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Klaus Krippendorff

On the Essential Contexts of Artifacts or on the Proposition that "Design Is Making Sense (of Things)"[1]

1) Part of this work was supported by the design firm RichardsonSmith, Worthington, Ohio, and Ohio State University, Columbus, while on sabbatical leave in 1986-87 from the University of Pennsylvania, Philadelphia.

Introduction

The etymology of *design* goes back to the Latin *de* + *signare* and means making something, distinguishing it by a sign, giving it significance, designating its relation to other things, owners, users, or gods. Based on this original meaning, one could say: design is making sense (of things).

Design is making sense (of things)

The phrase is conveniently ambiguous. It could be read as "design is a sense creating activity" that can claim perception, experience, and, perhaps, esthetics as its fundamental concern and this idea is quite intentional. Or it can be regarded as meaning that "the products of design are to be understandable or meaningful to someone" and that this interpretation is even more desirable. The phrase *of things* is in parentheses to cast doubt on a third interpretation that "design is concerned with the subjective meanings of 'objectively existing' objects." The parentheses suggest that we cannot talk about things that make no sense at all, that the recognition of something as a thing is already a sense-derived distinction, and that the division of the world into a subjective and an objective realm is therefore quite untenable.

However, *making sense* always entails a bit of a paradox between the aim of *making* something new and different from what was there before, and the desire to have it make *sense*, to be recognizable and understandable. The former calls for innovation, while the latter calls for the reproduction of historical continuities. In the past, sense was provided by alchemy, mythology, and theology. Now we speak less globally of a symbolic ordering that is constitutive of cognition, culture, and reality. Somehow, the word *design* has not remained in this creative state of paradox, but has shifted to one side. Its current meaning amplifies the aspect of *making* or, more specifically, of applying a technical-functional rationality to the material world at the expense of the *sense* that was to be achieved thereby. Perhaps, the pendulum has swung too far. Perhaps, technology has moved too fast for culture to keep up with it. Whatever the explanation, the current concern with

product semantics is nothing other than a reaction to the missing *sense* modern industrial products make or a deliberate effort to recapture this lost territory for design.

Product semantics

Elsewhere, we introduced *product semantics as a study of the symbolic qualities of man-made forms in the cognitive and social contexts of their use and the application of the knowledge gained to objects of industrial design.*[2] By this definition, product semantics is not a style, program, or movement. Rather, it is a concern for the sense artifacts make to users, for how technical objects are symbolically embedded in the fabric of society, and what contributions they thereby make to the autopoiesis of culture.[3] The definition recognizes formally what in the past good designers may have done intuitively but without a conceptual and linguistic repertoire to talk about it. Designers who are aware of product semantics may work quite differently from those who are not. They articulate different aims and criteria and tackle different design problems. The illustrations provided in this issue by practitioners speak for themselves.

Product semantics should not be confused with *ergonomics*, which is almost entirely committed to the afore-mentioned technical rationality of optimizing systems performance. The experiential fact that people voluntarily accept considerable inconveniences to drive the car of their dreams, live with furniture they like, or wear clothes for which they are admired, suggests that other than technical criteria dominate everyday life and individual well-being.

Product semantics is also far from being a mere marketing tool. Although it has contributed to economic success,[4] the celebration of wholeness, the concern with how material artifacts connect people to each other, the respect for mythology and archetypes that are rooted deep in the collective unconscious, and the interest in an ecology of symbols and mind go beyond industry's immediate concern with production and consumption.

Product semantics should not be tied to traditional semiotics either. The symbolic qualities or the meanings objects may have to different users easily escape traditional semiotic conceptions[5] insofar as they locate meanings either in the objective referents of signs (naive referential theory), in the imputed relation between signs and what they are intended to stand for or represent (referential theory proper), or in the somewhat more objectively describable form, nature, or features of sign vehicles (physicalistic theory). Such conceptions have been made explicit in the indissoluble triad of semiotics. The version in figure 1 is taken from Charles Sanders Pierce, who defined a sign as "something which stands to somebody for something in some respect or capacity."[6]

2) Klaus Krippendorff and Reinhart Butter, "Product Semantics: Exploring the Symbolic Qualities of Form," *Innovation* 3, 2 (1984): 4-9.

3) The idea of *autopoiesis*, the process of self-production, has its origin in biology and was introduced in Humberto R. Maturana and Francisco G. Varela, *Autopoiesis and Cognition*, Boston Studies in Philosophy of Science (Boston: Reidel, 1980). It is considered as a defining process of living systems and is contrasted there with *allopoiesis*, the process of producing something materially different from what produced it, including reproduction. The original authors are somewhat hesitant to apply the notion of autopoiesis to social systems. However, a culture as a whole certainly produces itself continuously and in the same physical space. The role of machines in cultural autopoiesis is explored in Dorion Sagan and Lynn Margulis, "Gaia and the Evolution of Machines," *Whole Earth Review* 55 (Summer 1987): 15-21. Alain Touraine's *The Self-Production of Society* (Chicago: University of Chicago Press, 1977) assumes a sociological perspective of autopoiesis.

4) See Robert I. Blaich's experiences with product semantics at Philips Corporate Design, presented to the National Conference of the Industrial Designers Society of America on "Forms of Design," (Evanston: Northwestern University, August 7-10, 1986). A similar report is included in this issue.

5) Krippendorff and Butter, "Product Semantics," cited above, and Klaus Krippendorff, *Überr den Zeichen- und Symbolcharacter von Gegenständen: Versuch zu einer Zeichentheorie für die Programmierung von Productformen in Sozialen Kommunikationsstrukturen*, Diplom Thesis (Ulm: Hochschule für Gestaltung, 1961).

6) Charles Sanders Pierce, *Collected Papers* (Cambridge: Harvard University Press, 1931-1953), 228.

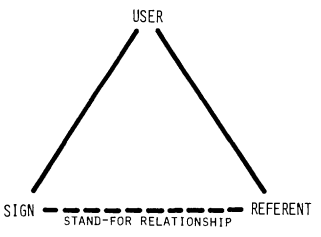


Fig. 1)

Although these referential notions must be overcome here, to be fair, traditional semiotic approaches are not entirely without merit for industrial design. However, I see only two valid applications. The first sheds light on the use of linguistic expressions (for example, printed user's instructions and labels) and nonlinguistic graphic/acoustic/olfactory signs (whether as symbols, icons, or indexes), all of which stand for something other than themselves (for example, for contents, internal states, options of functions, and movements available). The second concerns itself with how information from outside an artifact is processed and perceptively exhibited (for example, through TV monitors, loud speakers, information displays, and scales of measurement) to users who interpret what they see as covarying with distant or otherwise unnoticeable events. Neither of these applications of semiotics is my primary concern nor do I believe these to be central to industrial design.

A suitable starting point for product semantics is the experiential fact that people surround themselves with objects that make sense to them, they can identify as to what they are, when, how, for what, and in which context they may be used. Such objects can hardly be viewed as substitutes for something else, as traditional semiotics may have it, but they do reveal, communicate, or present *themselves* in the experiences of people. This is true for the whole spectrum of everyday things, from industrially produced consumer products to highly individualized works of art. To be of use to someone, things must be capable of this kind of presentation.

The self-reference this presentation implies does not fit into the semiotic triad, however. And for semiotics to exorcise self-reference from analysis because of its lack of fit and thus to impose other-referential notions, instead, encourages both a way of interpreting the world and a particular design practice. The latter particularly encourages products that either appear different from what they are (are made in the image of something else, hide their operation behind unrelated facades, deceive users with fake symbolisms) or are covered with linguistic instructions and graphics. I am convinced that this kind of semiotization of material culture alienates people from participation in the real world and has always been a mark of bad styling. Although product semantics is not committed to any style, good or bad, we should not simply dismiss semiotic ideas for their limitations, but rather avoid semiotics' epistemological traps.

Sense-making

When presenting everyday artifacts, such as furniture items, vehicles, tools, office equipment, and so forth, to ordinary people and asking them what they see, the range of responses is extraordinary. Very few responses occur in semiotic categories of

what the object resembles, represents, signifies, points to, and is about. Most are concerned with *what the object is, indicated by its name; what it is made for, what it does; how its parts are connected and work together; who typically uses it and in which situations; what others would say about it or about its use; what it is made of and by what processes; who designed it, who made it, who sold it; how its operational principles differ from the usual; relative size, appearance, workmanship, durability, price, how it effects the environment; and how efficient its use is; and so forth.*

When respondents are more familiar with objects or are presented with very personal items, additionally they relate to these in the following additional terms: *who gave it to them; how it was acquired; of whom it reminds them; in which circumstances it figured prominently; how much care, service, repair, or even affection it consumed; how well it fits with other possessions; how enjoyable its presence is; how it feels; and how close it is to the user's definition of him/herself.*

The list reflects what Ulrich Neisser[7] observed after many experiments of this sort: people do not perceive pure forms, unrelated objects, or things as such but as *meanings*. The distinction between what an object *is* and what that object *means* to somebody may not be demonstrable as far as perceptual data are concerned.

7) Ulrich Neisser, *Cognition and Reality* (San Francisco: Freeman, 1976).

The above answers suggest that *objects are always seen in a context* (of other things, situations, and users, including the observing self). Responding by saying what something is for puts that something into the context of an intended use. Responding by anticipating what others would think about its user puts that object into a social context that includes other people. Even naming what is seen puts the named in the context of language use.

The context into which people place the object they see is cognitively constructed, whether recognized, anticipated, or wholly imaginary. Seeing something in a store as a chair requires imagining its use at home or in an office, a context that may or may not be realized in practice. Estimating its durability requires constructing from past experiences contexts of misuse or extreme stress.

Meaning is a cognitively constructed relationship. It selectively connects features of an object and features of its (real environment or imagined) *context into a coherent unity.* The reasons for such relationships are numerous. Engineers and ergonomists have almost exclusively settled on functions, measurable, causal connections that are manifest in the push and pull of controlled physical forces. Although functional accounts (including semiotically informed "stand-for" relationships) are undoubtedly meaningful to some, ordinary people also employ many noncausal relationships, such as similarities, contrasts, family belongingness, associations, synchronicities, harmonies, or social conventions, to

relate objects to their environments. The perception of how something fits into a cognitively constructed context has no causal base, however.

What something is (the totality of what it means) *to someone corresponds to the sum total of its imaginable contexts.* A knife has all kinds of uses; cutting is merely the most prominent one. Prying open a box, tightening a screw, scraping paint from a surface, cleaning dirty fingernails are as imaginable as picking a pickle from a pickle jar. In the context of manufacturing, a knife is a cost. In the context of sales, a knife has an exchange value. In the context of a hold-up, a knife may constitute a significant threat. All possible contexts define what a knife is to people capable of using their imagination.

I am furthermore suggesting the following: *Making sense is a circular cognitive process that may start with some initially incomprehensible sensation, which then proceeds to imagining hypothetical contexts for it and goes around a hermeneutic circle during which features are distinguished — in both contexts and what is to be made sense of — and meanings are constructed until this process has converged to a sufficiently coherent understanding.* Explorations of something new and the "aha" experiences of having understood the idea respectively exemplifies the circular process of sense-making and its product. In perception, such processes may take little time, but the fact that the same stimulus may give rise to different responses in different situations by different people demonstrates the importance of individual cognitive contributions over those present in the "objective stimulus." A user's sense-making process is graphically depicted in figure 2.

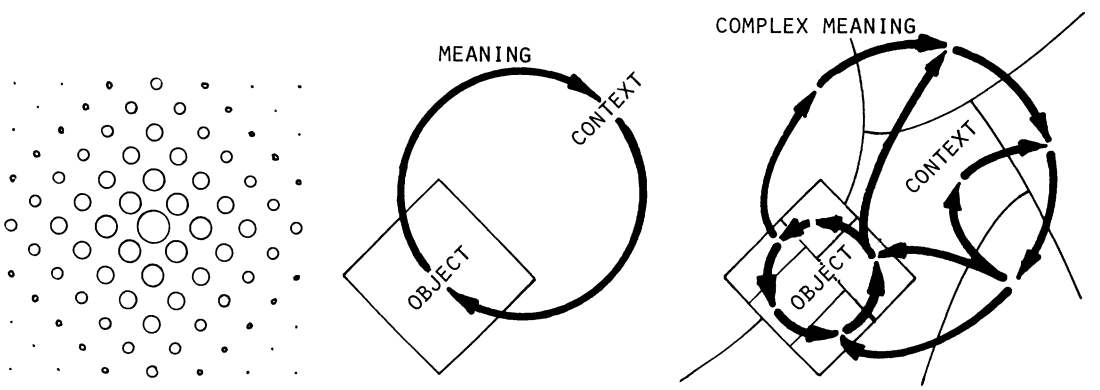


Fig. 2)

Fig. 3)

The Harris Comic of figure 3 illustrates on two levels what the somewhat abstract figure 2 is intended to show. The left frame ignores the fine lines and shows a configuration that affords not much more than that it is distinct from its context. The center frame makes more sense: two people are facing each other, but this isn't funny. The addition of the quotation is what enables the reader to integrate all the components into a meaningful whole. Moreover, the comic is based on changing the expected context of a recipe, that is, cooking, to that of home improvement, in which what the recipe informs receives a totally unexpected meaning.

Form and meaning contextualized

What is true for ordinary people ought to be true for professional designers as well, for both are equipped with the same cognitive apparatus. I am therefore suggesting that the *forms* designers create — in German, industrial designers are called "form-givers" — result from nothing other than a professional, as opposed to ordinary, sense-making. Form and meaning are intricately related, however, and their relationship is a fundamental concern of product semantics. Something must have form to be seen but must make sense to be understood and used. Form entails a description (of something), *without* reference to an observer or user (for example, see geometry,[8] physics, and objectivist esthetics, which need no reference to the person applying them). In contrast, meaning always requires reference to someone's (self or other) cognitive processes. Accordingly, the designer's "form" is the designer's way of objectifying and, hence, disowning their own meaning in the process of making sense for others. How this relationship comes about is depicted in figure 4.

8) In this issue, Helga and Hans-Jürgen Lannoch make the point that geometry cannot account for an individual user's point of view and, thus, is incapable of describing the meanings that spatial forms may acquire in human communication. Their proposal is to construct, instead, a different notion of space associated with natural language, called a *semantic space*, which explicitly includes human perceptions and attributions of meanings.

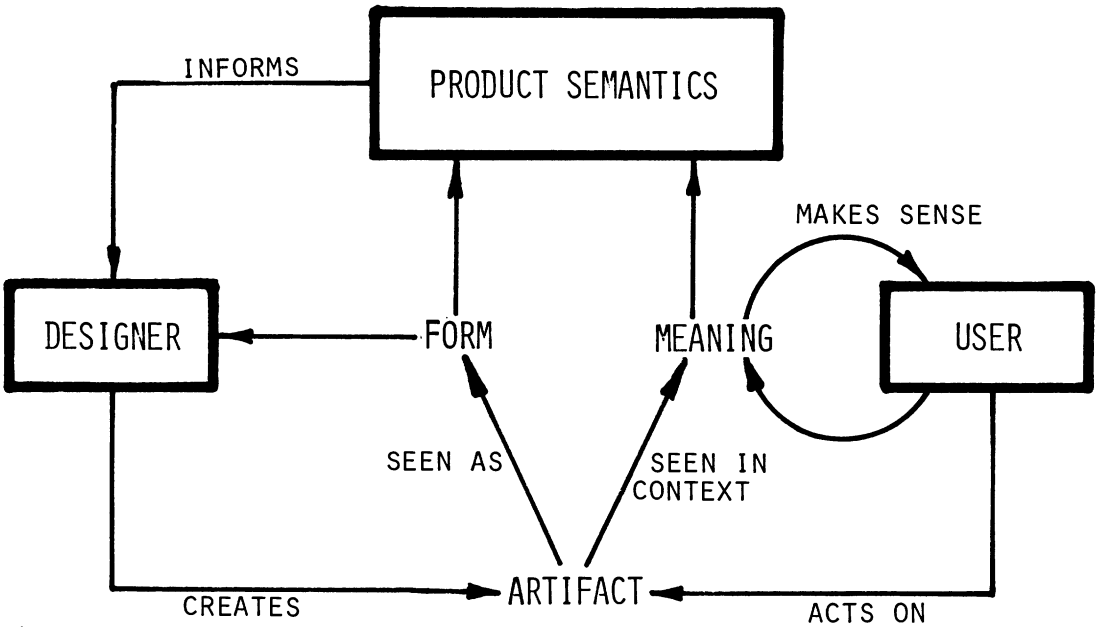


Fig. 4)

When one thinks of measurable performance characteristics, function has the same objective status as form. The slogan "form follows function" thus implies abstracting the ordinary (scientifically naive, nonengineering-trained) user out of the equation and discarding the meanings that users construct and see. The increasingly appealing suggestion that form may not follow *function* but *meaning*, brings the user back into the picture and strongly suggests that designers need to discuss not only the contexts in which their forms are used, but also how these forms are made sense of or what they mean to someone other than themselves. No one can presume that form (the designer's objectified meaning) and (the user's) meaning are the same; hence, the need for product semantics to study how they relate. The consequent prescription, adopted by semantically informed designers "form follows meaning," is intended to reflect on this relationship which essentially is a relationship between designer's and user's or client's cognition. Such a prescription is an empty slogan, however, unless it is clear how a man-made form (artifact) is conceived and how its meanings can be understood.

The circular process of constructing meaningful relations between objects and contexts and the somewhat pragmatical distinction between form and meaning suggest that overlapping principles are operating here. Developing a single theory of meaning applicable to all design situations may not be possible though. Just as in linguistics, where several longstanding controversies concerning conceptions of meaning have been resolved by pursuing in parallel several incompatible theories of meaning,[9] it seems plausible that product semantics may also have to settle on several parallel theories.

9) See Gilbert H. Harman, "Three Levels of Meanings," in Danny D. Steinberg and Leon A. Jacobowitz, *Semantics* (London: Cambridge University Press, 1971): 60-75.

The following text outlines four essentially different contexts in which objects may mean in different ways. These four contexts should provide fertile concepts from which powerful theories of meaning for industrial designers may grow:

- *operational context*, in which people are seen as interacting with artifacts in use
- *sociolinguistic context*, in which people are seen as communicating with each other about particular artifacts, their uses and users, and thereby co-constructing realities of which objects become constitutive parts
- *context of genesis*, in which designers, producers, distributors, users, and others are seen as participating in creating and consuming artifacts and as differentially contributing to the technical organization of culture and material entropy
- *ecological context*, in which populations of artifacts are seen as interacting with one another and contributing to the autopoiesis (self-production) of technology and culture

Operational Context

Operational experiences with things are most common in everyday life. Artifacts — from cups to cars and furniture to complex computer systems — are handled all the time. Unfortunately, people and organizations are often included in this category of objects as well. Although designers are intent to create forms that are *self-evident* — that is, *immediately identifiable for what they are*, *obviously clear as to how they can be manipulated*, and *motivate the user to interact with them* — practice suggests that artifacts often end up meaning something quite different from what was intended. A designer may conceive a car as a means for transportation but provide, instead, the material basis of social status changes, commitments to a factory tradition, affectionate gifts among friends, and something to do on weekends for someone else. Within limits, any designed form may mean different things, and they can become wholly different objects for different users.

An operational theory of meaning should explain how forms constrain the sense users make of things in their environment. There usually is give and take in sense-making processes. Distinctions are drawn, relationships are hypothesized, and both are confirmed or selectively dismissed after acting on their consequences.[10] Meanings are therefore not entirely invariant either; they are acquired and learned, they change with use, expanding or contracting, all depending on the inventiveness of the user, the affordances seen in a form, and the linguistic, cultural context in which this sense-making takes place.

Despite the range of possible meanings designers consider, a limited set of variables or semantic dimensions, as Lannoch and Lannoch call them,[11] describe most operational meanings of

10) Klaus Krippendorff, "An Epistemological Foundation for Communication," *Journal of Communication* 34, 3 (1984): 21-36.

11) Hans-Jürgen Lannoch, "How to Move from Geometric to Semantic Space," *Innovations* 3, 2 (1984): 20-22. Helga Lannoch and Hans-Jürgen Lannoch, "Vom geometrischen zum semantischen Raum," *Form* 118 (1987): 12-17.

objects — *identities; qualities; orientations; locations; affordances; states, dispositions, and logic; motivations; and redundancies.*

The notion of a cognitive model, with which users approach, explore, or interact with what designers consider a form is central to all of these dimensions. With semantic considerations in mind, designers may not start with the functions that a product is to perform, but with the cognitive models that users have at their disposal, can construct from available metaphors or metonyms or easily acquire through practice. If there is any intentionality in design, its forms should fit or be interpretable in terms of the cognitive models that lead to their safe and socially desired use.

Identities

Individuals typically approach the partitions in their environment with identity questions in mind. They may ask themselves what kind something is and which name applies. Thereafter, people may have associations or expectations which come to play, representing a set of behavioral "programs." The identity of a form usually serves as a key or directive to a more detailed examination.

Identities may be defined by the following characteristics of an object:

- *shape* (whole appearance)
- typical *pattern or organization* (the logic by which parts are connected)
- identifying *features* (which it has or does not have)
- characteristic *behavior* (how it interacts with other things and users)

Shapes, patterns of organization, features, and behaviors are some of the vehicles through which designers can invoke the perception of identities.

A distinction can also be drawn between identities that are cognitively skeletal and present "deep structures," the "gist"[12] or "wesen"[13] of something as opposed to those that rely on considerable detail, surface appearances, or elaborate meanings.

12) John Rheinfrank, personal communication 1986, and in various informal presentations.

13) Jochen Gros, "Das zunehmende Bedürfnis nach Form," *Form* 107 (1984): 11-25.

Qualities

Recent research into categorization, particularly by Rosch,[14] has shown that the classification of what something is or does relies not so much on formal resemblances, or distinctions among sets of objects as on cognitively constructed ideal types (unfortunately also called prototypes). People assert qualitative differences to these types. These qualities are often expressed by adjectival constructions — fast cars, high-tech bicycles, black tulips, sleek performances — and can therefore also be called *attributes*. The attribution of qualities tends to create subordinate categories, and their absence reveals the name of the ideal type of a category, often expressible by simple nouns. Differences between a chair and a

14) Eleanor Rosch, "Principles of Categorization," in Eleanor Rosch and Barbara B. Lloyd, eds. *Cognition and Categorization* (New York: Wiley, 1978): 27-48.

high chair, a book and a children's book, or a store and a grocery store show the differences between basic categories and subordinate categories. Athavankar[15] lists several examples (modified and extended here):

Subordinate category	*Source of the specific attribute*
baby shoes	user
sport shirt	attitude
evening dress	occasions
five-star hotel	social class/price
Shaker furniture	region and craft
baroque church	style
high-tech watch	technology
steam engine	source of energy
high-speed train	speed dimension
circular table	shape

Superficially, such attributes may seem to divide a genus into the species of Aristotelian definitions, but, according to the research referred to above, they are more appropriately thought of as indicating distances or differences between any member of a category and its most central exemplar; the ideal, or prototype. Below dimensions, characters, and features are distinguished and the latter is subdivided into parts, properties, and configurations, all of which may be used to explain the semantic differences in qualities.

Dimensions are always present in a particular form and indicate variable extents. Physical objects have volumes, masses, temperatures, speeds, colors, textures, and shapes, for example. Chairs are more or less comfortable to sit on, and the dimension of comfort is an inalienable part of the definition of chair, just as a ball has variable amounts of bounciness and a letter has variable amounts of information. (Note that the dimension of amount of information is not part of the conception of a ball and letters cannot bounce.)

Features may or may not be present in a particular form and, thus, do not enter the definition of its ideal type. Telephones may or may not have a redial button and therefore differ in *parts*. The canard-type airplane differs from a conventional airplane in its *configuration* of wings and rudders. Both are airplanes proper. Gases and fluids, for example, differ in certain *properties* that can be conceived of as different responses to particular actions including the reflection of light, or whether they can be breathed, placed into an open container, etc. Parts, configurations, and properties are all optional to the definition of a form said to have them.

15) Uday A. Athavankar, "Web of Images Within." ARTHAYA, *Proceedings of a Conference on Visual Semantics* (Bombay: Indian Institute of Technology, Industrial Design Center, January 20-22, 1987). This paper also includes an excellent overview of categorization (Rosch, *Cognition and Categorization*) from a design perspective. A modified version is included in this issue.

Characters are symbolic analogues to features in that they require semantic (dual) interpretations. For example, a column may have the property of supporting a certain load but may appear too fragile to be trusted for this purpose. Butter's truck interiors[16] have the characters of "high-tech," "low-tech," "contemporary," "functional," and "futuristic," respectively. Characters qualify objects as adjectives qualify nouns.

16) See Reinhart Butter's contribution to this issue.

Orientations

Users describe the forms of objects rarely in terms of three-dimensional geometry or by reference to the physical forces holding them together, but in relation to their own body, vision, or motion. Except perhaps for a perfect sphere, most objects have "faces" that under normal conditions face their user. For example, the screen and the important controls of a television set are "in front." The remainders are sides, top, bottom, or back. Rarely does anyone confuse such obvious orientations. There also is an inside and an outside. There are directional pointers in the shape of a gun, for example. Movements are described toward or away from a user. Underlying many orientations are metaphors of interpersonal communication: the front of a person faces the front of another and so is the front of an object defined to face its user. Other orientations are derived from viewing something from a distance, the preferred view being the one that provides the most relevant information.

Locations

Objects may have not only orientations relative to a user but also locations in a space constituted by other things. A picture may be kept inside a box, lay on the floor, or hang on the wall, framed or not. In right-side driving countries, the driver's seat is on the left side of the car. A kitchen appliance may be either stored on a shelf or sit on a working surface, perhaps together with required containers and supplies. A bicycle wheel may be either detached or mounted, and so forth. True, locations are sometimes expressible in geometric terms, but the examples express locations in reference to a semantical space and relative to other objects in a user's environments.

Affordances

Affordances, a term taken from Gibson,[17] denotes all possible behaviors (form) that confirm what a user expects the object to do (meaning). A chair should afford support of a user's weight. A telephone should afford talking beyond the range of voice. Note that *chair* and *telephone* and their affordances refer to cognitive models or constructions that users identify as things of a particular kind, not to what they "objectively" are. Whatever an

17) James J. Gibson, *Reason for Realism*, edited by Edward Reed and Rebecca Jones (Hillsdale, NJ: Erlbaum, 1982). Gibson uses the term *affordance* in a more objectivist or naive realist sense, suggesting that objects possess these capabilities for users to simply "pick up" or see. As one cannot possibly list all affordances of something without reference to someone, I am instead suggesting

to start out with that someone's cognitive models, including motivations and situational determinants, according to which expectations are formed and affordances are seen.

artifact's form, if it is capable of performing according to a particular user model, it can be said to afford it. If it frustrates such a model, it does not. Forms may mislead a user regarding affordances, suggest capabilities that are not there (errors of commission), or hide what can be afforded (errors of omission). Errors of omission are not so bad because inventing a new use for a well-known product is always possible and concealing how something could be handled from particular user groups may sometimes be desirable, for example, making it difficult for children to open a medicine bottle. However, our current consumer-oriented society is especially prone to errors of commission: promising something valuable that experiences do not quite bear out. Examples range from sophisticated looking, high-tech, electronic equipment, with many controls and indicators that are largely decorative, to plastic house plants with variable fragrances.

Designing with affordances in mind starts not with a specification of functions but with perceivable dimensions, characters, and features that feed into the range of readily available cognitive models, including linguistic metaphors and metonyms facilitating their onsite construction. Self-evidence, the efficient and instantaneous semantic indication of what something is, is an example of the "correct" presentation of a product's affordances to its user.

In analyzing how affordances are expressed, the tendency is to distinguish between *manual inputs*, the features that afford touch, movement, manipulation, and programming; *visual orientations*, the features enabling users to coordinate their actions with those of the artifact; and *responses in context*, the experiential effects of manipulations of the environment ultimately controlling *users' perceptions* and either supporting or disconfirming the cognitive model in mind.

States, dispositions, and logic

Even the most simple artifact can be thought as being in one of several *states*: a door is open or closed, a cup is full or empty, an engine is running or is off. Such near binary state systems can be described by propositional logic whose expressions are either true or false. The usefulness of such descriptions suggests that man-made forms have more to do with logic, language, and mind than with physical continua, including geometry. After all, people describe what they do in language, they communicate with others about what they wish to accomplish, and it is therefore no surprise that artifacts are designed according to an *operational logic* that makes sense. People seek to understand the world in these logical terms as well.

What makes artifacts complex is the multitude of states they may assume at different times and the multivalued nature of the

logic needed to describe their operation. However, unlike engineers who must be aware of all details of a complex system, designers must realize that users bring simplified cognitive models (homomorphisms) to bear on such systems and link experiences from other semantic domains by metaphor to enrich the cognitive models of what goes on within them. Naturally, in such simplified user models, anthropomorphisms often reign supreme. Thus, programming becomes a kind of teaching and states are seen as *dispositions*, that is, as a readiness to act in a certain direction. Behavior sequences are interpreted in terms of purposes, and whole systems, as having a will of their own, including psychopathologies, being either user-friendly (cooperative) or hostile (frustrating user expectations).

Indications of an object's states and logic need to afford users' conceptions, however different these conceptions may be from those of their inventors. In the extreme, the difference between engineering and scientific models (forms) and user's models (for constructing meanings) may be reflected in the difference between how the inside and outside appear respectively. In practice, different models may call for a *layered semantics* that enables users to penetrate through the simplest and, literally, surface appearance to deeper and deeper levels of understanding. The Xerox photocopying machine designed at RichardsonSmith is a good example. The surface can be handled with desk-top metaphors for paperwork. Opening it allows users to see paperflows and enables them to fix simple processing errors. Further penetration is reserved for qualified repair persons and the final layer for engineers.

Motivations

The notion of a value system posits values as unalterably fixed dispositions or as socially shared superindividual purposes, either of which are assumed to provide invariant motivations of individual behavior. This view denies the variety of individual cognitive constructions that users engage when interacting with their environment. Such a position is untenable. Instead, I conceive motivations as arising with the exploration of the opportunities objects afford users in particular contexts. Rheinfrank, et al.[18] distinguish between extrinsic and intrinsic motivation.

Extrinsic motivation derives from using something as a means to an end. The desirability of this end then motivates the means' use. Forms that promise the achievement of something desirable are attractive for this very reason, whereas forms that do not express such expectations cannot possibly provide a basis for instrumental use. This simple fact establishes the dependency of extrinsic motivation on recognizing instrumental opportunities in a form and, thereby, the primacy of semantics over axiology.[19]

18) John Rheinfrank and the Exploratory Design Laboratory at RichardsonSmith, Worthington, Ohio, have used this distinction repeatedly in work for various clients. Also see John Rheinfrank, "A Conceptual Framework for Designing User Interaction into Products," *Innovation* 3, 2 (1984): 28-32.

19) *Axiology* is the scientific study of values

and aims at a logic of objective value judgments as if values had nothing to do with the way people construct their worlds or their artifacts and communicate with each other through them. I am supposing here that individuals are more autonomous in their world constructions and preferences than an axiology might grant.

Intrinsic motivation stems from using something for its own sake, from interactive involvement regardless of possible gains. Whereas extrinsic motivation is always explained by reference to some product, result, or something outside of it, intrinsic motivation is uniquely rooted in the process of interaction. It stays within the confines of a circular cognitive process, for example, within the rules of an engaging game, and suggests an esthetics of process rather than of form.

Perhaps the crucial difference between extrinsic and intrinsic motivation is that they refer to two different cognitive paradigms, the instrumental and the symbolic. In the instrumental mode of thinking everything is directed toward and justified in terms of a goal — a problem to be solved, an obstacle to be removed, or desirable conditions to be optimized — whereby the artifacts affording such purposes have no value in themselves. In industrial design, this motivation unquestionably underlies industrial production, marketing, and advertising and is embedded in traditional functionalism. In the symbolic mode of thinking, everything seems directed to achieve balance: a sense of integrity, coherence, harmony, or wholeness of divergent parts, a sense of self-realization in interaction with others, a sense of oneness with the environment. Extrinsic and intrinsic motivations are not mutually exclusive, however. For example, a competitive game may simultaneously motivate by the prospect of winning and by being humanly engaging, regardless of outcome. Artifacts that cannot provide either kind of motivation are not usable in any sense and, hence, of little concern to product semantics.

Redundancies

Industrial production creates large numbers of identical forms that must be usable by and understandable to many very different users. One way of supporting this kind of production is to promote a uniform understanding; another is to build redundancy into the operational meanings of products. The former was the aim of functionalism; the latter is more in line with product semantics, and it recognizes that individuals differ markedly in how they construct and approach their world. People have sensory preferences: some are visually oriented, others tend to rely more on tactile, acoustic, or verbal information. People bring amazingly different cognitive models to a situation and develop different interaction and learning styles. People have different cultural histories that emphasize reliance on some clues over others or favor different paths of exploration. Unless designed for very homogeneous populations, industrial products must afford these differences, allowing visual, tactile, acoustical, and verbal indicators or clues to different interpretations of forms to exist side by side. This parallelism of expression may either be redundant,

consistently supporting the same operational meanings in diverse populations of users and thereby increase motivation, or it may lead to contradictions and paradoxes, cause confusion, and, thereby, decrease motivation by either removing the fun inherent in smooth and competent interaction (which could provide intrinsic motivation) or increasing the possibilities of errors (which reduces extrinsic motivation). Esthetics has always been associated with redundancy[20] and the operational theory of meaning extends this to all levels of users' involvement with artifacts and, ultimately, with themselves.

20) Gregory Bateson, *Naven* (Stanford: Stanford University Press, 1958), and Gregory Bateson, *Steps to an Ecology of Mind* (New York: Ballentine, 1972).

Sociolinguistic Context

Solitary use of everyday things is rare. We worry about what to wear to a party, consider the appropriateness of a gift, have opinions about someone's taste, imitate our idols' patterns of consumption, and talk about all of this to friends. These examples involve bystanders, critics, judges, or interested parties to which users relate. These need be neither real nor present, however. When acquiring a product, for example, buyers usually think of other individuals, both recognizable when seen and wholly imaginary, who serve as references for their decisions and are consulted in the buyer's mind. "What would my mother say about my wearing this dress" is the kind of question to which an approving answer may have to be found in order to feel comfortable wearing it. Although such a discourse may take place entirely inside a user's mind and between hypothetical people, it matches in importance what people talk about in fact. Discussion of everyday things takes place in language and subjects the things talked about to social definitions and meanings. In this context, *objects participate in human communication and support linguistically mediated social practices.*

In the absence of in-depth literature about this context, I will elaborate four sociolinguistic uses of artifacts and comment briefly on their implications for design:

- expressions of *user identities*
- signs of *social differentiation and integration*
- *content of communication*
- material support for *social relationships*

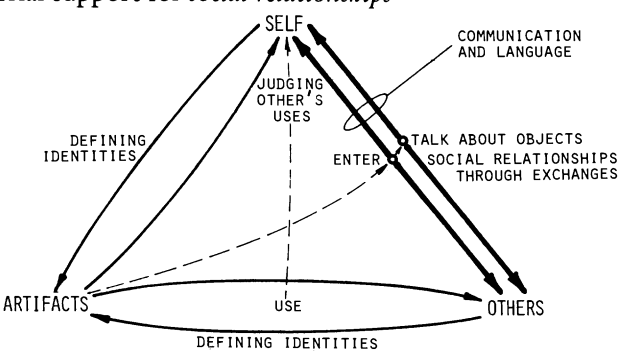


Fig. 5)

This context could be viewed by means of the triangle in figure 5 involving the self, others, and material artifacts among which a variety of relationships and their dynamics are at issue.

User identities

When it comes to showing who they are or want to be, people seem to totally abandon utilitarian criteria or at best assign them a subordinate role. This is obvious with jewelry and fashion, for which technical considerations are minimal, indeed; however, even in highly technical domains of decision making people often abandon technical criteria as well. For example, driving below 55 miles per hour, a Porsche drives as well as a Honda Civic or a VW Rabbit. Worse, a Porsche offers less space, incurs far higher maintenance costs, and is more likely to be stolen, but it gives its owner a special flair, a sporty, wealthy, "yuppie" identity few other cars can provide. These attributes make the difference, not the technical data published and discussed in the salesroom.

Designers are not free from identity considerations either. Designers who are unaware of product semantics may professionally advocate the most radical functional perspectives while surrounding themselves with demonstrably beautiful things, ordinary objects cast into elegant shapes, expensive designs by famous firms or architects. This is exemplified by Gerrit Rietveld's chair, which neglects all comfort for its exquisite geometric style. Indeed, people and even entire countries, are willing to carry considerable burdens, inconveniences, and expenses just to be special, which often means surrounding themselves with objects aimed at defining their identity, for themselves to feel good about and for others to recognize.

The criteria that govern choices of this kind show little resemblance with those of problem solving or representational uses. Means and ends are indistinguishable here, and objects and what they mean become one. The criteria are based more on gestalt considerations and are concerned chiefly with how users weave their own identity into the symbolic fabric of society. The way people relate to their homes may serve as an example here. Based on Jungian notions, Cooper[21] shows a home as the place where individuals feel in the center of their own self-constructed universe, at which point their identity becomes indistinguishable with the things chosen to symbolize it. Users then are in a part-whole (metonymic) relationship with the complex of objects surrounding them. (This relationship contrasts sharply with the means-end relationships of operational use.)

21) Clare Cooper, "The House as Symbol of Self," in N. M. Prohansky, W. H. Ittelson, and L. G. Rivlin, eds. *Environmental Psychology, People and their Physical Settings* (New York: Holt, Rinehart & Winston, 1976): 435-48.

Social differentiation and integration

People want to be different but never so different that they no longer resemble others in some respect. A user's identity is but one

extreme by which the self is distinguished from all others. By the above premise, individualization can never be total. The feeling of belonging to or being part of larger social entities, classes, professional groups, or religious denominations is, again, mediated largely through the deliberate use of particular objects. With the emphasis on similarities, Csikszentmihalyi and Rochberg-Halton[22] point out that such objects become *symbols of integration*. That many established designers drive BMWs, that architects are connoisseurs in fine restaurants, that "yuppies" live with chromed steel furniture, and so forth are slightly exaggerated examples of ways to express belongingness, shared attitudes, or common privileges.

22) Mihaly Csikszentmihalyi and Eugene Rochberg-Halton, *The Meaning of Things: Domestic Symbols and the Self* (Cambridge: Cambridge University Press, 1981).

However, marking belongingness to one group entails excluding belongingness to others. For objects to serve as symbols of integration, they must also draw distinctions between those who can afford, are able to, or are entitled to their use and those who are not so privileged. Thus, they function as *symbols of differentiation* as well. Things that are rare, expensive, or difficult to have access to or use are particularly suited to play this dual social role, and the extent to which industrial products must serve this function limits their mass production. For this reason, one cannot get everyone to wear the same clothes, live in identical apartments, or drive the same kind of car.

The delicate dialectic between differentiation and integration has often been overshadowed by status conceptions. Indeed, the process of differentiation and integration is rarely neutral and most cultures seem to rank people according to the power, respect, envy, or privileges they command. Only the artifacts chosen to support these inequalities vary. However, status is not a linear scale. There are status conflicts, incompatibilities, and shifts, and designers must recognize the social dynamics their products may initiate; for example, when objects designed for use in one group employ symbols of integration for another, or when high-status symbols are made easily accessible to low-status groups. Therefore, industrial interests to produce greater numbers of identical products can easily conflict with social needs for symbols of differentiation, integration, and status. Designers can respond by providing ways of individualizing, customizing, or altogether losing this social motivation for consumption or use.

Content of communication

Objects also provide important topics of conversations, and, by so doing, acquire meanings that are in fundamental ways different from operational use. Things are distinguished, named, and classified through language. Thus, objects that are not clearly distinguishable linguistically are also often confused in practice. For example, the generalization of the word *Jeep* to all rugged-

looking four-wheel-drive vehicles bothers American Motors, as seen in its advertising. It is in language that things are joked about, criticized, or praised. Products that can easily be made fun of rarely succeed. There is a legend of examples where jokes and funny names prevented products from widespread use. The official name for Volkswagen's rugged utility and hunting vehicle, Thing, for example, cannot easily be incorporated into linguistic discourse. "I am driving a Thing" makes many people wonder what is meant, whereas substituting the word *Jeep* or *Thunderbird* for it would not. The car never became popular, probably for sociolinguistic rather than functional reasons. It is also in language that objects are admitted into specific social practices. The distinction among wine glasses, and between them and other types of glasses, follows conventions negotiated in language and usage (which glass for which occasion) and is socially evaluated and judged.

Inasmuch as criteria for evaluating and judging objects are formulated in language and negotiated in communication among people, including users, forms may have to be designed in view of the categories and distinctions drawn by the speakers of language. Designers often seek to fuse two well-known technologies into a new device that cannot be easily recognized and talked about for its neither-quality. The language used by consumers often differs from the language used by designers, who must fit their designs into commonly available categories or cause enormous advertising costs to gain acceptance. Linguistic categories are also subject to their own dynamics. The transformation of portable radios into tape-playing "ghetto blasters" (boxes) shows how social definitions change and how particular groups can appropriate objects as symbols of their own.

Finally, language provides the research medium into users' cognitive models, motivations, and meanings. Charles Osgood's semantic differential,[23] to use a well-known example, calls for rating products by scales, whose end points are marked by polar opposites, for example, fast/slow, expensive/cheap, active/passive, attractive/repulsive, and, thus, involve objects in simple adjectival constructions. Protocol analysis,[24] on the other hand, maps how users describe themselves as interacting with objects. Either result is rooted in language and cannot be separated from respondents' linguistic use of objects in communication with others. When a truck cabin is said to be compact, sturdy, functional, comfortable, and so forth, this description may say more about the linguistic use of the words *truck cabin* than about truck cabins. Research methods in product semantics that use verbal instructions, stimuli, or responses are therefore also methods of establishing the sociolinguistic meanings into which designers have to fit their products. All efforts to establish design languages[25] attempt to

23) Charles E. Osgood, George J. Suci, and Percy H. Tannenbaum, *The Measurement of Meaning* (Urbana: University of Illinois Press, 1967).

24) K. Anders Ericsson and Herbert A. Simon, *Protocol Analysis: Verbal Reports as Data* (Cambridge: MIT Press, 1984).

25) For example, Richard Fisher and Gerda

Mikosch, *Grundlagen einer Theorie der Produktsprache* (Offenbach: Hochschule für Gestaltung, 1984); Toenis Kaeo and Julius Lengart, et al., *Productgestalt* (München: Siemens AG, undated).

make sense of objects by verbally putting them in the context of conversations.

Social relationships

Objects also play an important role in establishing, maintaining, or changing social relationships. This role is a necessary consequence of transferring the ownership of material entities among people and of the meanings objects thereby acquire. After repeatedly purchasing from the same merchant, a buyer may become a favorite customer, which entails a special relationship of trust that both buyer and seller recognize and seek to cultivate. In other words, consumer products must not only look worth their cost to the consumer at the point of sale, because this exchange is based on and feeds relationships of trust, products may have to be designed with this affordance in mind. Gifts, as another category of exchange of goods, provide a more interpersonal example. Although a gift is always thought to be of benefit to a receiver and affordable by a donor, it necessarily introduces some asymmetry into an existing social relationship. Receiving a gift not only requires that the receiver express some gratitude to the donor, but also imparts an unspoken obligation to reciprocate in the future. Similarly, symbols such as wedding bands are not merely signs of married persons but constant reminders of the special relationship between two people and the church or state that invests its power in protecting this relationship. (The word *symbol* comes from the ancient Greek tradition of two parting friends breaking a coin into two halves that each carries in the hope that this will bring them together again.) Industrial products, bribes, loaned or borrowed objects, gifts, and symbols are all involved in mediating social relationships, which designers may accidentally ignore and disable or deliberately honor and support.

Context of Genesis

Artifacts are not only instrumental to users (operational context) and constitutive of social realities (sociolinguistic context), but they are also created, produced, marketed, consumed, retired, or recycled, and experiences with them inform a subsequent generation of artifacts. This process forms a grand cycle, oversimplifyingly called the production-consumption cycle, which knits designers, engineers, producers, suppliers, distributors, advertisers, salespersons, consumers, users, waste managers, applied scientists, researchers, and regulatory agencies into an ongoing process of technological autopoiesis.[26] These participants have a stake in maintaining this process and can therefore be called stakeholders. Simplified and with the designers' part too exaggerated, this cycle is depicted in figure 6.

26) Sagan and Margulis, *Whole Earth Review* cited above.

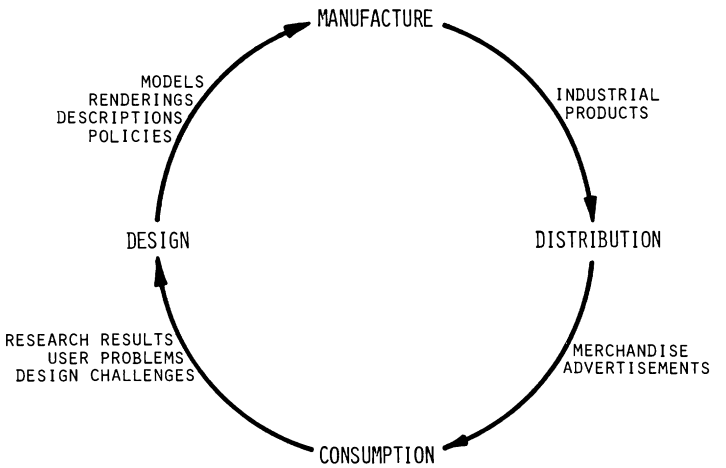


Fig. 6)

Design students learn and practitioners frequently repeat the misconception that industrial designers *create* industrial products for mass consumption. This conception lacks awareness of the differential roles other stakeholders play and unduly emphasizes tangible products over the process of generating them. Designers usually are involved with two kinds of activities, and successful designers engage both well. First, designers create highly individualized *patterns* in the form of drawings, sketches, models, descriptions of possible uses, specifications (of materials and production processes needed to enable others to realize their ideas as rendered), corporate strategies, and advertising campaigns. The materiality in which these patterns are embodied is irrelevant or secondary to the information they carry and the sense they make to others. Within the semiotic framework, designers create representations or descriptions of things; but because these creations are things themselves, I prefer to view them as information or manifestations of patterns in transition.

Second, designers must convince others to get involved or their creations (pattern) rarely bear fruit. In fact, most designers spend the greater portion of their time developing presentations, selling their ideas, and communicating with clients. Some designers claim that 80 percent of their time is presentation, 10 percent is administration, and 10 percent is searching for solutions. In convincing others, designers do tailor their patterns, like messages, to what clients want, are willing to accept, and are able to use (produce and pass on). With speech-act theory, one could say that designers are above all communicators and the patterns they produce must have some *perlocutionary force*[27] for other stakeholders to be attracted to and influenced by them.

27) John L. Austin, *How to do Things with Words* (New York: Oxford University Press, 1962).

Thus, in the context of genesis, *artifacts can best be seen informationally, as temporarily frozen manifestations of pattern.* The ideas in the designer's mind becomes frozen in the form of drawings. Drawings are used by engineers to develop production schedules. Production schedules enable marketers to settle on

distribution plans and advertising strategies. These attract potential users to acquire or consume the products. Industrial concerns usually stop here, but the process of transforming patterns into different materialities continues. Research on the patterns of interaction between products and users feeds back to and informs designers and producers. Users apply industrial products to their individual environments (an issue discussed in the section on ecological context), and all artifacts are ultimately retired, recycled, or decomposed and collectively influence the physical environment in unintended and barely understood ways. Problems recognized in the subsequent environment provide the fertile ground motivating new ideas. New ideas are but combinations, reorganizations, or modifications of patterns already in existence. Thus, the production of artifacts neither has a natural target nor terminates with an end user: *it continuously feeds on itself.*

In the context of genesis, artifacts — and natural objects could be included here as well — are always in transition. They are the products of one process *and* the inputs to others, semantically carrying their own history into the future. They are like messages in circuit, as Gregory Bateson[28] has taught, being continuously created, articulated, interpreted, and translated into other messages that collectively produce the very technology that produced them. The stakeholders in this process are then best described as communicators of organized matter that make a difference in their lives.

28) Bateson, *Steps to an Ecology of Mind* cited above.

The context of genesis affords several laws. Stated in factual terms, the most important law reads as follows: *The existence of any artifact is living proof of the viability of all of its genetically preceding manifestations.* Obviously, an idea that is unthinkable cannot be sketched. Something indescribable (something that cannot be expressed in words, drawn on paper, or otherwise communicated) to a producer cannot be built. A product that is unknown to potential users cannot be sold. The law boldly suggests that the chain of a pattern's transformation cannot be broken. Nothing comes from nowhere. The nonviability of any one manifestation in this chain can become the reason for a pattern to become extinct.

Stated prescriptively, the law could read: *Patterns should be designed to survive all the successive transformation into manifestations (artifacts) that are necessary to ultimately support themselves.* Thus, in the context of genesis, the unit of design concerns is not a consumer product but the circular process through which those patterns may travel that enable a particular behavior to evolve. If artifacts are to carry their own history into the future, they must be equipped with the semantics to do so.

For designers to take responsibility for this circular process the

following requirements must be satisfied:

- *Addressing the network*
- *Comprehensibility*
- *Resource availability*
- *Costs and benefits*
- *Adaptability*
- *Entropy and pollution*

Addressing the network

Ideas might not find their way through the complex network of a production-consumption cycle by themselves, unless they bear the addresses to the intended stakeholders. Indeed, many great ideas have been wasted by falling into the wrong hands or arriving at their destination at inappropriate times. In addition, and unlike mail, which bears just one address, designers are not the only ones who have clients. Clients have clients too. It follows that patterns must be designed to travel by efficient paths through a whole circular chain of stakeholders. Each manifestation must then include the addresses to the remainder of the intended path. The histories of artifacts may become lost but what gives them direction should not.

One mode of addressing used by designers employs symbolism, which some receivers find attractive and seek out for themselves when needed. Advertisers think that way, but only about buyers. Another mode uses a language that only the intended stakeholders know how to interpret. Drugs tend to be described in vocabulary only qualified doctors understand for fear they might get into the wrong hands. During the product development phase, successful design firms often involve as many stakeholders as possible in a process that includes reaching consensus on who does what, when, and how. Advertisements are naturally placed in magazines that reach desired consumers. The exclusion of children's access to medicine bottles was already mentioned. Ecologists have convincingly argued — though not in these words — that addressing should extend beyond marketing concerns to where retired products can be recycled or may be disposed of without causing environmental destruction.

Comprehensibility

Stakeholders cannot be expected to proceed with anything that does not make sense to them. To render intelligible what might otherwise appear nonsense is difficult. Even though designers might complain about the gory taste of engineers or about the culturally irresponsible opportunism of sales personnel, rarely does one group have what the other lacks. Difficulties in communication are usually rooted in different professional histories, experiences, conceptions, and interests. To overcome

these calls for agreement on a language capable of expressing patterns in forms that afford the stakeholders different cognitive models, refer to individually different experiences, and appeal to different values.

Functionalism in engineering, ergonomics, and marketing provided such a bridge in the past, but it did not embrace the social and cultural domains. Product semantics is an example of a developing framework by which designers can communicate about their previously inexpressible sensitivities, cultural responsibilities, and user concerns at the same time. It promises knowledge about how people make sense of their physical environment, presents methodologies and replicable tests for the design of human interfaces in a variety of contexts, and provides a platform for consensus about the concepts used. This framework is applicable not only to the stage of consumption, but to all stakeholders involved in the flow of pattern.

There are no perfect tests for whether an artifact works other than that its underlying pattern has succeeded in making sense to the stakeholders throughout a complete production-consumption cycle. Comprehensibility is a requirement for transmission of pattern (information) and a significant bottleneck for genesis.

Resource availability

For a pattern to be realized or implemented requires that stakeholders command adequate resources. There is no sense in proposing technologies of unknown availability, products for consumers who do not exist, or distribution mechanisms whose costs are inestimable. Recognizing the availability of adequate resources requires a level of understanding that goes one step beyond comprehensibility by involving the physical processes that designs or patterns need to inform.

For designers, this step implies explicitness as to how a pattern may be implemented, acted upon, or used and which physical conditions are required to succeed in this endeavor. Successful design firms not only present their ideas, but also bring potential producers, suppliers, banks, market researchers, user groups, and so forth together, inform their clients where adequate resources are available or how available resources may be utilized. In this respect, designers resemble technology managers rather than applied artists who produce their own works. In the absence of such efforts, designers are likely to be conservative of familiar practices, parochial in scope, or fail.

Costs and benefits

Within the production-consumption cycle, motivation tends to be unevenly distributed. For consumers, the time between paying for a product and experiencing the benefits of its use is short and

the margin of profit (benefits minus costs) tends to be small. Marketing and advertising seek to ensure that a product's form prominently expresses its benefits. In comparison, yields from investments in research and product development are large but typically arrive with considerable delay. It follows that producers have greater investments in the circular process than consumers, leaving little for recyclers and waste managers.

Whereas consumer benefits of a product can be expressed in that product's form, a major design problem in the context of genesis is to sustain the producer's expectations of benefits to the point of actual yield. Research and product development commitments usually follow from high expectations of benefits derived from convincing presentations by designers, supportive profitability analyses, and market research results. However, the initial enthusiasm erodes as development and production costs accumulate, unless this enthusiasm is continuously fed or nourished. It requires designers either to be part of the process or to communicate with their designs something that sustains this motivation at least to the point of actual yields.

Adaptability

Traditional machines, such as scissors, steam engines, bridges, and automobiles, serve just a few anticipated functions, forcing users to adapt. Designs for these products are equally fixed. This situation is changing through the invention of adaptive systems and user-programmable computers and the extension of design activities into social systems. The creation of production-consumption cycles represents the most sophisticated example. Such systems can have a life of their own, adapting to their own environments, learning from users, changing their behavior, growing and developing into product niches, and protecting themselves from misuse. They can also generate additional artifacts and be self-maintaining.

Since the advent of cybernetics, intelligent systems are no longer unusual. Human interfaces with such systems call for a product semantics quite different from simple and relatively fixed form-meaning relationships of traditional design applications. Intelligent systems are similar to behavioral chameleons, and their appearance should explain whether (and how) they grow like crystals or computer networks, learn like mice in a maze or generate novel responses from given rules.

Three directions for such a semantics are currently explored. One is the design of computer interfaces by means of screens and controls expressing the opportunities and tools necessary to make them do whatever users desire, their range of affordances being virtually inexhaustible. A second is the design of components that enable users to assemble a nearly unimaginably large variety of

applications, each corresponding to individualized needs. A third is the design of corporate strategies that are generative of a coherent line of products which are responsive to changing situations, new technological developments, and different user demands. These directions conceive patterns as language-like facilities — user-adapted programming concepts, combinatorial grammars, and generative design languages — whose particular "expressions" are always merely one of many and within that language possible forms whose particular realization escapes its designers' exclusive control.

Entropy and pollution

In the context of genesis, the communication of symbols, messages, and artifacts and the transformation of patterns they inform drive the flow of energy and matter in a production-consumption cycle. Two laws, simplified but of considerable generality, are relevant here:

energy used = work + reusable energy + entropy

raw material = organized matter + recyclable waste + pollution

The first equation restates the first two basic laws of thermodynamics. The second is the material analog of thermodynamics in which pollution is a dispersion of matter that is impossible or too costly to reverse and that represents maximally disorganized matter. Figure 7 depicts the application of these distinctions to any one stakeholder's work. What is true for individuals or groups also applies to whole systems. All production of organized matter or artifacts requires work but irreversibly increases entropy and pollution. Only the rate at which these measures of decay increase differ from product to product. Globally, entropy makes available levels of energy increasingly useless, and pollution makes available raw material increasingly costly. According to these laws, the physical production of things makes that production increasingly impossible.

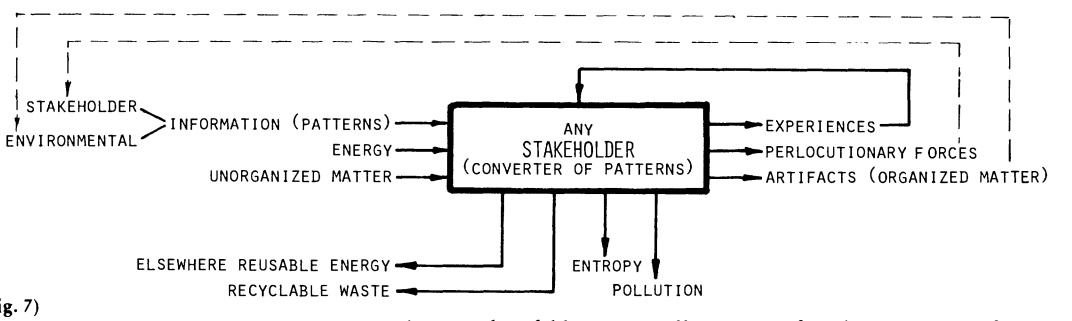


Fig. 7)

Designers should be especially aware of and responsible for the global effects of their creative efforts. From the point of view of a responsible product semantics, inventing and pursuing symbolic strategies that slow down the inevitable processes of decay are important. This may be accomplished by designing industrial

products that can be produced in an energy-efficient manner, can adapt to users' sense-making needs, can direct their own recycling, and can protect other species of artifacts from needless decay. This is the most general recommendation of a product semantics in the context of genesis.

The Ecological Context

Ecological concerns are usually articulated in terms of preserving the natural environment of some time ago. Although these concerns have some merit, they must include the artifacts people live with as well. Hence, I take ecology as a framework for exploring how the interaction among different kinds of artifacts make sense.

The idea of ecology comes from biology, where it is defined as the interaction of *populations of species* and is applied largely to plants and animals. It is attractive as a model for four reasons:

First, each population of species is regarded as living in its own environment to which it responds and by which it organizes itself into its very own categories (Uexküll's *Merkwelt*). The environment that a population affects (Uexküll's *Wirkwelt*) may only partly overlap with the former but may be "seen" or responded to by some other population (at least of human observers).[29]

Second, populations of species are thought to interact through such partially overlapping environments, without presumption that one "understands" the nature of the other, and the larger ecology is described as a network of such interactions. There is also no assumption of wholeness, no hierarchy, no master plan, no overriding purpose, and no central authority, even though some species are clearly more dominant than others. So conceived, an ecology is a distributed, heterarchical, and dynamic system.

Third, relationships between populations of species, whether they are cooperative, competitive, symbiotic, or parasitic, emerge in interaction or are "negotiated," so to speak, without some outsider unilaterally imposing them. There is no central ruler, only participants who may assert their will in their own environment of others. An ecology is not democratic, egalitarian, or just, but is responsive to every population.

Fourth, ecological systems seek balances or converge toward some equilibrium, at which point populations keep each other in check, maintain varieties of species, and ensure efficient use of limited resources. Gregory Bateson,[30] among others, described such an equilibrating tendency as distributed wisdom.

As Kenneth Boulding[31] points out, there are many species of artifacts, perhaps even more than biological species now existing. Items described in an unabridged Sears catalog are probably more numerous than biological species listed in a high school text on biology, and this catalog is far from being representative of the

29) Jacob von Uexküll, "Band X, Abhandlungen zur theoretischen Biologie und ihrer Geschichte, sowie zur Philosophie der Organischen Naturwissenschaften," in *Bedeutungslehre* (Leipzig: Johann Ambrosius Barth, 1940). Uexküll develops a general theory of species-specific construction of meanings and environments that can provide a conceptual framework for accounting for the interaction among species in an ecology. It is consistent with my approach to semantics. In the absence of a translation, his *Theoretical Biology* (London: Paul, Trench & Trubner, 1926) contains the rudiments of his approach.

30) Bateson, *Steps to an Ecology of Mind* cited above.

31) Kenneth Boulding, *Ecodynamics* (Beverly Hills: Sage, 1978).

products available worldwide. Species of artifacts also cover greater ranges than biological species do. They range wider in size: skyscrapers are larger than elephants, artificial molecules are smaller than amoebas. They range wider in complexity: computer chips have more memory than lower animals, not to speak of stock markets that even humans cannot comprehend, and they can function much longer than any living organism, as museums can testify. Human beings can be considered artifacts to the extent they are social beings, speak a common language, assume social roles, conform to behavioral conventions, and are, in these respects, replaceable. Organizations are artifacts as well, created by humans, interacting with one another in particular environments containing various resources, markets, stakeholders, and regulatory agencies. The implications for product semantics of placing artifacts in ecological contexts are enormous and call for a whole book. However, only three aspects of particular interest to design are discussed here: *competition*, *cultural complexes*, and *autopoiesis*.

Competition

In linguistics, in discourse analysis, in particular, differences in meanings of words are recognized by differences in the linguistic environments in which they can or do occur. Accordingly, words are synonymous if they are freely substituted for each other in the same text. So, the word *early*, as in the phrase "he came early," is usually substituted with *too soon*, making them synonymous, whereas *prematurely* can only occasionally substitute for *early*, the difference in context being the formality or informality of speech. The very same way of thinking about meaning applies to artifacts that might also be substituted for each other and, thereby, compete with each other for available positions. Cars substituted for horse-drawn carriages and depleted their numbers. Electronic messages and telefaxes are largely substitutes for written letters, save for the electronic environment needed, and are likely to reduce the use of postal services. Substitution is rarely perfect, however. Just as horses have found a niche in sports and pleasure that cars cannot easily penetrate, so has the telephone reduced letter writing but may not drive it to extinction.

Cars do not look like horses, but early cars very much resembled horse-drawn carriages, probably facilitating substitution, just as personal computers now look very much like typewriters and television sets, which they challenge. The form of these products is what directs whether they fit into contexts in which they compete with existing products and succeed or disappear as a consequence of the interaction they support. Designers must understand the dynamics of meaning that ecological interaction entails; they must create forms that survive such interaction, that

are sufficiently similar to competing forms, and that are sufficiently distinct to make a difference.

Cultural complexes

Competing artifacts interact so that an increase in the numbers of one decreases the numbers of the other. In contrast, cooperating artifacts develop a variety of dependencies that support their respective population sizes. There are dominance relationships in which one population enables the other to increase in size, but the latter's decline will influence the former only minimally. Batteries dominate flashlights, but there are so many other uses for batteries that a decline in the flashlight population does not significantly influence the battery population. There are supportive- dependency relationships in which one population of artifacts, sometimes called secondary gadgets, support but are existentially dependent on the use of primary artifacts. Software is related to computers in this manner. Software has enhanced computer use tremendously, but computers existed before software was marketed on a large scale. Among the various dependencies that emerge are those governed by taste, style, and family belongingness. While chairs always cooperate with tables as lightbulbs do with books, beyond these family resemblances, items of similar style are attracted to each other forming mutually supportive wholes. However, there may also be parasitism and predation in which competition and cooperation is not mutual, just as in a biological ecology.

The point of this argument is that dependencies that develop among interacting populations of artifacts grow into *cultural complexes*, which consist of many different artifacts whose cooperative forms of interaction have become so stable that they could be considered composite forms or systems in their own right. The car complex is such an example. It consists of drivers, car dealers, automobile manufacturers, streets, municipal transportation departments, gasoline stations, oil producers, all of which cooperate with each other in keeping cars running and themselves in place. (I am ignoring here competition within any one category which does not change the system.) This complex has threatened public transportation, such as trains, buses, and the railroad; invaded the postal service; and put its stamp on the architecture of cities, all of which are cultural complexes of their own.

Newly designed artifacts rarely simply replace old designs. They seek and encourage the emergence of somewhat different environments, initiate shifts within their cultural complexes, cause chain reactions throughout the larger ecology, and, therefore, need to withstand the self-protective responses by those affected. The omission of chrome on American cars made whole factories obsolete. The initial success of cars with the new

aerodynamic look forced many other manufacturers to rethink and find new forms. In an ecology with artifacts, the meanings of objects are always interacting and in flux. Changing one form may have enormous consequences for others.

Autopoiesis and conclusion

Ecologies with artifacts, including the cultural complexes outlined above, do not work without human participation. People design things, people direct production, and people put artifacts in their places. Without the collective use of symbolic strategies for local assembly and guidance, technology cannot behave as a self-productive or autopoietic system and would therefore decay.[32] True, designers can work within the functional tradition, with its linear logic of achieving terminal ends and a semantics of "stand-for" if not "make-believe" relations to reality. Its exclusive emphasis on allopoiesis — the production of something other than itself — makes a functional perspective inherently limiting, unable to conceptualize meanings that develop from circular interactions within an ecology of artifacts and unable to participate in creating symbolic strategies that make autopoiesis happen.

I have argued that, in the operational context, cognitive models held by human individuals locally guide the assembly of artifacts into individually meaningful wholes and that this takes place in each individual's environment as cognized.[33] This applies to individual users of artifacts as well as to designers. The context of genesis provides designers with cognitive models to create things. Both models realize that *form follows meaning*, which is shorthand for saying symbolic strategies, not physics, govern the collective use and assembly of artifacts into cultural systems.[34]

Mythology probably is the most important and unconsciously embracing governing structure in an ecology of artifacts. A culture can hardly be conceived without myths, and its vitality derives directly from them. In some cultures, mythology is codified in ritual performances and stories of supernatural beings and gods. These gods perform deeds of immense power and interact with each other and humans through artifacts. In other cultures, notably in the industrialized West, mythology has become more hidden, unconscious, and implicit in superstitious beliefs and repetitive cultural practices, but it occasionally surfaces through powerful tragedies, movies, literature, and science fiction, as well as major inventions that guide and occupy generations of people, designers, producers, and users alike. Mythologies give coherence to cultural complexes beyond individual understanding by legitimizing its components, assigning them to perform meaningful roles and directing them to interact with each other. Design strategies that go against mythology go against the ancient ecological wisdom that has been cumulatively acquired during

32) Sagan and Margulis, *Whole Earth Review* cited above.

33) For the distinction between cognized and operational models of reality, see Roy A. Rappaport, "Sanctity and Adaptation," *The CoEvolution Quarterly* (1974): 54-8, and his *Pigs for the Ancestors: Ritual in the Ecology of a New Guinea People* (New Haven: Yale University Press, 1978).

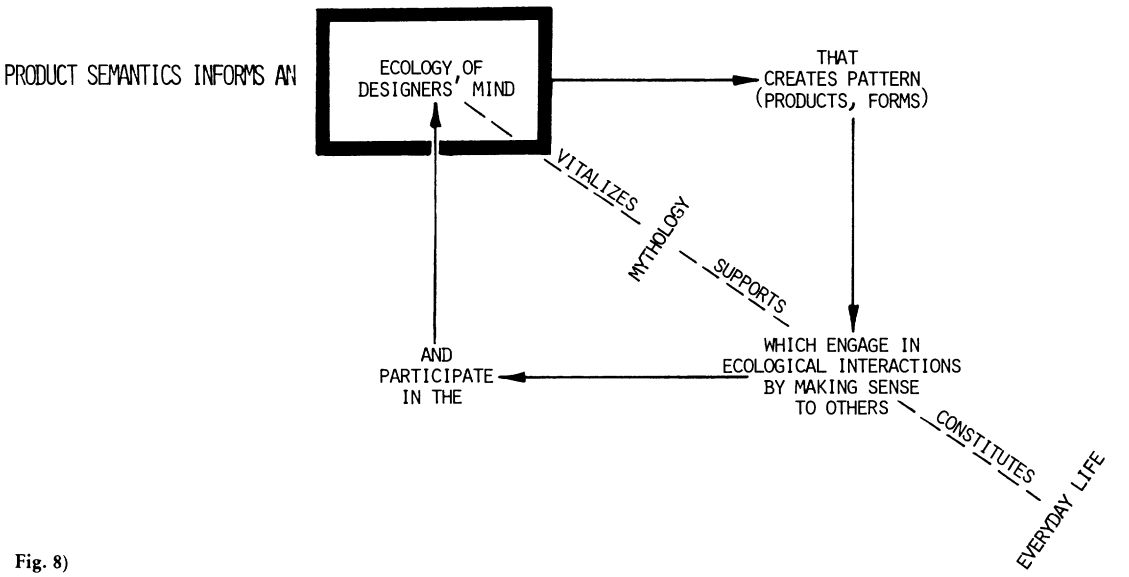
34) This is also stressed in Uexküll's work, *Bedeutungslehre* cited above.

centuries of human social experiences; these design strategies are likely to fail in the ecological interactions they have to withstand. Although largely unconscious, artifacts always mediate symbolically between the deep-rooted mythologies distributed in a culture and the material contexts of everyday life.[35] With the support of powerful mythologies, artifacts can gain considerable ecological strength; denying this connection, whether by ignorance or by preference for a functionalism that cannot cope with meanings, produces an inhumane technology.

35) See S. Balaram's analysis of Mahatma Gandhi's use of artifacts in this issue.

I have argued that, in the ecological context, cognitive spaces of different participants need not be the same for interaction to take place. Indeed, designers and consumers cannot be presumed to see the world with the same eyes much less so do computers, streets, forests, and grass. In any ecology, none of its participants — properly including animals and plants — can possibly understand the whole system of which they are part. Every participant is limited by his, her, or its own cognitive models and by their largely unconscious access to prevailing mythologies. Understanding an ecology is therefore necessarily partial. Superindividual wholes always are mythological indeed. Mythology in language bridges different cognitive spaces and serves as a medium for negotiating distinctions, differences, and typicalities and for coordinating the use of individual symbolic strategies. Designers are but one kind of participant in the ecological process, and the patterns they set in motion could travel over such bridges but never without involving the larger system of which they are a part. The designers of symbolic strategies for artifacts may claim to reign supreme in this ecology, but they cannot escape the hidden governance of collectively shared archetypes and mythologies whose meanings must be respected, grasped, tapped, and drifted with.

None of the four contexts of artifacts or the four constructions for the theory and practice of product semantics exists entirely outside someone's mind. They are suggested here as four principle types of cognitive models for designers to create forms that make sense for others. Thus conceived, product semantics is a radical proposal for *an ecology of designers' minds*. Its concepts of meaning enable designers to communicate through the designed world with other fellow human beings and to participate responsibly in an ecology that is, at least in part, their own creation. The properly self-referential nature of this kind of product semantics correlates with the cultural autopoiesis it viably informs (figure 8).


PRODUCT SEMANTICS INFORMS AN
ECOLOGY OF DESIGNERS' MIND
THAT CREATES PATTERN (PRODUCTS, FORMS)
VITALIZES
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AND PARTICIPATE IN THE
WHICH ENGAGE IN ECOLOGICAL INTERACTIONS BY MAKING SENSE TO OTHERS
CONSTITUTES
EVERYDAY LIFE

Fig. 8)