Steps to a General Theory of Habitability

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Abstract

A theoretical basis is presented for a unified discussion of the sustainability and habitability of the built environment. This theory is inspired by concepts in human ecology, information theory, and thermodynamics. It suggests, in a first approximation, to subsume the quality of the built environment in view of provision of comfort, flexibility, control, and informational quality as a "Habitability Index," which, ideally, could be ordered on a negentropic scale. Likewise, the environmental impact of buildings may be captured in terms of a "Sustainability Index," which is assumed to inversely correspond to the entropy increase (in the relevant environmental system) attributable to the building activity.

Keywords: *habitability, sustainability, entropy, negentropy*

Having given in to the temptation of various associative resonances in the paper's title, I would like to emphasize upfront the premises that have informed it's programmatic intention:

i) Construction, operation, and disposal of buildings and related infrastructures are responsible for a major part of the overall antropogene environmental impact (resource depletion, environmental emissions, waste production, etc.). This is in part due to poor design.

ii) People spend the major fraction of their lives in building interiors. It is generally accepted that the quality of the built environment has significant implications for people's health, comfort, and satisfaction. Due in part to poor design, most buildings fall short of satisfactorily meeting such requirements.

iii) Methods and tools to predict and consider the environmental and occupancy implications of building activity are not well developed. Moreover, what is available in terms of tools and methods is typically not considered in the architectural and urban design decision making process.

I suggest that points *i* and *ii* above correspond respectively to the questions of "sustainability" and "habitability" of the built environment. In the past, these terms have been used in many different ways (see, for example, Preiser 1983). However, I argue that sustainability and habitability, if used in the specific technical sense described in this paper, may serve well as the basic terminological cornerstones of a general theory of the built environment. In this paper, I cannot offer but a schematic outline of such a theory. Yet even if complete and comprehensive, I doubt a theory could as such "solve" the problem stated in points *iii* above. All we can hope for, at this point, is a more organized manner of stating the problem.

Design of buildings and related artifacts may be viewed as an integral part of the totality of (largely regulatory) operations initiated by human beings as they interact with their surrounding world. We may better understand these interactions using two somewhat abstract yet useful concepts. These are *i)* the human beings' *ecological potency* (e.p.) and *ii)* the surrounding world's *ecological valency* (e.v.) (see Knötig 1992 or Mahdavi 1988 for a detailed description of these terms). Stated in simple terms, the former concept refers to a dynamic human repertoire of capabilities and means of dealing with the world, while the latter concept denotes the totality of that world's characteristics as it relates to or accommodates such repertoire. This being established, design may be viewed as follows:

Designing, in the context of the built environment, involves the generation of formal/spatial entities based on (both "real" and "symbolic") organizational and functional considerations, physical/material specifications, and operational regimes with the (a *priori* expressed or a *posteriori* deducible) intention of favorably influencing the relationship between people's ecological potency (e.p.) and the ecological valency (e.v.) of their surrounding world. Note that:

i) I do not imply that the design activity is *caused* by a perceived imbalance in the e.p.-e.v. relationship *quasi* in the way "response" would follow "stimulus".

ii) The suggestion to understand design in the context of means and actions to "favorably affect the e.p.-e.v. relationship" may be considered too narrow or even deterministic, particularly if the desired outcome in that relationship is understood to be a static equilibrium: here equilibrium itself is in a transient state as changes continuously occur in e.p. and/or e.v. Furthermore, positive experiential qualities associated with certain non-equilibrium transitional states may

themselves be accommodated in designs, as a class of desirable e.p.-e.v. relationships.

iii) Building activity goes far beyond the realization of a reflexive individual activity model to temporarily improve the e.p.-e.v. relationship. Rather, it involves considerable modifications to the surrounding world, so that its transformed e.v. can provide a better long-term match to the e.p. of the inhabitants. Biologically inspired arguments from the cultural evolution theory may explain in principle the emergence of habitat patterns which in fact facilitate an improved e.p.-e.v. relationship (Mahdavi 1989, 1996a).

Sustainability and Habitability

The previous discussion implies a view of design as intervention involving three pertinent systems, i.e., System 1: Environment, System 2: Built Structures, and System 3: Inhabitants. A discourse of design may address these at various strategic levels of observation, and the boundaries of the system elements may be defined in various scales, from narrow to broad. Conventional practice has a radically limited view of each system: Environment is often only a "site," built entities are seen only in their individuality and devoid of an infrastructural context, and inhabitants' needs are typically considered only in so far as they are represented in code-type minimum requirements. At a highly abstract level, however, we may define the objective function of building activity as one that is geared toward provision of desirable occupancy conditions while reducing (ideally eliminating) negative ecological impact (Mahdavi 1997). Provision of desirable occupancy conditions may be seen in the context of the previously discussed relationship between the inhabitants' ecological potency and the habitat's ecological valency. However, facilitating the potential for a better match in this relationship is only one part of the equation. To satisfy the above definition of the objective function, it must be done in a "sustainable" manner.

Given this background, the objective function of the design activity may be conceptually expressed in entropy terms. This would suggest, in a first approximation, to subsume the quality of occupancy in view of provision of comfort, flexibility, control, and informational quality as a "Habitability Index" (I_h) which, ideally, would be ordered on a negentropic scale (Brillouin 1956):

$$I_h = f(\Delta N) \qquad (1).$$

Likewise, the environmental impact of buildings may be captured in terms of a "Sustainability Index" (I_s) which is assumed to inversely correspond to the entropy increase (in the relevant environmental system) attributable to the building activity:

$$I_s = f(\Delta S^{-1}) \qquad (2).$$

This yields the objective function:

$$maximize\ \psi,\ with\ \psi = I_s \cdot I_h \qquad (3).$$

In the above equations ΔN is the negentropy increase relevant to the inhabitants and ΔS is the resultant overall effective entropy increase due to an intervention (i.e., building activity).

Obviously, the operationalization of the above function involves major difficulties: measures of environmental impact are non-trivial and may vary according to the evaluation time horizons considered. The definition of occupancy quality is no less complex as generally agreed upon indicators are difficult to identify. Nonetheless, a good understanding of this correspondence is important, even if it may be "merely" *conceptual*. Below research directions are discussed that are likely to provide evidence for the *operational* relevance of the proposed view.

Sustainability and Entropy

For a long time, the evaluation of the environmental impact of buildings was limited to their energy consumption. The function proposed above not only allows for the incorporation of energy use in a entropic interpretation, but it also points to the limitation of energy use as a exclusive building performance criterion. Obviously, building energy systems can maintain target space temperatures (and other relevant indoor environmental parameters) over long periods of time even under extreme outdoor conditions. Needless to say, this local increase in negentropy is accompanied by an even larger entropy increase in the encompassing system that includes both the habitat and its environmental context, as in the process typically non-renewable energy resources are depleted, waste heat is generated, and pollutants are introduced into air, land, and water. In a sense, the entropy increase may be interpreted as corresponding to the "investment" that would be required to reverse the impacts of the intervention.

As such, building construction and operation practices have not been and are not concerned with setting up entropy-relevant balance equations to evaluate alternative means and approaches for indoor environmental conditioning. One should not forget that the emergence of energy use in the early seventies as one of the major indicators of a buildings' quality (or lack thereof) was principally attributable to eco-

nomic forces (abrupt rise in energy prices) rather than environmental concerns. Only recently a consensus has emerged suggesting that energy consumption alone is not a sufficient criteria for the evaluation of the thermal performance of a building, let alone its overall quality. Although energy requirement indicators reflect to a certain degree resource depletion (i.e., fossil fuel consumption) due to building operation, they fall short of representing the complex pattern of environmental impacts caused by the construction, operation, and decommissioning of buildings. This insight has led to increased research and standardization activities toward the development of more comprehensive indicators of environmental sustainability.

There have been many recent efforts to apply comprehensive life-cycle assessment (LCA) methods toward representation and evaluation of the environmental implications (energy use, depletion of resources, environmental emissions, degradation of landscapes, etc.). However, the majority of these efforts still do not sufficiently address the multiple phases of a building's life, i.e., design and construction, operation, and decommissioning (Etterlin et al. 1992, Fava et al. 1991, Goedkoop 1995, Graedel and Allenby 1995, Lippiatt and Norris 1995, Little 1995, Mahdavi 1997, Mahdavi and Ries 1996). Despite their potential toward comprehensive environmental evaluation of building designs, LCA tools have certain limitations: *a)* LCA's are data-intensive, and therefore require considerable time and effort to prepare; *b)* reliable and adequate data may not be available, *c)* results from the analysis may require an expert interpretation; *d)* aggregation of impact categories toward unified indicators may be problematic; *e)* the pertinence of LCA's results depends to a large extent on a comprehensive definition of the "balance domain." However, some of these problems may be alleviated in part by the use of computational modeling in general and a negentropic framework in particular (Mahdavi 1997, Mahdavi and Ries 1996).

Although very different in their scope, domain, objectives, and tools, most LCA methods attempt to accomplish a two-fold aggregation of:

i) multiple environmental impact measures into a small group of indicators (occasionally into only one super-indicator);

ii) multiple environmental impacts over a certain time horizon.

It appears that most LCA methods attempt to accomplish this two-fold aggregation *via* means that display an entropic-negentropic "touch," even though they rarely entail an explicit reference to an entropy-inspired terminological framework, nor do they provide for a coherent operationalization of entropic eco-indicators. It is useful to briefly dwell on the latter point using the example of the eco-balance method (Etterlin et al. 1992). This method groups the basis data into energy consumption (in $MJ \cdot kg^{-1}$ of material) as well as loads to water, air, and land (in $m^3 \cdot kg^{-1}$ of material). The key operation is the conversion of loads to the air and water from units which represent pollutant volume, into a unit which expresses the Critical Volume (V_c) of air or water which would be contaminated to its legal threshold limit by the pollutant:

$$V_c = E \cdot T^{-1} \qquad (4).$$

Herein, E is the actual volumetric emission of the pollutant and T represents the legislated legal threshold limit for the pollutant. Critical volume represents thus a measure of dilution (contamination, dispersion) which may be seen as corresponding to entropy increase. Obviously, there is still a long way from such simple measures such as critical volume to a more comprehensive and coherent entropy-based eco-indicator. Certain intermediate improvements are not difficult to bring about, whereas other more substantial and genuinely entropy-based formulations may require much more research. Below I provide an example for the former and some references for the latter.

One problem with the Critical Volume (and other similar simple eco-indicators) is its static nature; it is not an intensity term with temporal and spatial qualifiers. Thus, while it may allow for an approximate comparison of various building design options, it does not allow for the evaluation of the appropriateness of a specific design for a specific site or geographic domain. Let me explain this with an example from the environmental noise control. Imagine a fairly undeveloped urban zone with mix-use dedication and a legislated maximum ambient noise level of X dB. Contractors of the first factory in the area may argue that their factory should be allowed to generate whatever noise level as long as the actual ambient noise level in the area has not exceeded X dB. The problem with this argument is obvious. If the first factory is permitted to exhaust the emission potential all the way to the legislated maximum acceptable noise level, there will be no room left for others; they could create zero emission sources only.

To alleviate this problem, an eco-indicator would be needed that *a)* is dynamic in nature (i.e., can be expressed in intensity terms) and *b)* considers the inherent ecological properties (approximated in various approaches *via* terms such as "carrying capacity," "ecological impact valency," "ecological impact affordance," etc.) of the geographic area under consideration. To exemplify this point, consider the ecological impact indicator P due to building-related emission rates of n agents:

$$P = \sum(w_i \cdot e_{a,i}) \qquad (5).$$

Herein, $e_{a,i}$ is the predicted emission rate of agent *i* due to the proposed built structure and w_i is the weighting factor for the emission rate of agent *i*. A simple approximation of w_i is given by

$$w_i = (e_{i,max} \cdot n)^{-1} \qquad (6).$$

Herein, $e_{i,max}$ is the maximum permissible emission rate (which ideally should represent the ecological impact affordance) for agent *i* in the geographic domain under consideration. The emission rates can be expressed in area-specific (or per capita) intensity units such as $kg \cdot yr^{-1} \cdot m^{-2}$. A more elaborate approximation of w_i would be:

$$w_i = (e_{i,max} \cdot \sum e_{j,max})^{-0.5} \cdot n^{-1} \qquad (7).$$

From this definition it is obvious that the value of the ecological impact index would be 1 for the case where the ecological impact index equals the aggregate ecological impact affordance, that is when all building-related agents are emitted at the maximum permissible rate. Note that in this formulation small permissible emission rates lead to high corresponding weighting factors and result thus in a high value for the ecological impact indicator. It is conceivable that in certain cases (e.g., rehabilitation of ecologically damaged areas) maximum permissible emission rates would be zero or even negative. Such cases are not covered by the proposed formulation.

Beyond such incremental improvements, future research that would build upon works such as Ayres (1994), Ayres and Martinas (1994), Brillouin (1956, 1964), and Georgescu-Roegen (1971) may well lead to the formulation of a new generation of substantially refined, comprehensive, and computationally supported entropy-based eco-indicators. This could facilitate a sufficiently detailed evaluation of the entropic implications of architectural interventions as represented by equation 2. There is no question, however, that the approximation of the occupancy-related negentropy term (ΔN) in equation 1 involves no less challenging difficulties.

Habitability and Negentropy

I suggested interpreting building activity as an intervention in the surrounding world with the aim of positively affecting the e.p.-e.v. relationship. Obviously, this intervention has entropic implications, as expressed by equation 2. However, the degree of actual entropy increase does not necessarily correlate with the resulting "habitability," i.e., occupancy-relevant quality of the built environment in view of provision of comfort, flexibility, control, and informational quality. For example, it has been frequently argued that a building with a high energy consumption rate does not necessarily provide a higher degree of thermal, visual, and acoustical comfort. (In fact, some have even suggested a negative correlation.) This is part of the reason why it would be beneficial to evaluate such occupancy-relevant qualities on a separate negentropic "habitability" scale (cp. equation 1).

How does one generally go about evaluating habitability? Three programs readily come to mind:

i) The prescriptive program involves the quasi lexicological definition of minimum requirements regarding the constitutive building elements, components, and systems and their relationships. The idea is that meeting such requirements would warrant habitability.

ii) The performance program implies the definition of target performance criteria together with their attributes. The idea is that a building's habitability can be evaluated by measuring its behavior against the target performance criteria.

iii) The flexibility program suggests that given variations in occupants' ecological potency, buildings' habitability should not be linked with meeting any rigid set of performance criteria. Rather, the idea is to measure the habitability in terms of buildings' capability to accommodate a wide range of spatially and temporary variable environmental expectations.

Put in provocatively simple terms, all programs suggest one has to do *a* if one wants to achieve *b*. However, the prescriptive program defines *a* and not *b*, the performance program defines *b* but not *a*, and the flexibility program defines neither *a* nor *b* (although it sometimes defines performance variables without specific target attributes). But what sources of information lead to the definition of attributes for a *b*-type parameter? Typically, psychophysical correlations have been the prime candidate. Thermal comfort research exemplified this point *par excellence*, as successive efforts have been made to correlate certain measurable environmental and personal variables (such as indoor air and radiant temperatures, air speed and relative humidity, clothing and activity, etc.) with occupancy reports on thermal sensation as expressed *via* a standardized psycho-physical scale (Mahdavi 1996b). These efforts have typically relied on both physical and physiological models and statistically systematized observations.

If, in fact, clear and measurable performance variables and associated (desirable) attributes can be established, then we should be able to work out the basis for a negentropic formulation of habitability. We expect a "well-tempered" indoor environment to be in a specific behavioral state among a very large number of possible behavioral states. In this context it does not matter if the performance program is considered or the flexibility program. While in the former case, the assumption is that the desired state is known *a priori*, in the latter case it is continuously re-established based on occu-

pancy feed-back: a building that offers the possibility for *ad libitum* realization of a large number of indoor environmental states, obviously ranks high on a negentropic scale of habitability. (An essentially identical reasoning is sometimes used to define a key feature of "intelligent" buildings. It implies that a building should be considered as more intelligent if it allows occupants to individually adjust their immediate environment according to their preferences. Micro-zoning as applied to air conditioning and lighting systems and the so-called user-based environmental systems are examples of methods and technologies toward facilitating such adaptability.)

However, matters are more complicated. A major problem lies in the fact the psychophysical scales are notoriously debatable. An increasing number of researchers would agree that it is highly problematic to postulate a deterministic relationship between measurable environmental factors and occupants' evaluation of environmental conditions (Mahdavi 1996b). To systematically elaborate on this point, a suitable terminology is needed. In this context, it is appropriate to remember the general-level distinction between the material-energetic and informatory aspects of the environmental relationships (Knötig 1992; Mahdavi 1988, 1992, 1996c). According to the human ecological terminology, a "material-energetic" aspect as well as an "informatory" aspect can be assigned to every entity, state, and process. The material-energetic aspect refers to the assumption that there is nothing called "existing" unless some amount of matter and/or energy is involved. The informatory aspect refers to the assumption that matter/energy has a certain distribution in space and time which can be understood as a structure. An information content can be correlated to this structure.

The idea is that people's evaluation of the environment involves both the material-energetic and the informatory aspects of the relationships between inhabitants and the built environment. In a nutshell, it appears that human evaluation processes are generally easier to describe and predict in exposure situations dominated by the material-energetic aspect of the environmental relationships. In extreme cases of high-intensity exposure, the necessity for protective regulations is self-evident due to the obvious health hazards (e.g., physical damage to the hearing organs) for the involved individuals. It is thus not surprising that most efforts toward predicting the outcome of human evaluation processes have focused on the identification of a measurable material-energetic scale (such as sound pressure level) to which subjective judgments (such as the degree of annoyance) are expected to correlate. To further explore this point, let us consider a few ideas and case studies from the acoustical and thermal building design domains.

Noise levels and subjective evaluation of the acoustical environment. The impact of internal information processing on the degree of expressed dissatisfaction associated with various energetic levels of exposure has been demonstrated in many experimental psycho-acoustic experiments. In one experiment (Schönpflug 1981), participants were exposed to white noise (of different intensity) while performing certain tasks (time estimations). This study showed that the participants who received positive feedback indicating successful performance evaluated the same acoustical exposure more favorably than the participants who received negative feedback indicating failures in their performance. Since the feedback messages were manipulated (not reflecting the true performance), their effect on the subjective evaluation cannot be explained in terms of an acoustically induced impairment. The explanation lies rather in the nature of the information processing that was triggered by the combined effect of acoustical exposure and negative feedback regarding performance. This process generated apparently an internal "model environment" in which noise was identified as the source of annoyance and blamed for one's performance failures.

Traffic noise control strategies. A comparative study of the effectiveness of different traffic noise control strategies (Kastka 1981) indicates that the fine structure of the evaluation processes of exposure situations cannot be reflected in a simple specifier. Moreover, this study shows clearly the critical importance of the informatory aspect of environmental relationships for the evaluation of noise exposure conditions. The study included the analysis of the annoyance of inhabitants before and after installation of noise barriers, and traffic quieting measures in two locations in Germany.

According to the result of this study, the annoyance reduction effect of the barriers is not as large as their "objective" noise level reduction effect (in average about 8 dB). While the stimulus-centered annoyance component decreases proportionally with the sound level reduction, the subject-centered component decreases to a much lesser degree as might have been expected due to the magnitude of the sound level reduction. In contrast to this, the traffic quietening measures show a considerable positive change in the evaluation in the acoustical exposure situation, although, in this case, the sound level reduction was insignificant (in average about one dB). This discrepancy in the effectiveness of the above described noise control strategies can only be understood if the involved information processing phenomena are considered. The traffic quietening measures reduce the annoyance probably not through changes in energetically relevant component of the acoustical environment, but rather through the changes in the negative attribution (meaning) of the traffic for the inhabitants. Apparently, the quietening measures effec-

tively reduce the dominance of the environmental factor "traffic" in the inhabitants' internal "model environment".

Thermal comfort in theory and practice. Given the limited availability of energy resources prior to the industrial revolution, environmentally responsive design of building structures practically remained the only way to alleviate the impact of the climatic extremes on human habitation. From late nineteenth century, the efforts toward augmented control over "environment" have been increasingly directed toward the use of rather energy-intensive building service technologies. Assuming, for argument's sake, that these building service systems and technologies in fact maintain exactly and effectively a predefined set of environmental conditions throughout the entire interior spaces of buildings (a highly debatable assumption), one must still address the question if there is, in fact, a "predefined set of environmental conditions" that, if offered, would assure the comfort and satisfaction of the inhabitants (cp., Mahdavi and Kumar 1996).

A brief review of the evolution of thermal comfort research demonstrates a process of continuous refinement of increasingly comprehensive predictive models based on classical heat transfer, the body's physiological processes, and statistical analysis of human perception (Mahdavi and Kumar 1996). The important question that now arises is the applicability of these models and their derivative standards in real world situations. Much as the researchers would have liked to base their findings on "real-world" situations, they had to perform their experiments mostly in climate chambers where the factors influencing thermal comfort can be selectively measured and closely monitored. This controlled research design which may have permitted the relative importance and interactions of several independent variables to be disentangled involves the risk of reducing complex comfort evaluation processes to rather simplistic stimulus-response patterns (McIntyre 1982).

Thermal comfort field studies. In this context, it may be helpful to mention a number of recently conducted field studies (Busch 1992; de Dear et al. 1991; Schiller et al. 1988) that involved the comparison of the results obtained from field data with predicted values using comfort models (in situ measurement of the environmental and behavioral variables known from climate chamber experiments to influence thermal comfort). The results of these experiments have not always supported those of the climate chamber method. Thus, the thermal comfort researchers have been confronted with the problem of accounting for this discrepancy in a consistent and scientific way so that either changes can be incorporated in the standards or some alternative approach can be found toward enhancement of the thermal conditions for occupants in real world situations.

Considering the evidence collected in the field and given the fundamental complexity, variance, and dynamism of the relationship between people's ecological potency and the ecological valency of their surroundings, it is safe to postulate a certain "systemic" limit in predictability of thermal comfort and thus in provision of maximum thermal satisfaction in uniformly conditioned indoor environments. Furthermore, even if it would be possible to confidently predict that a certain percentage of inhabitants will be thermally comfortable given a set of predefined thermal conditions, we would still have to seriously question the admissibility of the simple exclusion of a large number of people as thermal "outcasts."

Personal environmental control. In response to the problem of uniformly conditioned buildings, an increasing number of researchers, engineers, and designers are considering new approaches and alternative ways of dealing with the problem of defining and providing adequate thermal conditions in the built environment. The proponents of "user-based" thermal conditioning systems question the appropriateness of uniform environmental conditioning in all but single-occupancy spaces. They suggest that one abandon the strategy of minimizing the number of dissatisfied in uniformly conditioned spaces and allow instead for a flexible multizone context that can be differentially and dynamically controlled by individual occupants. This provides, from the human ecological point of view, a potentially wider range of possibilities to maintain adequate relationships between inhabitants' ecological potency and their surroundings' ecological valency. By giving freedom to occupants to adopt their immediate surroundings, one hopes to specifically counteract problems arising out of inter-individual differences. At the same time, this process of partly transferring the controls to occupants may, psychologically, elevate the level of satisfaction with the thermal conditions while relaxing the requirements concerning the "comfort variables" of the ambient environment.

Thermal pleasantness. Most thermal comfort prediction models rely on a psychophysical scale, which includes thermal neutrality as the desirable thermal condition, and as the target of the thermal design. Thermal neutrality denotes a thermal condition in which people do not wish the environment to be warmer or cooler. However, as Kuno mentions, "there are situations when we can feel pleasantly cool or warm" (Kuno 1995). Following this line of thinking, Kuno developed a two-dimensional model of thermal sensation to clarify the distinction between comfort and pleasantness. According to this model, the experience of thermal pleasantness results from the body's physiological inertia in dealing with quick (or discontinuous) changes in ambient conditions

that are initially experienced as uncomfortable. As a consequence, one must experience the "uncomfortable zone" before entering into the "pleasant zone." According to Kuno, this two-dimensional nature of thermal sensation semantics is clearly expressed in Japanese language, where "Dan" and "Ryou" involve connotative references to the experiential hues of thermal pleasantness.

Discussion

While I believe that the proposed theory provides in principle a suitable theoretical basis for the consideration and evaluation of the habitability and sustainability of the built environment, I have no doubt that much work remains to be done for the "operationalization" of the corresponding indices. We have made some considerable advances in envisioning an entropy-based sustainability indicator. And it would not be all too difficult to formulate a negentropic habitability index based on statistical "dose/response"-type relationships. But the understanding and prediction of inhabitants' evaluation of exposure situations in circumstances where the individual information processing plays a decisive role has been and remains an extremely difficult task. Information theory provides a basis for a "content-neutral" quantification of information *via* utilization of the negentropy concept. From thermodynamics, we know that the knowledge of the microscopic state of a system is inversely proportional to its entropy, i.e., information may be interpreted as negative entropy or negentropy. However, in order to measure the semantic component of information, we would have to achieve the near impossible goal of fully understanding the deep structure of human information processing, including the inter-individual differences in contextual, experiential, and associative conditions of perception and evaluation processes.

This does not mean, however, that the cumulative experiences in the architectural and urban design community as well as scientific research in this area (particularly in human ecology, cognitive psychology, and experimental sociology) have not provided us with some valuable clues as to the scope of the necessary environmental conditions (including the required levels of flexibility and adaptability) to facilitate higher levels of habitability. An evaluative approach based on such clues and on the conceptual framework of human ecology may not eliminate the shortcomings and inconsistencies of current practices in architectural and urban design. However, it is likely to add conceptual transparency and coherence to procedures for deriving aggregate judgments on the habitability and sustainability of the built environment.

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