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Subjectivity Dispelled: Physical Views of Information and Informing

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Abstract

This study generalizes the notion of information beyond its traditional scope and, at the same time, reduces the concept of information to patterns of discrete physical states and informing to patterns of physical states being developed and spread among entities. In its ultimate elementary states, reality appears to be discrete, so would be its representation and its elementary changes. If so, states of digital computers could exactly represent states of segments of reality and their changes. This view removes ambiguities surrounding information and informing; it generalizes and renders them countable, with no recourse to probabilities; and it lays the foundation for their rigorous description, analysis, and synthesis, whether for operations or extension of knowledge. It discusses macro and micro views of information as physical states: (a) macro from the perspective of decision making as representing a change that causes a state transition of the situation, and (b) micro as transversal associations of elementary signals in communication channels. Subsequently, it dispels subjectivity of information and informing.

Keywords: Information, discrete physical states, informing, developing and spreading patterns of physical states, macro- and micro-viewed information and informing, primary and secondary informing, primacy of information over data, operational versus linguistic semantics, informing resonance, boundaries of informing, objectivity of information

Motto: *In a well-defined context of operations and extension of knowledge, factors in form play roles as objective as factors in substance.*

Introduction

Many streams of research deal with information and informing. It is an interdisciplinary mix: cybernetics (the study of communication and control processes), operations research (analysis of processes for decision making), operations management, systems theory, systems analysis, praxiology (the study of human action with regard to effectiveness, ethics, and efficiency), psychology, sociology, political science, and also cognitive informatics (the study of natural intelligence and internal information-processing mechanisms of the brain, as well as the processes involved in perception and cognition). The 20th century has become known as the century of quantum mechanics and the theory of relativity in physics, nuclear energy, electronics, aviation, computing, and space exploration. The 21st century emerges, at least, as the century of information, microbiology, bioengineering, nano technology, and quantum and bio-based computing.

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Information and informing are of a transdisciplinary nature. They are a heterogeneous collection of disparate views of the subject that are made from a variety of perspectives. Information may be considered to be a simple pair of values, a rule, a lengthy message, a concept, an idea, a design, etc. It is difficult to articulate valid statements without contradicting or excluding at least some of them. It is like attempting to make valid statements about all kinds of brick houses and the bricks they are made of. Callaos and Callaos (2002) tried to reconcile the disparate views by resorting to the concept of distributive truth. It tempts empiricists but does not suffice for articulation of a comprehensive theory for informing science. A unifying approach needs identification of something common, a common denominator. A physical operational approach seems to be promising. It views information as a factor in operations that triggers a state transition of a previously defined situation or as an elementary transversal association of physical states—signals in communication channels that leave no room for subjectivity if the latter is the opposite of objectively provable existence.

Information is recognized, at least by some, as the third essence that supplements matter and energy in viewing the universe; it describes its structural aspects represented by patterns. It is an intrinsic, thus always present and objectively observable, component of all physical systems that are ascribed to their organization or lack thereof (Stonier, 1997, p. 12). In the physical view presented in this paper, ***information*** is anything *in form* that can be communicated (in contrast to factors *in substance*). Information, as factors in substance, affects operations and their results. A pattern, whether in form or in substance, is also represented by physical states of matter and energy. As such, information is as objective as other factors in substance.

Patterns in form may represent actual, virtual, or hypothetical reality. Thus, not the pattern but what it represents may be fuzzy and murky. Informing may induce physical changes in entities informed. These changes are subject to the same physical laws as the rest of the physical world. Fragments of a discrete world can by mapped one to one into symbolic patterns (e.g., *states of information systems,* as defined by Wand and Wang, 1996)—patterns in form. In turn, patterns in form can also be impressed on fragments of the world by constructive operations that completely or partially replicate (e.g., *car key replication*) or transcribe (e.g., *copying, DNA transcription, memorization*) them. How and with what further consequences it occurs, contrary to other views (e.g., *studies of semantics*), depends rather marginally on the pattern per se while mainly depending on the entities informed and the situations they are in.

The physical view of information and informing clarifies issues that sometimes become muddied or indeterminable when informing is examined from other perspectives, such as those of a psychological, sociological, or political nature. Key questions that the physical view addresses unambiguously are as follows:

1. Is informing limited to cases involving human clients?
2. How should information and data be distinguished?
3. How does informing (between informing entities and entities informed) differ from what takes place within the entity informed—the client?
4. May the qualifier "subjective" be meaningfully applied to information?

To attain a comprehensive and cohesive view of information and informing, the physical aspects should be considered first, because they naturally constitute the load-bearing structure (a basic term in engineering) for other considerations, as it is hoped that the reader will later realize.

This paper begins by defining the role of information as a factor in form. The physical view is presented in macro and micro terms. The macro view provides sufficient details for most practical consideration of information and informing for routine operations. The micro view provides the ultimate detail of the same phenomena. By virtue of its definition, the physical views address the first of the four questions by positing that there is no need to limit informing to human clients.

The paper then turns to the remaining three questions, beginning with the physical perspective of what information is versus what data is. The boundaries of informing and the concept of resonance explains how informing physically impacts informing entities—clients are presented, again making the argument that they are not limited to human communications. Finally, the degree to which information can realistically be labeled objective or subjective is considered. The conclusion is that the physical view of information and informing offers a welcome reduction in ambiguity with respect to many issues of informing, which should encourage further research that is both rigorous and useful.

Background

The major developed or still emerging theories related to information and informing are:

1. the mathematical theory of communication, by Shannon and Weaver (1949) – focuses on the technical aspect of data transmission and defines the amount of information as a surprise effect but not information or informing per se.
2. the qualitative theory of information, by M. Mazur (1970) – provides the ultimate micro-detail insight into the phenomenon of information and informing within the context of system control (see Figure 1) and derives from Shannon and Weaver's formula for the amount of information without resorting to probabilities; hence, it is also applicable to static objects.
3. the theory of informing for operations, by Z. Gackowski (2009) – provides a framework and model of information and informing for routine operations, viewed through the lens of operational and tactical decision making, and articulates its first principles.
4. the theory of non-routine informing, by G. Gill (2010) – focuses on informing business about the rugged landscape of all kinds of exploratory efforts.
5. cognitive informatics, by T. Wang ("Cognitive informatics," n.d.) – focuses on studies of natural intelligence and information-processing mechanisms of the brain as well as the processes involved in perception and cognition.

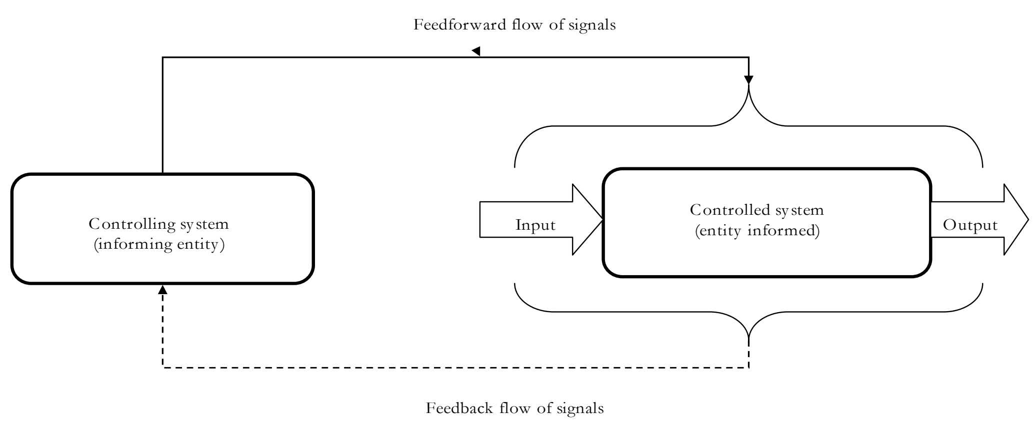


Figure 1: Control Loop

These theories may be considered the milestones in the development of a broad transdisciplinary theory. This paper deals with the second and third theories. They are explicitly grounded in the physicality of information and informing, excluding, however, the technology of signal processing. To introduce the reader to this approach, it is useful to consider the essential role information plays as a factor in form—a pattern in whatever situation; this role becomes another common denominator of information and informing in all disciplines (Gackowski, 2009, p. 13).

Information as Factor

Why do we care about information in the first place? There is a ***reality*** with entities, such as objects and events, both of which share certain properties and relationships among them. They can be described by states that are intrinsic to entities and their states relative to other entities. Elements of reality may facilitate or inhibit operations. A ***factor*** is anything that affects results of actions. To this effect, factors must meet certain requirements. In social environments, ***requirements*** pertain to their **physical aspects** and the **needs** and **expectations** of significant stakeholders. Factors may be **in substance** or **in form**.

- ***Factors in substance*** must be transported to where they are needed. They entail the first three known Ms (material, machinery, and manpower), products, services, energy, or means of warfare, with their respective ***properties*** (specific states of their dimensions).
- ***Factors in form*** can be observed, communicated, and/or transported. They are symbolic representations of reality or its contingencies (possibilities). They entail any kind of pattern of physical states (information about something previously unknown or uncertain [e.g., *location*, *time*], data about *existing objects* or *events* that occurred and their *properties*, and other elements of knowledge [e.g., *relationships* among the above*, rules of reasoning and proceeding*]).

Factors may be **available** or **not yet available**. Unavailable factors are not part of this view. **Available factors in substance** are considered **resources**; those in form are considered **data**. Not-yet-available factors must still be acquired or delivered. They are **routine** or **non-routine**.

- ***Routine factors*** are known by their type and role; if **in form**, they constitute the acquired **routine information** for routine decision making, which, again, should be considered first because they are the bread and butter for our sustenance now and for any exploratory efforts not discussed here.
- ***Non-routine factors*** are still unknown or unrecognized but of potential significance, such as new materials, tools, or devices. If ***in form*** (inventions, patents, methods, algorithms, programs, etc.), they constitute ***non-routine information*** of a strategic and/or exploratory nature, which requires a separate study.

In common parlance, any factor in form is frequently referred to as **information**.

Informing between human-controlled entities involves ***information processing*** that is realized by **designed processes** that transform factors in form from their input states to their output states. These states are limited to marks on processed factors in substance—carriers. The nature of marks is symbolic (***mark:*** "*Something that signals the existence of something else: indication, earmark, evidence, notice, sign, symptom, token, trace, warning, clue, foretoken, hint, signal, mark, suggestion*" (Excerpted from *American Heritage Talking Dictionary,* 1997)). Marks are factors in form that merely, by their presence or absence, represent patterns; they do not transform the carrying substance (e.g., *paper, magnetic tape, disk, or electrons with regard to their spin in quantum computing*).

General Physical View of Information and Informing

The physical view focuses generally on what physical information is and on the physical aspects of informing and its impact on the reality of interest; it excludes the technological issues of signal processing. If ***information*** denotes anything *in form*, then ***informing*** can be defined as nothing more than **developing** and **spreading patterns in form** that are represented by physical states. Mapping reality of interest into symbolic replicable patterns constitutes ***primary informing*** that enhances knowledge of the entity informed. ***Entities*** (informing or informed) may be inert matter, living organisms, robots, or humans. Among humans, it entails developing patterns of knowledge (***primary informing***) and spreading patterns to enhance one's control over the environment and other entities (***secondary informing***).

Patterns may be **factors in form** or in substance. The latter are not discussed here. Patterns in form can be observed, communicated, or transported as physical states only. Seeds and genomes (DNA, RNA) of living organisms are good examples of patterns in form that are found in nature. ***Patterns in form*** (later referred to as patterns) are one or more dimensional arrangements of objects or elements of sets (collections of objects of certain properties, e.g., *dots*) or combinations thereof (e.g., *letters, numerals, other special symbols*) such as numbers, words, names, identifiers, relationships among them, shapes, graphs, diagrams, schemas, matrices, formulas, rules of reasoning and proceeding, drawings, or pictures that may point to (represent) fragments of reality (e.g., *location, time, recipe, algorithm*) or to contingences (possibilities, e.g., *concepts, ideas, designs*).

Whether informing takes place for extension of knowledge (in particular, replicable) or for efficient action, only a fragment of the entire reality is of interest. Thus, ***reality of interest*** may consist of a **system of investigation** or **a system of operations** and their respective **environment**. ***Systems of operations*** and ***systems of investigations*** are considered ***work systems*** with **real elements** and **interactions** among them and are **oriented** toward accomplishing their respective **purposes as defined by their main effects—the *main dimensions for measuring results*** of operations**.** A ***system's environment*** consists of elements and relations of the universe that <u>do not belong</u> to the system under consideration and <u>are affected</u> by its functioning <u>and/or affect</u> its functioning to such a degree that it must be accounted for during system development and operation.

Informing distinguishes **informing entities** and **entities informed**. Entities communicate by passing patterns in form. ***Informing entities*** **develop** and **spread** patterns. ***Entities informed*** **adopt** or **internalize** patterns obtained by observation, monitoring, communication, and/or transportation. ***Development of patterns*** occurs **randomly** or **on purpose** by trial and error. ***Accidental development*** of patterns entails accidental movements of elements of reality that lead to alignment of some of their elements according to the then prevailing forces. In living nature, the processes of insemination, pollination, or impregnation are examples of informing by patterns. ***Purposive development*** of patterns entails controlled trials and errors that are oriented toward defined effects—***points of reference*** by observing, analyzing, and synthesizing factors in form, and, finally, by designing, implementing, and validating solutions.

Patterns may or may not be **adopted** or **internalized** by entities informed. Only entities that are **amenable** to alignment of their states according to a pattern may be induced into adapting it when they are within **communicable reach** of the informing entities that are spreading patterns. Entities informed are ***amenable*** to adopting patterns if these patterns can be at least partially replicated within them and the replicated patterns can form or attain **stable equilibrium**; for instance, in inorganic matter (e.g., *crystal*), in life matter if they offer a competitive advantage (e.g., *beneficial genes*), or applied in systems by design due to **improved effectiveness, ethics, and/or efficiency** (e.g., *advantageous methods, patents, know-how*). In living entities, it may be only contentment, fun, or feeling good. Thus, amenable entities informed may **resonate** with regard to some corresponding patterns in which they may be in contact.

Detected patterns may trigger a state transition of mental, formal, or physical models of the situation (objects, events, properties) of interest for the entities informed. Such changes are mainly of a structural nature, with mostly negligible expenses of energy and matter but always with a non-zero difference in the models' entropy. It may cause the decision makers, humans, living entities, or control units of automata of finite states to perform a sequence or a network of subsequent state transitions. These subsequent state transitions, however, may release enormous energy (e.g., *nuclear fission*). Entities informed that adopted a pattern may spread it further. It is by resonance among entities that matter organizes itself independently of human actions.

Operationally Macro-Viewed Information and Informing

The operational macro view of information focuses on its role as a factor and the impact of informing, not on what they are per se. Within the context of routine operations viewed through the lens of decision making (Gackowski, 2009), ***information*** can be functionally defined as a **factor in form**—a pattern in form that **changes** situations and their respective mental, formal, or physical models (including neural networks) within entities conducting operations. A pattern is

- ***operationally relevant*** if it <u>*matches*</u> any of the variables (pattern types) that represent the situation; otherwise, it is ***operationally irrelevant.***
- ***operationally meaningful*** if it matches (is relevant) and <u>*differs*</u> by its content (variable's value)—quantitative change; otherwise, it is ***operationally meaningless*** because it overlaps with some of the already available factors in form—***data.***
- ***operationally material*** if it is of operational meaning and <u>*changes*</u> the results—the main effects of operations serving as points of reference; otherwise, it is ***operationally immaterial*** (the model is indifferent—neutral with regard to the change).
- ***operationally materially significant*** if the materiality <u>*is not less*</u> than the threshold of significance; otherwise, it is ***operationally materially insignificant.***

This is an ***operational macro view of routine information***. If a detected pattern also causes qualitative changes (usually accompanying quantitative changes), it is ***non-routine,*** operationally macro-viewed ***information*** that is subject to strategic consideration that requires a redefinition of the present models (mental, physical, formal) of its use. Substantive qualitative changes are not discussed here. They are the subject of the non-routine informing that is studied by Gill (2010).

If a detected pattern causes change, it is associated with some <u>non-zero</u> **amount of information** and a **change of the entropy** of the communications system (informing entity, communication channel, entity informed). By definition, such patterns are always relevant and of operational meaning, but they <u>may be</u> only operationally materially significant. Operationally defined information that is viewed through the lens of decision-situation models, whether for action or for extension of knowledge, does not leave any room for subjectivity. In operations, information, data, and elements of replicable knowledge as factors in form are as objective as factors in substance, with no room for subjectivity. Discussions of information and informing without a defined frame and point of reference leads to endless, aimless, and fruitless speculations, even hallucinations.

A macro-viewed ***elementary information item*** is at least a **pair of values** that is always manifested in a specific **format** where the first value **identifies** the selected set—dimension (e.g., *Kelvin scale of absolute temperatures*, *a list of enumerated members*, etc.)—and the second value represents a specific element of the set (e.g., *37*, *member's name, its position relative to the beginning of the scale,* etc.). Those values may directly represent something they stand for, or they may only point to the representing values; they may be given explicitly or by association in a meta description (e.g., *data dictionary entry in a database*).

It seems that those values (content), their format, and their granularity (precision) are the only intrinsic (inherently, naturally belonging) properties of any elementary factor in form. All other dimensions that are broadly discussed in information-quality studies pertain to specific uses of factors. Nevertheless, all quality requirements with regard to their intrinsic or use-related dimensions are always task specific and are therefore contextual. For instance, changes, outcomes, operational meaning, or materiality of such defined information, surprisingly to many, rarely can be attributed to its content because they are mainly determined by the entity and/or the situation in which the information is used.

Why? The value (content) may play different roles. In most cases, it conveys only its common linguistic meaning (linguistic semantics). However, in the most important cases, it is entirely divorced from its linguistic meaning. For instance, "operation peace" may be the keyword that triggers a vicious pacification of a village. Thus, it may convey only a specifically assigned operational meaning (e.g., *keyword; password to grant access, go ahead, proceed, or cease operations*). The assigned operational meaning may or may not be known to outsiders, only to the communicating entities who established it by mutual agreement—conventions. Similarly, what happens within the entity informed depends only marginally on the content of the information (information value). The same word, the same gesture (nodding your head in some cultures means affirmation; in others, it means negation), or the same sound causes one entity informed to react differently from another one (one ignores it, the other one reacts with an outburst of anger), depending on how they were conditioned or programmed by their past experience, which is entity and situation specific.

In normal, rational, relatively stable environments, actions carry more weight than words, whether for extension of knowledge or improvement of effectiveness, ethics, and/or efficiency of operations; therefore, the operational meaning (operational semantics) deserves primary attention. In emotionally laden environments, both may play important roles, and the linguistic semantics get the upper hand, as demagogy usually does.

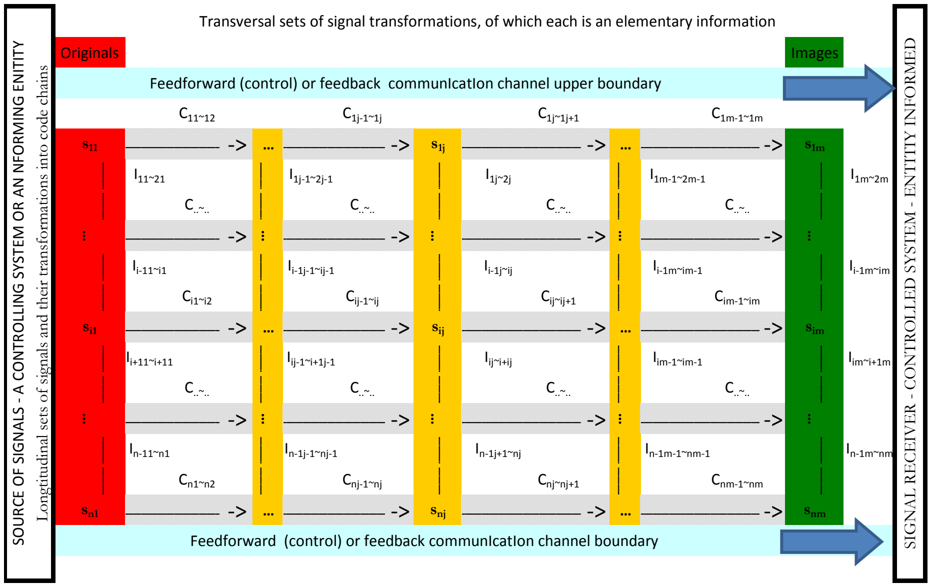
When it comes to quality of factors in form and their use, there is nothing of a general nature and summarily directly measurable. Such an assessment is possible only at a higher level and indirectly within the context of the supported operations. Practically, the best and, at present, unsurpassed definition of quality seems to be the one paraphrased from Wikipedia ("Quality," 2009): "Users' ***quality of information*** is an aggregate of their entire experience at all the touch points related to its use." A touch point may entail one or more aspects (dimensions) with related user requirements. Generally, only the universally necessary ones for effective informing to occur can be explicitly articulated with regard to their role (Gackowski, 2009, pp. 67-84).

An information item, once internalized (recognized and accepted as usable or even useful) by the entity informed, becomes its data item, which may or may not be a part of organization's data.

The Qualitative Theory of Information: A Micro View

The qualitative theory of information (Mazur, 1970) takes a micro perspective. It focuses on the elementary **information** (not the **amount of information**). Mazur assumes that one monitors the situation (reality of interest) by means of signals being fed back to the controlling system and control signals being fed forward in the opposite direction through communication channels (natural or by design), as previously illustrated in Figure 1. Within communication channels, illustrated in Figure 2, he recognizes signals $\mathbf{s_{ij}}$ grouped into **longitudinal** (along the channel) subsets s_i, where i = 1 … n, and **transversal** (across) subsets s_j, where j = 1 … m. A ***signal*** is a **physical state** that can be distinguished from other states and communicated. Output signals s_{i1} that leave controlling or informing systems are **originals**, while input signals s_{im} to the controlled or informed systems are their respective **images**.

An elementary association, transition, or transformation between transversal pairs of signals Mazur labeled ***information*** (e.g., $\mathbf{I}_{11\sim21}$), and between longitudinal pairs of signals, he labeled **code** (e.g., $C_{11\sim12}$). They form respective chains. Thus, a single transversal transformation from one signal to another constitutes elementary ***information***—a countable unit. To be consistent with Mazur, we will use "information" in the English unconventional plural form where necessary.



Summaraized and expanded model of a feedforward or a feedback communication channel based on Mazur's (1970) "Qualitative Theory of Information" as chains of signal transformations; transversal for informations and longititudinal for codes

Figure 2: Communication channel with information chains and code chains

Mazur analyzes the essential types of code and information chains and demonstrates a logical symmetry between them. Transformation of information chains of originals into respective chains of their images defines ***informing*** (e.g., *transformation of points of landscape into points on its map*). Originals s_{i1} are transformed into their respective images s_{im} by transversal chains of **inter-signals** s_{i2} through s_{im-1}.

The above leads to the distinction of three basic types of informing: (a) ***simulating****,* when chains of images contain more information than chains of originals, (b) ***dis-simulating****,* when chains of images contain fewer informations than chains of originals, and (c) ***confusing***—a combination of simulating and dis-simulating informing. ***Trans-informing*** is the term Mazur uses for faithful or perfect informing. It serves as a point of reference for distinguishing rigorously defined four (less than perfect) degrees of informing. He dedicates separate chapters to ***degenerated informing,*** such as **pseudo-informing** and **disinforming,** with different degrees for each of them. They are formally defined and elucidated by practical examples.

Mazur also distinguishes different degrees of simplified or reduced informing, labeled ***parain-forming***, which are of great practical importance. Parainforming occurs with incomplete (to different degrees) code chains that are complemented by parainformation that is already retained by entities informed from previous control processes. There are various degrees of parainforming. At the lowest degree, it is a single binary variable (e.g., *on* or *off*) that is complemented by the parainformation already stored within the entity informed (e.g., *computer program*), while the highest degree constitutes a nearly complete set of code chains (e.g., *all program instructions*) that are complemented by a single parainformation (e.g., its *absolute address* in computer memory where it is stored).

The opposite of parainforming is ***metainforming*** (informing about information, e.g., database definition of an information item in its dictionary), which may complement each information. It has practical applications even in legal distinctions.

The last chapter crowns Mazur's (1970) treatise, *Qualitative Theory of Information* (Ch. 13), by demonstrating the quantitative aspects of micro-viewed information (the transversal association of signals in communication channels), which renders information discrete and countable. The **amount of information,** as defined by Shannon and Weaver (1949), is replaced by the **number** of (elementary) **informations** (transversal associations). Mazur distinguishes between information that is **useful** (to inform), **redundant**, or **parasitic**. Within the useful informations, he also distinguishes between ***describing*** and ***identifying*** informations, where the first one is the **minimal number of informations** needed to represent a communicated message, while the second one **relates the message to a selected point of reference**, for instance, the beginning of a scale (e.g., *absolute zero on the Kelvin scale of temperature*).

The mathematical formula for the **number of identifying informations** is identical with that of the **amount of information** defined by Shannon but without resorting to probabilities. In science, it usually means that such a theory provides the ultimate insight and precision in describing and analyzing a physical phenomenon, here the phenomenon of information and informing. Mazur presents a complete classification of informing processes in tabular form. His formal and physical approach to micro-defined information and informing enables one to determine the number of describing informations as well as for abstract entities such as geometrical figures (e.g., *circle, map*, or any other *pattern*), where referring to probabilities makes no sense, in contrast to communicated patterns.

Mazur's qualitative theory of information defines it up to its micro elements, which, as groups, seamlessly fit the macro-viewed information items as factors in form in operations that represent a change of reality that subsequently changes the decision-situation model. The same applies to macro-defined informing as spreading patterns among communicating entities. Mazur does not use the term, data; however, what he labels **parainformation** represents a factor in form that is already available to entities informed, hence a **datum—the given**. The prefix "para-" indicates that a parainformation is still a factor in form, but its image has no capacity to inform; as internalized, it is already part of the entity informed.

Similarly, Mazur's theory does not address quality aspects of information use, such as operational recognizeability, relevance, meaning, materiality, availability, and credibility, with the exception of completeness; however, they can be easily defined and applied within his theory.

What Do the Physical Views Deliver?

The previously presented physical views of information and informing enable clarification of a number of controversial issues in the professional literature and MIS textbooks. These include

- data versus information
- natural boundaries of informing and its transdisciplinary nature
- physical conditions for effective informing resonance
- objectivity versus subjectivity of information and informing

They are the subject of the remaining parts of this paper.

Data versus Information

The physical views provide a simple dichotomy for distinguishing between data and information. Within informing situations, one may distinguish factors in form that are

- already given, known, and available to the one who builds an **initial model.** They are rightly denoted ***data*** if they represent the reality of interest (existing objects, events that occurred, and their properties). If the observed, monitored, communicated, and/or transported patterns do not differ from the available data, they convey a zero amount of information, as defined by Shannon and Weaver (1949); they do not differ from the **parainformations** already available (to entities informed), as defined by Mazur (1970), and they do not change the entropy of the system.

- still unknown, doubtful, to be obtained or only confirmed. If the observed, monitored, communicated, and/or transported patterns differ from what is available (known to humans), they represent a change. If so, they always convey a non-zero amount of information, as defined by Shannon and Weaver (1949); they differ from the parainformations (those already available), as defined by Mazur (1970). They change the entropy of the system and are of operational meaning, as defined by Pierce (1958). Within both theories, and within a rigorously defined context of decision making, they constitute ***information*** as patterns in form that are observed, monitored, communicated, or transported between entities being in different states with regard to those patterns.

Entropy, here, is a statistical measure of the disorder or randomness in a closed system that consists of an informing entity and an entity informed. Macro- or micro-viewed information is used by the acting entity informed in decision making for well-defined activities together with the already available data, knowledge, concepts, and wisdom.

Information and informing engage relatively minuscule amounts of energy and matter, but definitely they are **physical phenomena** that are subject to physical laws; their essential function is to represent **structural relationships** by **patterns in form.** Information is primary, while data are always secondary, as derived from information that has been recognized as factors in form of interest and internalized as organizational or system-specific data. This is the essence of the principle of **primacy of informing and information over data**.

Before factors in form become data that represent facts (things in existence or events that occurred, including their properties), they must be observed or monitored (primary informing), recognized as operationally relevant, of meaning, and significantly material for effective action or extension of knowledge to be internalized by the entity informed, not necessarily a human. They may be spread by replication, communication, and/or transportation to other entities informed (secondary informing). This insight refutes the common superficial perception that information is derived from data. On the other hand, by researching or analyzing data (e.g., *data mining*), one may develop abstract data constructs, different views of the situation, new concepts or hypotheses, and different models of reality (e.g., *analysis of the same data from astronomical observations led Copernicus to the concept of the heliocentric planetary system, defying the previous commonly shared geocentric view*), or ideas that contribute to knowledge. This, however, is not routine data processing but research.

To deserve operational attention, changes should be **materially significant** concerning the purpose and circumstances that are not necessarily limited to human-controlled operations. Subsequently, actions change reality by impressing it according to the used pattern. The ultimate purpose that is intrinsic (naturally belonging) to informing is always, whether acknowledged or not, to maintain and/or extend control over reality, if nothing more, by a higher survival rate of living organisms or business companies.

For theoretical and practical reasons, it is time to set aside vaguely expressed opinions about this subject with no rational arguments supporting them. As long as one stays within a well-defined context (frame and point of reference) from the standpoint of the mathematical theory of communication, the qualitative theory of information, decision sciences, management sciences, and operations management, there is no room for fuzziness regarding the dichotomous nature of data and information and which comes first. They may be spread later to other entities (secondary informing). In rigorous science, ambiguity of terms may be tolerated as long as neither quantitative nor qualitative differences exist; they may serve as synonyms. Within the realm of scientific discourse, one must take exception with the popular deeply rooted misconceptions that data can yield operationally meaningful information or that there is no difference between them.

One may, however, raise a legitimate question about why practically all known MIS textbooks in their glossaries state, "*information …are data arranged in a meaningful manner that add value to the user*" (O'Brien, 2008, Glossary) or similar. Their authors ignore Nietzsche's (Encyclopædia Britannica*,* 2007) perspectivism and Einstein's (1961, p. 13) restricted relativity of observations by not distinguishing the

- **organizational perspective** from the **perspective of specific decision makers**,
- **organizational data** from specific **decision-makers' data**, and
- **primary informing** from **secondary informing.**

Thus, students are left with a false impression that information is mostly derived from data, while, actually, primary informing enhances our knowledge, and secondary informing spreads it or mainly enhances one's control over the environment, including one's society.

In the now prevalent environment of indirect informing, organizational data are not yet specific to decision-makers' data. In organizations, with a clear division of labor between those who, by direct observation, monitoring, communication, and/or transportation, acquire and internalize factors in form (deemed useful for common use as organizational data) and those who later use data for decision making and acting; the common data are not yet their data. To use them, users must first familiarize themselves with the organizational data (secondary informing) until they become internalized by a process of self-informing. Uninformed users perceive organizational data as information because someone's data are still information for them.

Thus, within the context of indirect informing, from the perspective of users of ***data***, the organizational data appear as bona fide information. It is a similar illusion as the initial experience of the inhabitants of the planet Earth. They perceived its movement as the movement of our familiar sun over their horizon. The principle of relativity of observations, if applied, offers a broader understanding of reality. Indeed, organizational data unknown to me, when communicated to me, are bona fide information (secondary informing) that changes my mental or formal model of viewing reality. The same applies to robots and systems that are controlled by artificial intelligence. Students deserve a broader perspective than that of individual users of ***organizational data*** that are mostly not *their* data. In direct informing, what I learned are my data, and what I do not know is information to be acquired by primary (observation) or secondary informing.

Physical Boundaries of Informing and its Transdisciplinary Nature

In a normal situation, what the triggered state transition will cause depends mainly on the reality of interest (the system of operations and its environment) of the entity informed. What the entity does, what the consequences will be, and how it handles the change only marginally depends on informing; it mainly depends on the system informed: how it is structured, controlled, or managed. These are separate but intersecting issues. Physical views of informing enable one to define the ***natural spatial*** and ***temporal boundaries of informing*** (Gackowski, 2009, p. 43) as

- the **entry** (for originals) **and exit** (for images) **points** of the informing process where it intersects with the reality of interest that is the subject of other disciplines; and
- the **moments** when the informing process generates originals and terminates it when the delivered images trigger a state transition in the entity informed, which, in turn, may trigger subsequent system-specific state transitions within the entity informed.

However, as is the case with all boundaries, including national boundaries, they are being crossed from either side for good and evil causes, openly or clandestinely. In reality, such a natural distinction becomes opaque or blurred by the drive, will, interest, or purpose of either side. The concept of informing resonance presented by **Gill** (2008) also seems to be fruitful for other reasons. Informing resonance may penetrate very deeply, for the better or worse, into the inner working of entities informed, whether they are technical or human systems. It may affect other systems by effective attention getters, attractive offers, marketing, propaganda, cyber attacks, radiation attacks, special psychological operations, planted agents, false representations, or even corruption.

The communication that triggers a state transition may be as simple as a binary signal (on, off), a value (number, word, code, password, etc.), text message, map, picture, biological pattern, etc.; it may trigger a single or a series of discrete state transitions—one at a time with serial transmission or a group of state transitions occurring with parallel transmission. Even a complete replacement of all the data or parainformations available to the entity informed may take place (e.g., *memory upload, brain wash*).

On the one hand, what the subsequent state transitions (consequences) will be or what the informed entity will do are mainly subject to physical laws, process control, animal training, education, propaganda, psychology, sociology, political science, etc. but less on the information per se (value, granularity, format). On the other hand, the omnipresence of informing for extension of knowledge or effective operations demonstrates the ***transdisciplinary nature of informing.***

Physical Conditions for Effective Informing Resonance

Informing entities may exchange patterns when they can take on different corresponding states within similar ranges so that, by resonance, they may equalize and/or synchronize some of their corresponding states (Gackowski, 2009, p. 41).

These ***universally necessary conditions*** that are ***sufficient for effective informing resonance*** between entities (e.g., *inert matter, living organisms, robots, or humans*) are as follows:

1. There must be an initial difference in states between informing entities and entities informed. In the mathematical theory of communication (Shannon & Weaver, 1949), the difference is measured by entropy. In the qualitative theory of information, the difference is defined by enumeration by of the non-matching elementary informations (transversal associations of signals in communication channels) that link those entities.
2. The non-matching states of the pattern must be attainable by the entity informed and preferred by its nature or its design. The concept of informing resonance was proposed by Gill (2008) but applied only to human mental models. It is a universal phenomenon, whether we deal with mechanical, electromagnetic, molecular, or mental entities and their models. When entities resonate, they communicate.
3. If equalization and/or synchronization of states have occurred, a communication must have taken place, a state transition within the entity informed (its physical, formal, or mental model) must have been triggered, and the entropy of the communication system must have been changed. Thus, the received communication has been recognized and was not available or known before; otherwise, it overlaps with an equivalent pattern that is already present.
4. However, to become operationally effective, the communicated pattern must be adopted or internalized. In natural processes, it means that a stable, static, or dynamic equilibrium has been established within the entity informed according to the communicated pattern under the forces then in effect. Living, evolving entities adopt, internalize, and pass on patterns that improve their success in expansion and survival. For human-controlled op-

erations, a situation-specific (actually or potentially) useful pattern, such as actionable data and/or elements of knowledge, is accepted as qualified to update databases and knowledge bases for its use; otherwise, the communicated pattern is irrelevant. Nevertheless, it might have been relevant but was only handled otherwise (Gill, 2008). Thus, for informing to be effective for operations, the communicated pattern must resonate with the receiving, decision-making, and action-executing mechanisms of the entities informed. Their human equivalents are those who are in charge of receiving the communication, making a decision, and executing it as it occurs in complex organizations. Informing is ineffective if a communication fails to resonate at any of the intermediary stages of internalizing information for subsequent use.

Objectivity versus Subjectivity of Information

Inexplicable differences in viewing information as associations, thoughts, ideas, concepts, and reactions of different individuals lead to a common perception that information is subjective, even existing only in the minds of humans. Information viewed as patterns of physical states exists independently of the human mind. It may be generated by humans, living organisms, or even inert matter (*crystals*). Once the originals leave the informing entity (see Figure 2), they exist independently of the originator during their own lifecycle until, over time, they fade away beyond recognizeability (e.g., *radio signals, inscription on a grave stone, seeds*), whether resonating or not with any entity informed. Information needs not reflect reality; it may represent only a contingency (possibility). Whether a pattern maps reality or what it was supposed to represent, it is a matter of quality of mapping, not subjectivity or objectivity; it may even disinform on purpose. Quality of factors (whether in form or in substance) is a separate issue that is unrelated to subjectivity of phenomena; it is a matter of quality management and control. The content of an information item (information value) viewed macro or the structure of the information chain viewed micro is always entity and situation specific; it may be of its own unique imprint (e.g., *signature, fingerprints, retina*), which is not subjective. It exists objectively.

The physical views of information and informing for operations provide incisive insights that everything hitherto considered subjective is the result of insufficiently transparent, unrealized, but still objectively existing differences in the representation (images—patterns) of reality or contingencies presented. With full transparency for objective observers, as it is with robots and computer-controlled devices, such differences cannot be identified. Recent progress in research of DNA, RNA, and the genome project reveal micro specificity of living organisms and elucidates many previously inexplicable differences in development and behavior. The least transparent of all is still the human mind. Further advances of technology certainly will gradually enable mapping of the human brain as a system of states of its neuron axels. Gradually, we may also reach natural barriers of cognition similar to that articulated in the Heisenberg uncertainty or indeterminacy principle, which considers how measuring certain properties of a system may unpredictably change other properties of that system.

The above insights enable one to articulate a hypothesis that ***subjective*** or ***subjectivity*** of information and informing actually are products of **unrealized specificity** of acting entities and the situation they are in. If ambiguities arise, they are the product of the inability to define well the reference point and the situation, but then it pertains to the assessment of any factor, even in substance, that is not specific to information and informing. Where technology allows reliable insight, as in the case of robots, computer-controlled devices, and lower levels of organisms, there is absolutely no room for subjectivity, as it was proved with regard to the existence of "ether" in physics. Physical views of information and informing for operations or extension of replicable knowledge dispel subjectivity as the once mythical "ether." This is a radical departure from *subjectivity* to *physical objectivity* of information and informing that defies most current views. We touch here the fundamental dichotomy in philosophy. Within a well-defined context of operations and extension of verifiable and replicable knowledge, factors in form (e.g., *data, information, elements of knowledge*) play roles as objective as factors in substance (e.g., *material, energy, tools, weapons, etc*). Similarly, information processing is as objective as processing of material and energy.

The use of the qualifier *subjective* is the product of making statements without a well-defined context. The point here is that most of the so-called "information" in current circulation is junk information, with content or values that represent or point to ill-defined objects, events, or properties. It is important to recognize this weakness. One may, however, argue that it is far beyond the scope of informing science to try to clarify subject-matter ambiguities that abound within informing entities and entities informed. For the sake of the effectiveness of informing, it must be considered a shared responsibility of all participants and components of informing. When most authors of MIS textbooks ignore or complain that the concept of utility of information in business is "*more elegant than practical*" (Alter, 2002), it is not because of a deficiency of the concept; it is because of ill-defined business objectives, measures, and the situation.

Conclusions

The presented findings demonstrate that the physical views of information and informing elucidate and demystify many murky issues, confusions, misunderstandings, and misconceptions surrounding them. In a simplified summary, elementary information can be:

1. reduced to transformations or **transitions** from one signal into another in their **transversal associations** in **communication channels** that are used for feedforward (control) or feedback, where ***signals*** are distinguishable physical states of any kind; even in brains, they are states of neuron axels.

2. subject to many kinds of **informing,** such as primary and secondary, simulating, dissimulating, confusing, and trans-informing with different degrees of perfection (**valid information)** and degenerated informing, such as **pseudo-informing** and **disinforming**, which transform **originals** (from the **informing entities**) into their **images** at their final destinations (**entities informed**) via intermediary signals (**inter-signals**).

3. **already available** as **parainformations** defined by Mazur (1970, p.153), or conventional **data viewed from** the perspective of entities informed and the **not-yet-available** to be acquired, whether by observation, monitoring (**primary informing**), communication, and/or transportation (**secondary informing**) macro viewed **information.**

4. enhanced or modified by **metainforming.**

5. **redundant**, **parasitic**, and **useful** (the minimum necessary), which is divided further into **describing** and **identifying** information that is countable, where the formula for the **number of the identifying informations** is identical with the formula for the **amount of information,** as defined by Shannon & Weaver (1949), without resorting to probabilities.

6. **stripped** of **subjectivity** when viewed within a well-defined operational context. One may articulate the following hypothesis: the qualifier "subjective" actually means the unrealized entity and situational specificity of information, informing, and their impact on results. Factors in form are as objective as factors in substance.

Decision makers may not be familiar with the data stored by their organizations. To use such data, they must learn about them and become familiar with them through secondary (self) informing. Indirect informing (through intermediaries) is now common. From such an individual perspective, organizational data are perceived as bona fide information that changes specific decision makers' mental or formal models of reality in the process of secondary informing. Authors of MIS textbooks do not make such distinctions and leave MIS students with the impression that information, not sometimes but always, is derived from data, while, originally, all data or parainformations must be acquired first by primary or secondary informing about reality.

The physically grounded views bring us closer to a general predictive theory of information and informing with lasting irrefutable distinctions and results that can be validated by computerized simulations of real-life scenarios. It eliminates many mystifications that abound in the literature. It renders redundant elaborate considerations such as those

- by Boland (1987) – about "*inward forming*" of a person, while physically grounded macro-viewed information (Gackowski, 2009) or micro-viewed informing that delivers information patterns that differ from the available corresponding parainformations (Mazur, 1970) and triggers a state transition in entities informed of any kind: inert matter, living organism, robot, or person. The consequences of such transitions are always entity and/or situation specific, which, when not fully realized, are interpreted as subjective. Boland unnecessarily limits the information-triggered state transitions to humans only.
- by Dervin (1983, p. 7) – *"all information is subjective—the real, while the objective or external is only the representation of the real" or "information is not a thing but a construction"* (?), while physically there is only one information, whether macro or micro viewed, that may represent a construct as well. On one hand, if the real is subjective, it cannot be considered real, for one cannot objectively prove its existence if it is not objective. On the other hand, a representation can be considered objective only when it maps faithfully provable reality; if it does, it cannot be subjective, as posited by Dervin. If there is any discrepancy between the reality and its representation, it is a matter of quality of mapping, which is not specific to information; it equally applies to factors in substance.
- by Neill (1992, p. 34) – *"knowledge representation is not knowledge but representation of knowledge,"* while knowledge, if only verifiable and replicable, to be recognized as knowledge (properties, relationships, rules of reasoning and proceeding), must be manifested in form or be embodied in substance (e.g., *a product*). Both are physical states, even those in human minds (states of neuron axels); otherwise, they are not provable.
- by Stonier (1997, p. 12) – *"information is an intrinsic component of all physical systems and requires a reevaluation of the law of physics."* Lacking arguments, Callaos and Callaos (2002) labeled Stonier a "radical objectivist." Anthropocentric scholars, similar to former geocentrists, believe that only humans, not other entities, may generate and use information; their claim about anything that cannot be manifested to an external observer is questionable.
- by Floridi's (1999, p. 106) erotetic definition that *"information is provided when data answer an explicit or implicit question made by a data receptor,"* while physically viewed information and informing, if effective, always trigger physical state transitions in entities informed independently of questions asked.

Callaos and Callaos (2002) boldly embarked on integration of those disparate concepts of information into a comprehensive *"systemic notion of information"* without excluding any of them based on the *"distributive notion of truth"* (p. 10) and stated,

- *"The conclusion is evident: information is generated inside the mind of a person, a subject. It is not an objective entity independent of any person. It is dependent on the person where it is generated by the data stimulus, as well as on his/her individual experience"* (p. 3). While whatever the mind generates depends on the person, it is person- and situation specific, and, if articulated and communicated, it becomes objective reality with all its consequences, even if the person did it poorly. Do not blame the messenger (information) or communication (the process) for the content of the message, whether generated by humans or other informing entities, which is always entity and situation specific. Information simply *is* as matter and energy *are*, as it is recognized at least by some. Patterns may be developed not only by persons but also by computers, organic matter, and even inert matter (crystals).

- "[D]atum *as the objective side of the coin and information is its subjective side"* (p. 3), while, physically, a pattern representing a factor in form for operations is either given and known or not yet available to be acquired. Both are as objective as both sides of any coin.

- "*A signal or datum is mathematically the independent variable in Shannon's equation and information is the dependent variable*" (p. 6). Shannon never defined information (the thing) but developed only a measure of its amount, which again is always situation specific, even for the same pattern.

- "[*A*] *datum might be informative or not*" (p. 7), when something is given (as what datum means) and known to a decision maker, such a datum can never bring about a change on the model of the situation. It may play an important role, be of high impact, but as already known, it cannot be informative at the same time for the same entity informed or client when one observes its role in a defined operational context.

Callaos and Callaos (2002) failed to notice that statements made about physical phenomena without a defined frame and point of reference and a yardstick for measurements as described by Einstein (1961, pp. 5-8) will appear incoherent and contradictory. The mentioned before "distributive notion of truth" does not explain the differences, does not advance replicable science, but delays, postpones, or outright avoids any explanation. The postulate of perspectivism and relativity of observations applies to the entire universe including operations, which always are entity and situation-specific, while with humans are also of teleological nature.

Most scholars limit the role of information and informing to entities with mental processes of cognition, while information that characterizes the structural aspects of the universe does not require for its existence (so do matter and energy) to be observed, recognized, and subject to mental processes. At the same time, data and information are objects of all mental processes of entities informed. Those, in turn, in operations use matter and energy to change reality. Utility value or added value is usually considered a human concept that is attributed to objective processes. To the contrary, survival rate is not a human concept but a harsh reality that is related to processes occurring independently of human perception while economy is a physical law of nature. Water and electric always follow the path of least resistance; innate matter and energy tend toward their even distribution (states of higher entropy), which is nature's reality and a universal law.

Thus, not the **physical** (commonly considered *narrow*), but the **anthropocentric** (commonly considered *broad*) perspective, blurs a clear perception of information and informing, including their consequences as objectively perceivable phenomena as far as the available technology allows to recognize them. The real dichotomy lies between the explored and realized versus the unexplored and unrealized, not between the objective and subjective, as commonly presented. Here we touched the fundamental concepts in philosophy and its inherently anthropocentric bias. The key to a full comprehension and appreciation of the physical views is to focus one's attention, not on what information and informing is or might be per se and in general, but on its role as an **objective** factor in form in operations and extension of replicable knowledge. This lays the groundwork for more rigorous research.

This paper grew from previous studies about informing for operations, particularly routine operations, and is presented to elicit challenge, critique, discussion, and suggestions.

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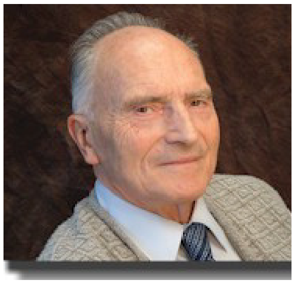
Biography



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