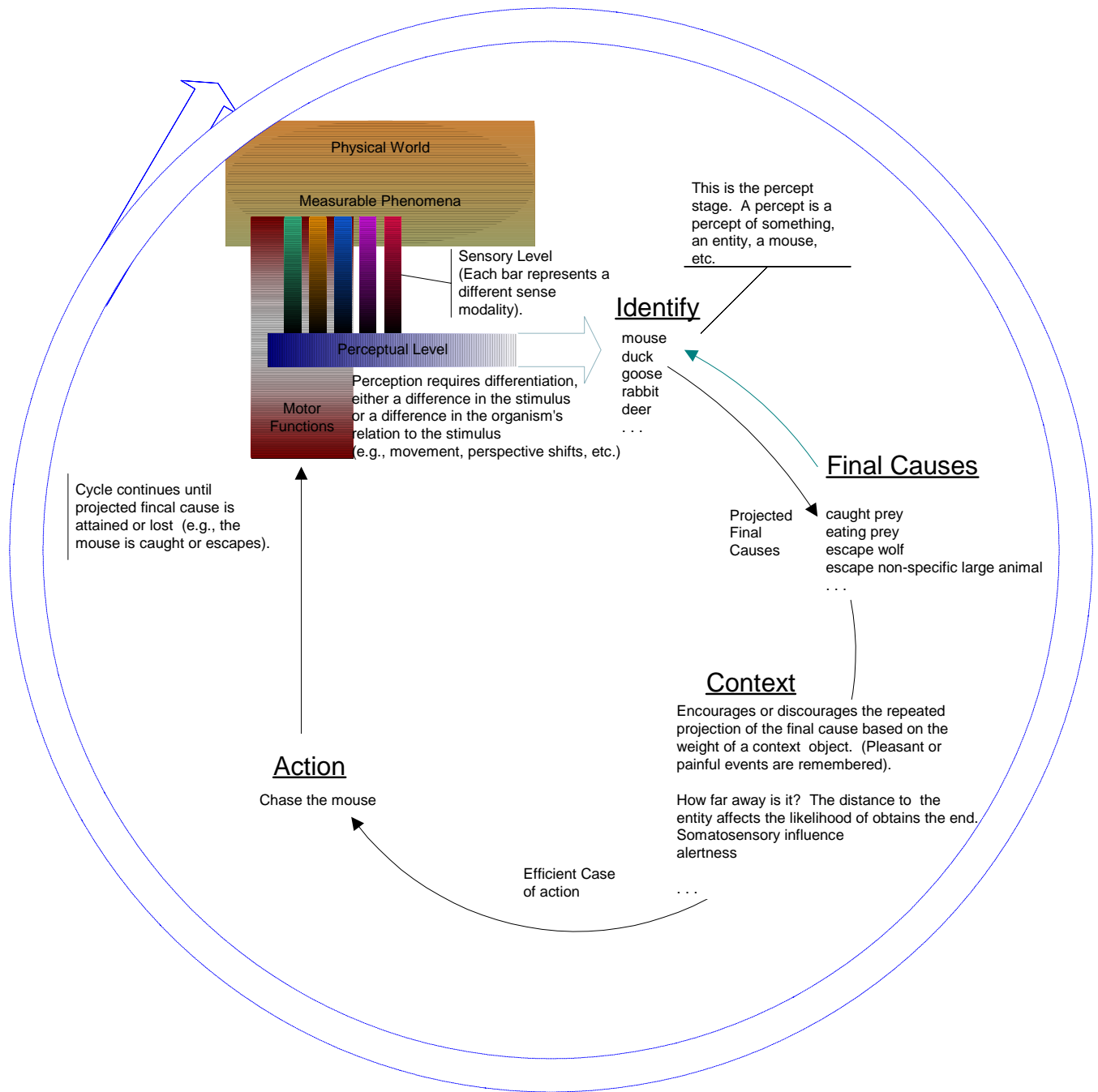
Here is a more advanced scenario: a fox, out hunting, sees a mouse. Once prey is identified (a final cause projected and then acted on) every subsequent action must also flow through the identify-final-cause-projection-action cycle, with much of the sensory input being feedback from the primary action (chasing a mouse). But as new entities in the physical world are identified by the organism this activity may be interrupted at some point by higher priority projected final causes. For example, the mouse's path of escape may take it near a larger predator that may catch the mouse or may even treat the fox as

prey, in which case "catch prey" is abandoned and a new projected final cause takes over, some form of escape.



stereotyped behavior example for the fox example:

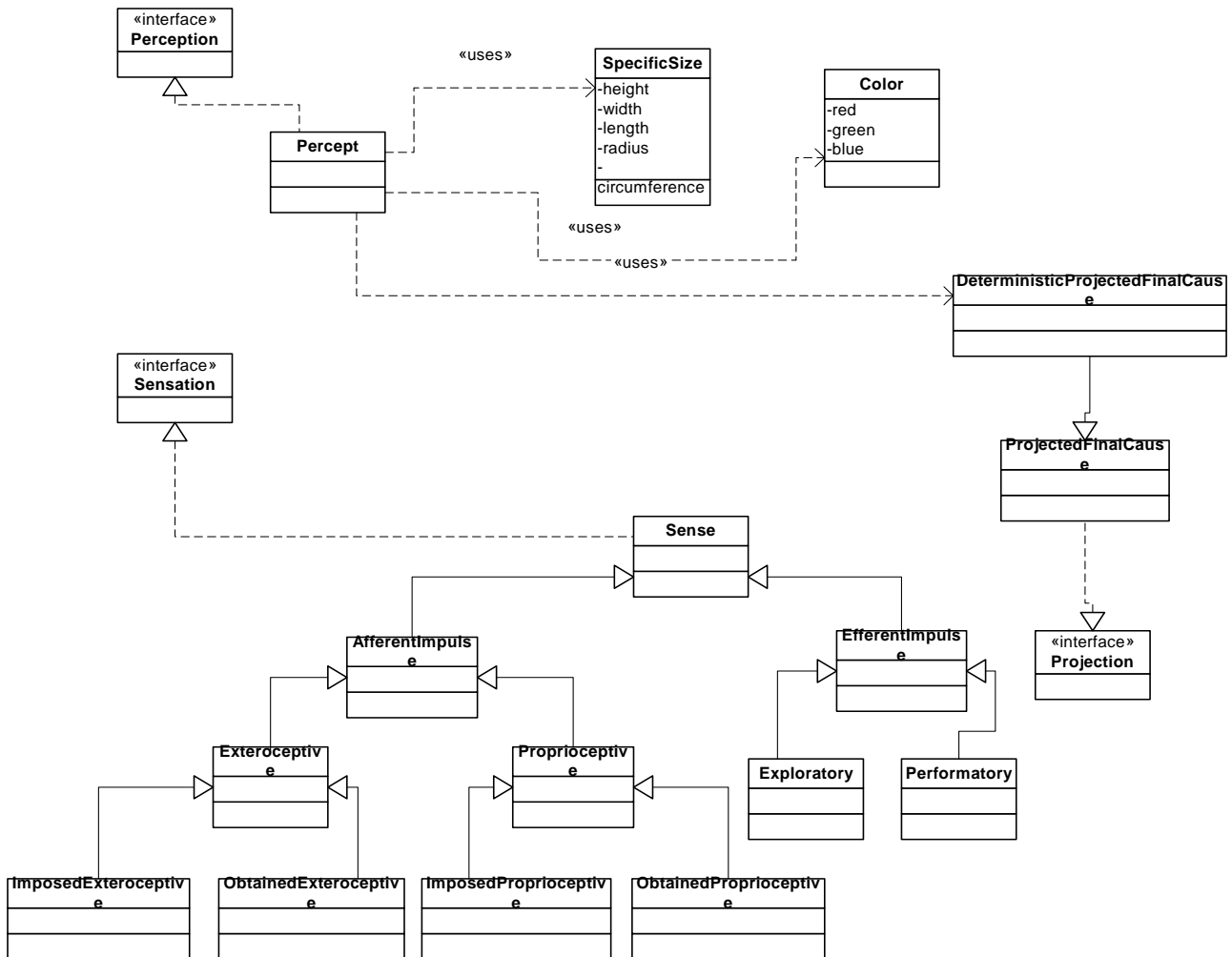
sensory input 1 of action "seeing a mouse"	---- >	projected final cause "eating the mouse" "mmm...tastes good"	---- >	becomes the efficient cause "chasing the mouse"
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The cycle of action reinforces the final cause or diminishes it. As long as the projection is still valid (i.e., as long as the fox can still imagine catching the mouse) the action will continue, barring other overriding disruptions, a truck honking its horn as the fox is about to run across the street.

The cycle is weighted by previous successful cycles (the fox previously caught and ate a mouse). Previous failures will

reduce the weighting, and the fox will give up the chase sooner than later (in effect saving energy that it expects to be wasted).



Conclusion

A perceptual organism's life broken down into these constituents becomes nothing more than a staggering number of projected final causes that either became efficient causes of action or not--that were either pursued and either completed or failed.