# Indexical Constraints on Symbolic Cognitive Functioning

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**Abstract**

This paper derives a number of logically necessary principles that govern cognitive functioning, and reviews empirical evidence supporting the validity of these principles. It advances an argument in which mental representations are conceived as indexical signs, in that they are causally related to the objects they represent. This indexicality gives rise to four general principles of cognitive functioning. First, mental activity is strongly influenced by that which is present. Second, mental activity exhibits relative insensitivity to absence. Third, minds exhibit difficulty representing negation, because representing negation entails representing the absence of that which is negated. Fourth, thinking is believing, in that representing a proposition implicitly entails accepting the truth of the proposition.

## Theory

Scientific theories delineate the boundaries of the possible. They identify what can and can not occur in this particular universe and they explain why certain phenomena are impossible. In Physics, for example, the second law of thermodynamics holds that entropy can not decrease in a closed system. This, in turn, explains why a perpetual motion machine can not exist. In Biology, the theory of evolution by natural selection holds that traits that solely benefit the reproduction of other individuals' genes will not proliferate within a population. This, in turn, explains why altruism is rare in nature. Cognitive scientists, however, seem thus far to have identified few, if any, necessary constraints upon what type of mental phenomena are possible. I therefore undertook the following research with two goals in mind: First, to identify logically necessary principles that govern cognitive functioning.; and, second, to use these principles to integrate diverse empirical findings into a coherent conceptual framework.

My approach is semiotic, in that I treat mental representations as signs, things in the nervous system that stand for or signify things outside of the nervous system. More technically, the American philosopher C. S. Peirce defined a sign as an entity that represents some object to some interpreter. Peirce (1966) distinguished three broad categories of signs: symbols, icons, and indices. A *symbol* bears a purely arbitrary and conventional relationship to that which it signifies. All non-onomatopoetic words in a human language (both spoken and written) are symbols.

An *icon* bears a physical resemblance to that which it signifies. A portrait is an icon of the person who posed for it, as is a pictograph of its referent.

An *index* signifies its object by virtue of being physically connected to it, or by having a cause-and-effect relationship to that object, such that the index is the effect and the object the cause. The following examples of indices may help to clarify the concept:

A thermometer indicates temperature, because the ambient heat causes the mercury to rise in the tube. A weathervane indicates wind direction, because the wind causes the vane to point in a certain direction. Smoke indicates fire, because the fire causes the smoke. A fever indicates illness, because the infection causes the immune system to raise body temperature.

The physical connection between an index and its object gives rise to three properties not shared by other types of signs: First, an index signifies presence; second, an index can not signify absence; third, an index is veridical; it can not lie (though it can be misinterpreted).

If mental representations are signs, what type of sign are they? The question is by no means trivial. Symbols, icons, and indices differ from one another in important ways, particularly concerning the degree to which they are constrained by the objects they signify. Of the three classes of signs, a symbol is the least constrained by its object, for a symbol can signify whatever the people using it choose it to represent. By contrast, an index is the most constrained of the three, for the relationship between an index and its object is not a matter of social convention, but of the invariant properties of matter encoded in the laws of physics and chemistry or in the anatomy and physiology characteristic of a given species. Conceptualizing mental representations as one type of sign rather than as another, therefore, will influence our models of mind in important ways.

To answer the question, consider first perceptual representations. According to James (1892), perception is "the consciousness of particular material things present to sense" (p. 179). Gregory (1987) has written that perception

gives us "knowledge of the causes or sources of sensations" (p. 600). Finally, a natural science perspective entails the assumption that the perceiving mind is physically connected to the phenomena it perceives via mechanisms of energy transduction.

Perceptual representations thus appear to exhibit a number of indexical properties. First, our perceptions indicate to us the presence of that which we perceive. Second, our perceptions do not, and can not, indicate to us the absence of that which we perceive. Finally, seeing (or hearing or smelling or touching) is believing. Although we can and do err in our perceptions, by misinterpreting the evidence of our senses, in general we do not question the validity of our perceptions. We implicitly take our perceptions to be true indications of the state of the world or of our own bodies.

I therefore propose as the first premise of my argument that perception is an indexical form of representation. As my second premise, I propose that the properties of perception are the properties of cognitive functioning in general. This latter premise, expounded many years ago by psychologists of the Gestalt school, finds support in the work of scientists such as Hebb (1980), Bruner (1973), and Shepard (1981).

Taken together, the two premises suggest that indexical properties should characterize all forms of cognitive functioning. A somewhat weaker, but more tenable conclusion is that indexical properties should constrain all forms of cognitive functioning. Four general principles follow from this conclusion. First, mental activity will be strongly influenced by that which is present. Second, mental activity will exhibit relative insensitivity to absence. Third, minds will exhibit difficulty representing negation, because representing negation entails representing the absence of that which is negated. Fourth, thinking is believing, by which I mean that representing a proposition implicitly entails accepting the truth of the proposition.

One can evaluate the merit of the preceding argument in two ways. First, one can evaluate it in terms of its logical coherence. It seems coherent to me, but others more skilled in this type of analysis may be able to find fault with my reasoning. Second, one can treat the general principles derived from the premises as empirical predictions, and determine whether minds, human or otherwise, do, in fact, behave as the theory suggests they should.

## Data

The conceptual framework developed in the preceding section thus proposes that perception in particular, and mental representation in general, functions as an indication of the world. As such, mental processes are concerned primarily with ascertaining what is present in or true of the organism's environment (including, for those with more complex nervous systems, what will be present or true in the near or not-so-near future). Though human minds can, with some effort, detect absence or conceive propositions as being false, the ability to do so is relatively weak (and perhaps fragile) compared to the ease with which we detect presence and implicitly believe whatever information comes to mind.

In the area of detection, for example, psychophysicists have found that people detect the appearance (onset) of a visual (Bartlett et al., 1968), auditory (Zera and Green, 1993), or tactile (Sticht and Gibson, 1967) stimulus more readily than they detect the disappearance (offset) of the stimulus. In visual search tasks, moreover, people more quickly detect the presence of a target feature among a field of distracters that lack it (Q among Os) than the absence of a target feature among a field of distracters that have it (O among Qs) (Hearst, 1991).

Finally, Fischoff, Slovic, and Lichtenstein (1978) presented subjects with various versions of a diagram describing ways in which a car might fail to start. These versions differed in how much of the full diagram had been deleted. When asked to estimate the degree of completeness of these diagrams, the subjects were very insensitive to the missing parts. Even the omission of major, commonly-known components (e.g., the ignition and fuel systems) were barely detected.

Without detection there can be no learning, and so it does not surprise that animals, including humans, learn contingencies involving presence more readily than they learn those involving absence. For example, pigeons and many other species discriminate much better between two stimuli in feature-positive situations (in which the presence of something signals a reward) than in feature-negative situations (in which the absence of a feature signals a reward) (Hearst, 1991). In addition, Nisbett and Ross (1980) have documented that people have more difficulty detecting covariations when the presence of one stimulus covaries with the absence of another than when it covaries with the presence of another.

Horn (1989) reviewed the considerable body of empirical evidence concerning the psychological asymmetry between affirmative and negative propositions. Wason (1959; 1966), for example, reported that people find it easier to reason with affirmative statements (e.g., modus ponens) than with denials (e.g. modus tollens). Clark (1974) found that negation is more difficult to comprehend than is affirmation, and that in sentence verification tasks, people take longer to verify denials ("x is false") than to verify affirmatives ("x is true"). Clark also found that people take longer to verify absence than presence, which seems further evidence for the mind's relative insensitivity to absence. Finally, psycholinguists have documented that the ability to deny propositions (i.e., truth-functional negation) is one of the last linguistic abilities to emerge in childhood (Gilbert, 1991).

The claim that thinking is believing strikes many people as counter-intuitive, if not patently absurd. Yet there exists both philosophical and empirical support for this position. Spinoza (1993/1677) and William James (1892), for example, both argued that representation entails belief.

Moreover, in recent decades psychologists have accumulated a large body of findings which suggest that belief is automatic upon comprehension, that beliefs persist even when explicitly discredited, and that the strength of a belief varies as a function of one's familiarity with the information a given proposition contains.

Gilbert (1991), for example, found that subjects who listened to a counter-attitudinal communication while attending to an irrelevant stimulus were particularly likely to accept the propositions they comprehended. He also reported that when "resource-depleted" persons are exposed to doubtful propositions, their ability to reject those propositions is markedly reduced.

Swann and Giuliano (1987) found direct support for the notion that simply entertaining a belief elevates the perceived informativeness of evidence that may confirm that belief. According to Gilbert (1991), this suggests that in the process of entertaining an hypothesis, people may actually embrace it—thus raising the perceived diagnosticity of confirmatory evidence. Finally, Clark's and Chase's (1977) model of sentence verification suggests that all sentences are initially coded as true, and that the comparison stage leads to further mental work only when the sentence turns out to be false.

The research concerning belief perseverance suggests that people are particularly poor at ignoring, forgetting, rejecting, or otherwise failing to believe that which they have comprehended. Ross, Lepper, and Hubbard (1975), for example, found that subjects in a study believed things they were told about themselves despite having been warned in advance that the information was invalid. The subjects seemed unable to represent statements in a truth-neutral fashion, even when directly motivated to do so.

Nisbett and Ross (1980) reported that when people formulated a theory based upon some putatively probative evidence and later discovered that the evidence was false, the theory often survived such total discrediting. Finally, Johnson and Seifert (1994) found that people do not forget misinformation. Once having been informed that a person died of food poisoning contracted at a particular restaurant, people continued to express the belief that the restaurant serves bad food even after being informed that the person actually died of a heart attack unrelated to the food.

Finally, I note that belief is not an all-or-nothing phenomenon, but, rather, varies along a continuum from more to less. What then, determines the extent to which one accepts the validity of a proposition? If we implicitly interpret our thoughts as evidence indicative of the presence in the world of that to which the thought corresponds, then it seems reasonable to assume that the stronger the presence of some information in our minds, i.e., the clearer, more distinct, and more familiar the thought, the more likely we are to accept the validity of the situation posited by the thought. Thus we expect the validity people attribute to propositions to vary, in part, as a function of their prior exposure to the information.

Empirical findings support this expectation. Arkes (1991), for example, found that the more often a person encountered a proposition, the more likely they were to judge the information it contained as true. Both Loftus (1979) and Roediger and McDermott (1995) have shown that familiarity manipulations induce false memories. Finally, Gerbner (1978) found that the more time a person spent watching television, the more likely they were to overestimate the incidence of violence in their own neighborhood.

## Conclusion

The three empirical generalizations discussed in the preceding section, the mind's greater relative sensitivity to presence, the psychological asymmetry between negative and positive propositions, and the automaticity and perseverance of belief, all have been known to psychologists for some time. It would be odd indeed were three such robust properties of the mind entirely unrelated to one another. The novelty and value of my contribution, such as it is, lies in my having conceptualized these three characteristics of cognitive functioning as differing manifestations of a single basic property of mind, and in my having attempted to articulate the nature of that property. Whether or not one agrees with the position I have taken in this paper concerning the indexicality of mind, I hope I have persuaded the reader that progress in cognitive science will be aided by the identification logically necessary constraints that govern cognitive functioning.

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