



# Cybernetics, operations research and information theory at the Ulm School of Design and its influence on Latin America

David Oswald<sup>1</sup>

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## Abstract

The Chilean Cybersyn project, an attempt to manage a nation's economy by cybernetic methods, has evoked more and more interest in recent years. The project's design lead and several team members were alumni of the Ulm School of Design—an institution that has been labelled “Bauhaus successor” and today is famous for a no-arts and method-led design approach with strong societal aspirations. The school also influenced the emerging design discipline in Latin America during the 1960s and 70s. This article reviews topics in the Ulm curriculum that influenced “Ulmian” thinking, but often remained unnoticed in design centred publications. Cybernetics, Operations Research and Information Theory and their relation to design are discussed and the related scholars are portrayed critically.

**Keywords** Cybernetics · Latin America · HfG Ulm · Ulm School of Design · Max Bense · Horst Rittel · Gui Bonsiepe · Cybersyn

## 1 Introduction

Alumni of the HfG Ulm had a considerable influence on Design in Latin America in the 1960s and 70s. Quite exceptionally, and characteristic for Ulm, these design alumni were not only trained in traditional design skills. They had been exposed to a wide range of disciplines, embracing social sciences, technology, and sciences, such as Information Theory, Operations Research—and Cybernetics.

Max Bense was one of the key figures in the early Ulm years. He coined the school's little known Information Department—a small department that heavily influenced the school's intellectual climate. There, Bense introduced Information Theory and so-called Information Aesthetics to the curriculum in the 1950s. He also introduced the students to Cybernetics. In 1955, Norbert Wiener took up Bense's invitation to be a guest lecturer in Ulm. In the late 1950s, Horst Rittel succeeded Bense and gave even more weight to mathematical methods, Cybernetics and the related Operations Research. Rittel's time in Ulm can be considered a prerequisite for his work on problem solving and the development

of the concept of “wicked problems” in the 1970s (this is to be discussed in more detail in section three).

The influence of Ulm on Latin America's emerging design practice and design education was due on the one hand, to 31 Latin Americans who had studied in Ulm some of whom returned to their home countries, and on the other, to German alumni migrating to Latin America to work and teach there, such as Gui Bonsiepe. (Fernández 2006; Souza Leite 2012) In the Chilean Project “Cybersyn”, the rare combination of design informed by Information Science and Cybernetics met a demand: in retrospect, Gui Bonsiepe, who had studied with Max Bense, Horst Rittel, and also Tomás Maldonado in Ulm's Information Department, seemed almost predestined to lead Cybersyn's design team.

In this article the main focus will be on Cybernetics and related topics in the curricula of the Ulm School, to shed light on the aspects of the educational background of Ulm-influenced protagonists in Chile and Latin America during the 1960s and 70s often overseen or disregarded. Detailed documentation of Ulm's influence on Latin America's design community is to be found in Fernández (2006). Extensive publications on the Cybersyn project can be found in Beer (1981), Medina (2011), Bonsiepe (2012), and Espejo (2014).

✉ David Oswald  
david.oswald@hfg-gmuend.de

<sup>1</sup> Hochschule Für Gestaltung Schwäbisch Gmünd,  
Schwäbisch Gmünd, Germany

## 1.1 HfG Ulm

In 1953, the Ulm School of Design (Hochschule für Gestaltung, HfG) was founded by Inge Scholl, Otl Aicher and Bauhaus alumnus Max Bill. Scholl and Aicher had founded an adult education centre in Ulm shortly after World War II. In this *Volkshochschule* (literally translated "people's high school") they sought to contribute to the re-democratization of German citizens and a new political and cultural beginning in what was very much a post-Nazi period. In the late 1940s Scholl and Aicher also developed plans for a full-time school to educate self-confident and responsible citizens. The designated core subjects were "political method" and progressive and informative journalism. However, design-related subjects such as product design and urban planning also formed part of their holistic approach. When Max Bill joined the project, the focus rapidly shifted from a political school with some design aspects integrated, to a design school that integrated political and social aspects. In other words: an updated successor to the Bauhaus. However, they decided not to name the school "Bauhaus Ulm"—although Gropius (1951) had given his permission to do so—and chose only to adopt the caption of the late Dessau Bauhaus, which the Nazis had shut down: "Hochschule für Gestaltung". This narrative of the school's foundation explains why Ulm differed so much from other design schools in Germany at that time and why it featured a programme called "Information" that initially covered topics, such as journalism and verbal communication, and shortly after included Information Theory, and Cybernetics—in a design school (Fig. 1).

The Ulm adult education centre had already been a meeting point for intellectuals and scholars of a wide variety of disciplines. The list of professors, guest lectures and speakers at the HfG boasted top scientists and contemporary intellectuals. Shortly after the war, the HfG was one of the rare safe-zones for anti-fascists and those who had suffered discrimination and persecution at the hands of the Third Reich Nazis. This point has to be made, because the fascist mindset did not simply vanish with the death of Hitler. It remained commonplace to regret "what happened to the Jews", yet regard Otl Aicher a traitor for deserting the Nazi Wehrmacht. One could rest assured Nazi perpetrators would not be present at the Ulm school. Students and lecturers were often from an international background, some actually Jewish and even people of colour dared to come to Ulm—in spite of Germany's recent complete moral bankruptcy.

Ulm was a place of controversy. It was a period in which design began its struggle to be accepted as a discipline in its own right, alongside science, technology, and art. At this stage design was required to define itself internally—a

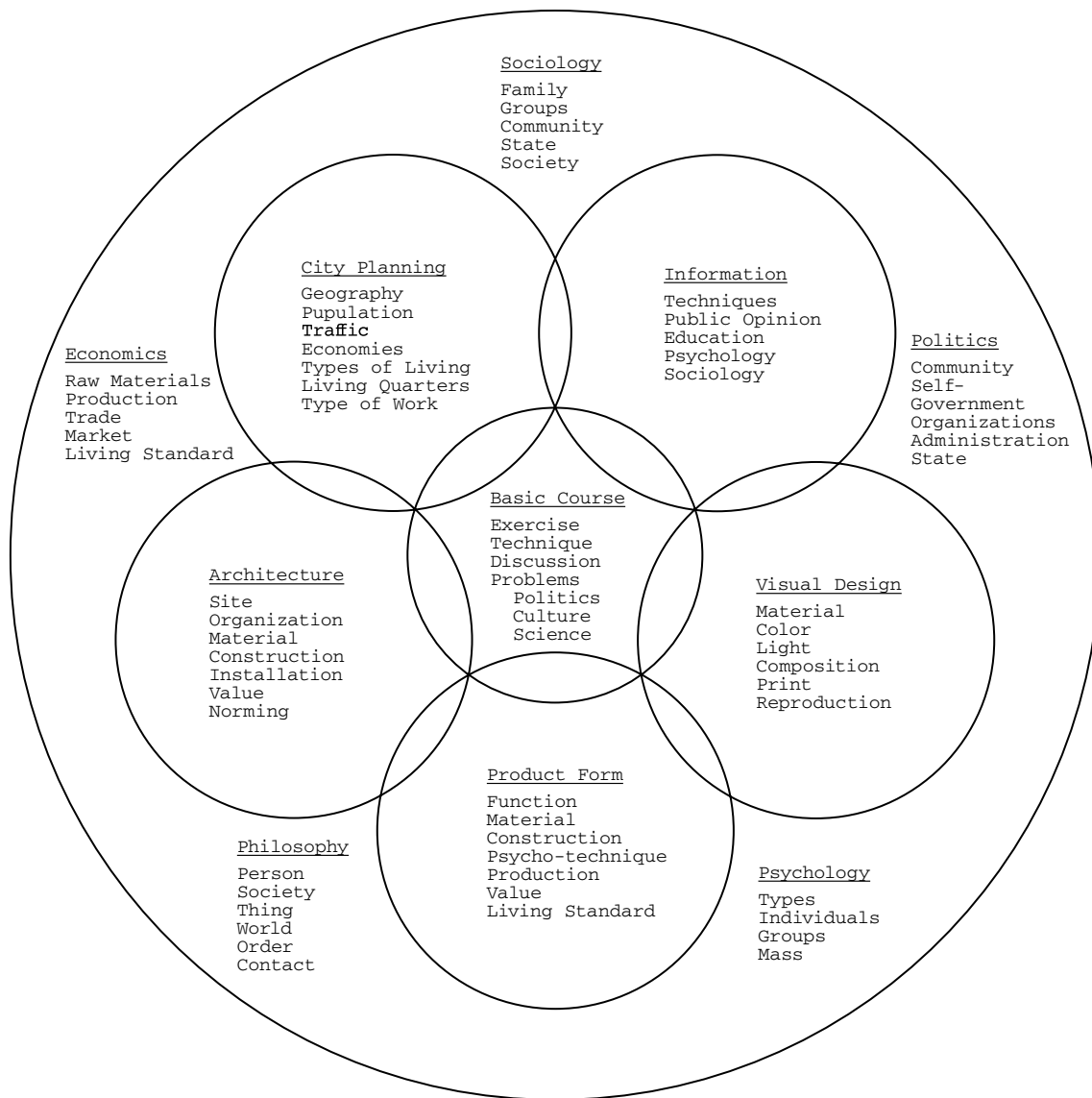
process not as virulent today, but still not over. While the question of design's relation to art was agreed on quite quickly in Ulm ("design is not art" or even "design is the opposite of art"), the relations between science and design were discussed at greater length and intensity. In brief: after a first phase when scientific approaches were introduced to replace "artistic intuition", there was a scientific overshoot phase with a fraction of the staff dreaming of objective calculability of all design solutions (Aicher 1975). Finally, a concept of design prevailed in which design decisions are informed by science, the design process is method-led, and solutions are rationally justified, comprehensible, but also contingent to a certain extent. Design should not and cannot be completely absorbed by science (Bonsiepe and Maldonado 1964). However, compared to design methods today which are mainly derived from anthropology, empirical social research, and psychology, Ulm had a strong emphasis on mathematical methods, such as topology, geometric transformations, combinatorics, permutation, statistics, as well as philosophy and linguistics, such as formal logic and semiotics (Bonsiepe and Maldonado 1964; Bonsiepe 1967).

## 1.2 Ulm's information department

Alongside the Product Design and Visual Communication programmes, Ulm featured a small department barely remembered today: in 1955, the Information programme was described as follows:

*"The Information Division [...] is concerned with the problems of information and communication. Its sphere of action ranges from simple press reports via advertising and broadcasting to the results of Cybernetics."* (HfG 1955)

The initial plans of the school's founders were to establish a programme that would *inform* democratic citizens—as opposed to the Nazis' purpose in *manipulating* them. When Max Bill joined the founders, the department's focus broadened towards applied writing, e.g., for advertisements. The department's focus shifted yet again, when Max Bense became director of the department and the first students began to study "Information" (as a full-blown study programme) in 1955. Bense had been one of the first guest lecturers to teach in Ulm after the HfG opened in 1953. Holding a full professorship in Stuttgart, Bense was engaged only as a part-time department head in Ulm. However, this did not keep him from announcing radical changes: he introduced Information Theory, statistics, and other scientific, empirical, and mathematical methods to the analysis and creation of texts, without making a distinction between artistic texts, such as poems and novels, and applied writing, such as press releases or advertisement copy. In the future, Bense claimed,



**Fig. 1** Diagram of the initially planned departments and topics of the Ulm School (Scholl and Aicher 1951, redrawn by the author). Next to classic design topics it lists topics, such as community, self-gov-

ernment, economy, state, and society—topics that inform and frame the design process, but also may be helpful to understand cybernetic thinking

texts should only be viewed in terms of "the extent to which they contain information" (Bense 1956a). Ulm's product design and visual communication departments are known for employing systemic approaches, and methods of modularisation. Bense treated text with comparable methods: his experimental curriculum lists transformation, abstraction, grid technology, assembly, concentration and dispersion of forms (Bense 1956a).

The Information Department can be considered a residue of post-war plans for a political school and consequently a reaction to German fascism. It also represented the biggest conceptual difference to the Bauhaus at the time of Ulm's founding. Though by far the smallest department in Ulm

(it is highly unlikely that typical young applicants attracted by a design school would have been motivated by a study programme heavily engaged in theory, science and publishing) the Information Department became the school's intellectual core. Information Department lecturer's also taught students in the other departments thus introducing an inordinate degree of general and scientific knowledge to design education.

Bense gave a lecture series titled "Cultural Integration" for students of all departments. In the early years after the Second World War, many of the students lacked a proper formal school education. Max Bense contributed to filling such knowledge gaps, by teaching a broad spectrum of general

philosophy, logic, philosophy of technology, aesthetics, and theory of science (Walter-Bense 2003). Bense had already gained prior experience in teaching "uneducated" students. In the early years of the socialist German Democratic Republic (GDR) he had helped set up a "workers and farmers" university in the city of Jena in East Germany (Wachsmann 1991 p. 6). External to the Information department itself, however, his lectures were considered too demanding by many design students in Ulm, and his abstract and highly intellectual topics often did not attract much student interest.

Bense's favoured topics changed during his tenure in Ulm. In the early 1950s he focused on Cybernetics. Then he discovered Information Theory, and in the 1960s he turned towards semiotics. He served as department head for as long as it took to accompany his first cohort of students to their diploma (1955–1959). Upon leaving Ulm in 1959 he described his work thusly, "For four years I have been pumping some intellectual substance into the school" (cited after Rübenach 1987: 53). For further reading on the Information Department see (Oswald 2012, 2015, Oswald et al. 2015; Wachsmann and Oswald 2015).

## 2 Max Bense and cybernetics in Ulm

Bense had studied physics and philosophy in the 1930s in pre-war Germany. In his regular full-time position at Stuttgart Technical University he had been teaching philosophy and theory of science since 1950.

It is arguable whether or not Cybernetics is a helpful theoretic framework for applied verbal communication. However, Bense had been fascinated by Cybernetics since he read Norbert Wiener's reference book "Cybernetics: or Control and Communication in the Animal and the Machine" (Wiener 1948) in 1949. (Walter-Bense 1999) He introduced Cybernetics to the curriculum of the Information Department and to the general topics agenda of other Ulm design programmes, alongside theory of science and philosophy.

Several aspects of Wiener's work were appealing to Bense: first and foremost, the materialistic and, therefore, atheistic approach of explaining machines, animals and human beings with the very same principles, i.e., interpreting human beings as machines—highly complex machines, but still only machines. In addition, as a consequence, understanding the human mind as a phenomenon that solely emerges from their bodies, bound to matter. Second, Bense embraced the implicit promise of Cybernetics: that the technical world, the human environment—i.e., basically the whole world—can be controlled and steered. Or in other words: the world is designable. Bense talks of the "fundamental make-ability of the world" ["grundsätzliche[n] Machbarkeit der Welt"] (Bense 1960 p.10). This concept implies that humans should not rely on the "hand of god"

and that they should take their fate into their own hands. Maybe it also implies that humankind should not leave economic markets to Adam Smith's (1776) notion of the "invisible hand"—that implies giving up steering and control completely.

Nowadays, the idea that humankind has the technological power to "design" and control the world completely, smacks of technocratic feasibility fervour and male megalomania. The Second World War had shown that technological progress may also lead to high tech wars, industrialized death and nuclear destruction. Yet, until the late 1960s an uncritical and optimistic view of technology was predominant in politics and in the design and engineering communities. In the 1960s, Concorde and the rotary engine were developed with little concern about fuel consumption, and nuclear power plant safety was thought merely to be a question of sufficient redundancy in their technical control systems. The "limits of growth" (Meadows 1972) was not yet on the agenda, and carbon dioxide was known only for being the gas in sparkling drinks.

### 2.1 Max Bense's information aesthetics

Bense is largely associated today with his "Information Aesthetics". A doctrine he developed based on the mathematical theory of information, introduced by Shannon and Weaver (1949). Bense hoped his "Information Aesthetics", would provide a theoretical framework to support the design process, design analytics, and decision-making. Today, "Information Aesthetics" is probably the most misunderstood aspect of Bense's work. Despite titles such as "The Programming of Beauty" (1960), Bense's Information Aesthetics are not at all about calculating beauty. Nor are they concerned with rules of proportions or form giving. Aside from the question of whether a mathematical theory of proportions and form would be possible or even desirable, Bense's Information Aesthetics were widely ignored by Ulm's product design and visual communication students. For them, they were of little use in the design process. Geared towards maths and numbers, Information Aesthetics were unable to address classical design domains, such as use processes or aesthetic qualities.

Particularly in the present day, Information Aesthetics is often misinterpreted as a clean and reduced style of information design. Of course Swiss typography and Ulm's visual "style" was highly influential for what is now termed information design. However, the term information design did not exist in Ulm. The "Ulmians" considered all visual design to be first and foremost informative, i.e., to be information design. When working on concept papers for the foundation of the Ulm school, Max Bill even postulated that the aim of advertisement was to *inform*. (Bill 1950) The view nowadays appears to be a classic confusion of wish and

reality, a normative statement in the form of a descriptive one. However, in the late 1940s and early 1950s the vision of a ratio-led informed society—in contrast to a manipulated one—was thought to be within reach. However, it cannot be repeated too often: Bense's Information Aesthetics has nothing to do with what is termed information design today. It is not the opposite of a persuasive or emotional design *style*, in spite of the Ulm context appearing to suggest something of this nature.

Bense's idea of calculating an aesthetic measure is situated in the tradition of mathematician Georg David Birkhoff who presented a first calculation formula in 1928 to that end. The two aspects Birkhoff employed in his formula were order and simplicity—the two formal cornerstones of modernist design teachings. In addition, vice versa, disorder and complexity, which have been considered negative. Birkhoff takes the two parameters and puts them into relation. His aesthetic measure ( $M$ ) is the amount of order ( $O$ ) divided by the amount of complexity ( $C$ ):

$$M = O/C.$$

A high level of order, therefore, results in a high aesthetic measure, whereas high complexity reduces the aesthetic measure. Or vice versa: disorder reduces the aesthetic measure, simplicity increases it. Obviously, the beliefs of early modernism and the early Bauhaus, with its almost esoteric worship of simple geometric basic shapes and pure basic colours, had been inscribed into this formula. Birkhoff's formula is based on this subjective aesthetic judgement and on unverified premises. Frieder Nake, who had studied and worked with Bense and became one of the first computer art pioneers in the late 1960s, repeatedly pointed to the simple and often overseen fact that there is a fundamental difference between a measure and a value. A measure simply is a numerical result of a measurement—that is why it is called a measure. It does *not* contain a qualitative judgement or a valuation. By contrast, a value is based on valuation. (Interview with Frieder Nake by the author, 01 February 2014. See also Nake 1974) In the German language, the difference is semantically even stronger than in English: "Maß" [the measure] and "messen" [to measure], in contrast to "Wert" [the value] and "bewerten" [to assess, judge, value, value]. In Birkhoff's formula both aspects remain undifferentiated and are mixed carelessly. Hence, the design of the formula suggests that a high measure (i.e., a higher number) is equivalent to a high aesthetic value in the sense of being more valuable, or more beautiful. In addition, debatable is Birkhoff's decision to choose the form of a mathematical formula in the first place, implying the possibility of putting order and complexity into numbers, i.e., that order and complexity can be measured after all in the contexts he uses as examples. As a consequence he does precisely that. He

develops methods to measure and calculate the amounts of order and complexity of polygons, nets, and vases, (Birkhoff 1928, p 189) and later those of music and poetry too (Birkhoff 1933). The way in which he does so, however, is so questionable that Frieder Nake dubs both the method and the corresponding results "complete nonsense". (Interview with Frieder Nake by the author, 01 February 2014) In the formula for calculating the aesthetic measure of a polygon some variables make sense, such as "symmetry" or "balance". However, they are used without any empirical proof or explanation of how they can be put into numbers—but subjectively. In addition, Birkhoff even introduces a variable called "friendliness" (of polygons!). Actually a study on possible inter-subjective common ground in which individuals would consider a "friendly" or an "unfriendly" polygon may produce interesting results. However, Birkhoff did not consider empirical tests to be necessary. In addition, polygons are still relatively simple subjects to analyse. The more complex Birkhoff's example subjects became, the more absurd the measuring attempts. Regarding poems for instance, Birkhoff derived the amount of order by a more than simple calculation: he counted and summed up alliterations, musical and homophonic sounds, and all rhymes, after which he subtracted all "superfluous" alliterations and the number of consonants (sic!). A formula that would render a poem in Italian language automatically more orderly than a poem in Russian language. A more mechanic and superficial way of analysing poems can hardly be imagined.

Bense avoided this confusion of measuring and valuation and interpretation, when he developed the aesthetic measure for his "Information Aesthetics". However, Bense did not emphasize often and clearly enough that in his Information Aesthetics, a higher aesthetic measure does not mean that something is more aesthetic in the sense that it is more harmonious, beautiful or pleasurable to look at (interview with Frieder Nake by the author, 01 February 2014).

In the mid-1950s Bense read Shannon and Weaver's "Mathematical Theory of Communication", already published in 1949. Based on their experience in communication technology at a telephone company, Shannon and Weaver introduced a purely mathematical definition of information and the now well-known model of communication: sender–channel-(noise)–receiver. Bense was fascinated by the method they described to calculate the amount of information a message contains (Walter-Bense 2004). Thereby, all subjective interpretation is eliminated, even order or disorder play but an indirect role.

The aesthetic measure now is derived exclusively from quantity and the probability in which the elements of a message or artefact—the sign elements of which it is composed—occur statistically. This measure may change with more or less order, but it does not necessarily have to. In Shannon and Weaver's Information Theory, signs that are



less probable are more informative and, therefore, result in a higher amount of information. Or vice versa: the more probable a message is, the less information it contains. In the extreme case that a message being safely expected by 100% before it even arrives has no sense in being sent—for the amount of information it contained would be zero. This sounds reasonable. In addition, Bense often draws a parallel between a low statistical chance of occurrence in Information Theory and originality and surprise in art. One hundred per cent foreseeable art, is of course probably boring—but surprise should not be the only or a dominant criteria in defining art. In other words, a certain extent of unexpectedness is surely necessary for art, but is not sufficient. However, looking at the calculating method for the statistical occurrence more closely, it becomes clear that it is helpful, first and foremost, in calculating the capacity of a technical communication channel—precisely for which Shannon developed it. For the purpose of understanding human communication, however, this model is of barely any help, as it works completely independently from content and meaning. The following example may illustrate this: if an abstract picture is generated of squares with randomly assigned colours, a human perceiver will be unable to derive much information from that picture (other than "chaos" or "colour noise"). Rearranging this given set of squares, however, into a mosaic picture with some sort of order or even an iconic subject allows the human perceiver to find more information in it—in an everyday sense related to human communication. By contrast, both the Shannon formula and Bense's aesthetic measure will not see a difference at all. Provided that the sign repertoire (in this case all possible colours) and the probability of their occurrence remain unchanged, the amount of information also stays the same. Provided that the picture elements are the same, it has no bearing on the aesthetic measure at all whether these elements are arranged in a geometric pattern, a picture of a flower, or pure arbitrary noise. In addition, indeed, content and meaning are completely irrelevant for the technical transmission of a message. No matter whether telegraph, telephone, or e-mail, the medium is not concerned about content. Love letters are transported as indifferently as shopping lists. Unsurprisingly, and typical for all calculations, the result of the Shannon formula is merely a number. A short love letter may result in 32,88 and a long shopping list in 191,02. Incidentally, already in 1949 Shannon proposed the measuring unit for information to be termed "bit", which today is used for digital data files. Whether composition, colour, form, meaning, or context: all disappears into a single number. Transferred to today, Bense's approach suggests discussing the aesthetics of any artefact solely based on the disk space its digitized version would occupy. However, Bense does not see the disappearance of meaning as a loss, but as a liberation. For him, this is an opportunity to get rid of subjective meaning and

sentimental interpretation of literature and fine art, expelling it by the precise methods of natural science. In so doing he not only attacked art history and its frequent blurry interpretations, but also provoked the social sciences by demanding one to refrain from psychological and sociological "chatter" in aesthetics (Bense 1960). In the age of technical civilisation, Bense even wants the art discourse to be objective. In addition, by "objective" he means measured and calculated, with numbers as the outcome. Obviously there existed a strong provocative motive behind these radical postulations. As a professor of the Technical University in Stuttgart, Baden Württemberg (one of the most conservative and Christian areas in Germany at the time), Bense was largely renowned and challenged for his explicit and radical atheism (Zeit 1961). However, he surely also enjoyed the indignation and outrage he created in philology by calling for a reduction of the analysis of poems to "measuring the amount of information they contain" (Bense 1956a). It would be wrong, however, to reduce his enthusiasm for calculation and his rejection of sentimental exegesis to provocation alone. In addition, Bense is not a solitary figure of such attitude. The enthusiasm for a merely calculating scientific objectivity and the blindness towards the losses this attitude brings, was widespread not only in Bense's Stuttgart circles, but also at the Ulm School in the 1950s and 60s. Frieder Nake sees in this a reaction to the Nazi period in Germany: "In this way Bense reacts, in my interpretation, to his experiences with fascism: everything tending towards meaning, also tends towards emotion. In addition, as soon as you managed to throw the people into emotions, you can play with them perfectly." (Interview with Frieder Nake by the author, 01 February 2014). Taking this concept as given, the best antidote against emotional manipulation are the rational methods of natural science—information instead of manipulation.

In his preface to the second volume of his *Aesthetica* series, Bense (1956b) writes that along with the "aesthetic sign theory" of the first volume, an "aesthetic based on Information Theory" is now to be established. Subsequently, Bense degrades semiotics—a discipline that (not only) deals with meaning and meaning-construction—as a subdomain of the purely quantitative Information Theory: "Sign processes change to information processes." (Bense 1956b:9) By contrast, for his then assistant and later wife, Elisabeth Walter-Bense, Information Theory was a not too interesting minor side arm of semiotics. (Walter-Bense 2004) Elisabeth Walter-Bense, who was the first to translate Peirce's writing on semiotics into German, would have her view confirmed later. In addition, Max Bense lost his interest in Information Theory over time. The topic became rare in his publication list during the 1960s (Walther-Bense 2007).

Bense's hopes to see his theory of information aesthetics applied to design practice at the Ulm School, (Walter-Bense 2004, p 71) were quite dashed by Ulm's staff and students. A

rare and late application of the Shannon formula in Ulm can be found in Gui Bonsiepe's article "A Method of Quantifying Order in Typographical Design" (1968, pp 24–32). However, even in this singular case all the measuring, counting, and calculating seems to reveal only correlations that the eye of a trained practitioner is able to see easily without any numerical analysis. Bonsiepe himself suggests this in his introduction to the article: "But the idea that a number—apart from its function as a numerical tag—has any expository force or can convey information about the work is still open to doubt." (Bonsiepe 1968, p 24) Bonsiepe's doubts were justified. Bense's approach was simply not helpful in design projects. As a consequence, Bense returned increasingly to semiotics in the 1960s—a theory framework in which meaning and its coding, its construction, and its imparting is an integral part. In contrast to other protagonists of the Design Methods movement of the 1950s and 60s, Bense never quite explicitly renounced his overly mathematical and statistical approaches of the 1950s.

## 2.2 Bense and Brazil—"Brasilianische Intelligenz"

Bense was not only interested in the philosophy of science and technology, but also literature and art. In concrete art particularly he saw the artistic equivalent to his rationality-lead philosophy of science. He appreciated concrete painting and sculpture, with its pure colours, often mathematically defined geometrics and proportions—avoiding all meaning in the sense of iconic depictions or symbolism. In addition, Bense admired and endorsed concrete poetry. He appreciated how concrete writers experimented with syntactical deformations, random processes, and visual nonlinear structures. In addition, again, meaning, in a classic sense, was often destroyed by the concrete poets, or at least derogated. Bense even wrote some concrete poetry himself.

His first connection to the Ulm school had been via Max Bill, whom he had admired as a concrete artist. Both, Max Bill and Max Bense had connections to the Latin American concrete art community especially in Argentina and Brazil. (This has already been documented elsewhere in more detail. For Bense see Walter-Bense 1997 and 2012. For Bill see for instance Gottschaller 2019). A remarkable documentation of these rich connections to Brazil can be found in his book "Brazilian Intelligence—A Cartesian Reflection". (Bense 1965, translation by the author). The book is a collection, or rather a conglomerate of different text types and styles. Framed in an often poetically written travel report, the text strays between genres, such as diary, political essay, philosophical treatment, architectural critique, laudation, and political pamphlet and polemic. One could call it experimental and associative—or chaotic. However, it has certainly not been written with a great deal of concern for its readability (assuming that a clear structure and train of

thought is what readers appreciate). The book may serve as a great source for scholars wishing to trace personal connections between Bense and Brazilian architects, designers and authors. However, a more detailed, sober, and concise overview of Bense's relations to Brazil was written by his wife Elisabeth Walther-Bense (1997). In the context of this article, however, Bense's book first and foremost displays the very roots of Bense's radical rational thinking in Descartes. The book's subtitle is "A Cartesian Reflection". Bense sees in Brasilia, Brazil's newly built modernist capital, a perfect realization of modernity that started with Descartes' philosophy of enlightenment:

*"This completely artificial city is the first visible expression of cartesianism that became design. [...] From the perspective of the saturation-aesthetics of human emotions, this city may be unbearable. From a perspective of intelligence-evoking provocation-aesthetics, it is a case of spiritual creation of the first rank: It is an irrefutable aggression of intelligible processes against the materials ones, it is an extension of aesthetic orderings in relation to physical non-order. Thus, it is architectural Platonism, which can void all Hegelian art-pessimism."* (Bense 1965:24, translation by the author)

Read from today's knowledge and a 21st-century perspective, the book clearly reveals Bense's deficits, or even short-sightedness, and the suppressed cut-outs in his thinking. Bense outs himself as an orthodox, if not fundamentalist, follower of Descartes. He shares Descartes' rejection of religion, tradition, and emotion, and conversely Descartes' rigorous demand for rationality. It is packaged in a strictly anthropocentric view of the world, with an instrumental view on nature. The world exists for "man" only. Nature must be tamed and used as a resource. In spite of all anti-religious assertions, these ideas can be traced back to traditional Jewish and Christian beliefs. Both, "man's" singularity ("created in gods own image") and the order to subdue the earth ("let them have dominion [...] over all the earth") is to be found in the Old Testament (Genesis 1:26–29). Furthermore, Descartes' strict separation of body and mind goes well with these religious traditions. Descartes' notion of humans as complex machines, however, is a clear anti-religious and materialistic testimony. It anticipates perfectly, the cybernetic equalization of human, animal, and the machine Norbert Wiener postulated in the late 1940s. When Bense wrote the book in 1965, the consequences of the unlimited exploitation of natural resources were something of which scientists or politicians were not yet aware. However, the "Dialectic of Enlightenment" and the dangers of creating a modernist myth of pure rationality had already been present for more than a decade by then (Adorno and Horkheimer

1947). Bense manages to praise Brazil as the super-model for modern cities while ignoring all potentially negative aspects of centralization, ecological destruction and social issues of urban planning. For Bense, favelas and poor satellite towns seem to be something natural. While Bense is convinced that the world is inherently designable, i.e., changeable, he does not see any need for changes in society that would render something like favelas redundant.

*"Brasilia, since 1960 the new capital of the country is realized without any concern about traditional mystic ideas. Only what was made appears, everything given disappears. City of the automobile, not of the pedestrian like Rio. Bourgeoisie in light suits, all races, poor and rich." (Bense 1965 p 18, translation by the author)*  
*"[E]very urbanism also is the civilization's notion of the future, especially an urbanism that penetrates deep into the wilderness, in order to create a city based on the general plan that displays the scheme of an airplane, and that is today, like it was in its beginning, completely dependent on the airplane." (Bense 1965 p 15, translation by the author)*

In light of today's knowledge it is easy to criticise car-centred urban planning, the shallow symbolism of a plane-shaped city, and deforestation. However, it still requires a critical approach, or at least being looked at in a differentiated way. To defend Bense's honour: of course, it does make a difference if someone does not care about rain forest destruction in the early 1960s or even fosters deforestation in the 2020s. The same is true concerning rationality. While a technocratic reduction on ratio, and the destructive power that comes with it, must be criticized, we see today what happens when the pendulum swings to the other extreme: the amount of irrational denial, alternative facts, and unsubstantiated beliefs we are confronted with today is just as worrying as technocratic feasibility fervour. Hence, criticizing a constrained rationality must not be understood as an argument for irrationality. It is merely a call for facing the simple fact that humans are also emotional beings, and it is a call for being aware of the problems caused by constricted rationality paired with a purely instrumental view on the environment as an exploitable resource.

But already in the 1960s not everyone agreed with Bense's maths-and-ratio-only driven approaches. In the Information Department in Ulm female students in particular report having been enervated by Bense's provocative and reductionist teachings and complained about his disrespectful comments on sociology and psychology (see for instance Koch-Weser 2015. Elke Koch-Weser was a student from Brazil with a German family background).

Another extract may illustrate Bense's changeful writing style, along with some ethnic and sexist stereotypes, that today would be considered clearly offensive:

*"An evening with Clarice Lispector, Lucio Costa and Aloisio Magalhães in his small cubist house over Leme, right below the favelas. Lucio did not speak about Brasilia that he designed, and Clarice not about the novels she wrote. Lucio formulated a political concept of the world based on technical rationality, and Clarice softly reinterpreted her mild fear of [Brasilia's] architectural geometry as a preference for passion. Lucio always with the relaxed hand gesture of someone for whom occasions are decisive and creation is only an interruption of the contemplative flow of being. Clarice Lispector with the open forward-pulled face of an, of course Slavic, Nofretete and the pointed mouth over which still the power of distant kisses lingers.*

*Brazil's inner complexity was present, the complexity of not a sweet, but a wild life on the streets, on the squares, in the hallways, in the rooms, in the coffee bars, in the water, between palm trees, on the benches, and in the buses. Tangle of all figures and emotions between Amazonas and La Plata. Big, fat, small, ugly, crooked, skinny, dead, living, attractive, repellent figures and deep, flat, simple, complex, lethal, perverted, satanic, ridiculous, and black feelings, which threat with suffocation, but in which no creation originates. All pairings, all copulations, all divorces, all persecutions, all enjoyments, all experiences of hate and pain in midst corrosion and production. The bay of Guanabara as melancholic metaphor for all processes of confusion and release." (Bense 1965 p 58–59, translation by the author)*

### 3 Horst Rittel in Ulm and after Ulm: cybernetics, operation research, and wicked problems

After Bense left, and with a new programme head, the department shifted its focus back to journalism. The young mathematician Horst Rittel was engaged in 1959, to teach subjects such as Cybernetics and Information Theory. Horst Rittel is known today as a specialist in planning theory and as the "inventor" of *wicked problems* (Rittel and Webber 1973). Both Bense and Rittel had a big effect on Ulm, and in return both learned a lot there. Bense, who had been acquainted with art but not design prior to Ulm, had to learn that (mathematical) Information Theory is not a great deal of use in design projects. He also had to understand that his numerically driven "Information Aesthetics" did not excite any interest in the professional fields of product and communication design. Rittel was neither acquainted to art nor to design when he joined the Ulm school. However, in contrast to Bense he was immediately interested in



"design as problem solving". By his nature as a mathematician, he applied to design what he brought along: maths, statistics, Cybernetics, and the linear optimization methods of Operations Research. It has to be said plainly: Horst Rittel is known and appreciated today for his "wicked problems" and the insight that complex design decisions always are subjective, political, and cannot be solved based on a linear understanding of problem solving. While in Ulm, however, he fought hard for the exact opposite: for an even stronger scientification and objectification of design decisions. At the time Rittel was in good company. In the early 1960s scientific and often maths-related methods were the flavour of the decade. For instance Christopher Alexander also, underwent a comparable conversion: he propagated a very rational, analytic and science-led approach to "form-giving" in the 1960s (Alexander 1964) and took a mental U-turn to the deliberately inexact pattern theory in Alexander (1977). The prototypic role model for these conversions was probably Ludwig Wittgenstein. While "early" Wittgenstein (1921) demanded to use language only in a precise and unambiguous way, the later Wittgenstein (1953) came to the conclusion that language cannot and should not be disciplined to make it unambivalent, since the very nature of language is to be ambivalent and permanently evolving. For Wittgenstein, the range of meanings of a term, therefore, is always based on but a blurry family resemblance between these meanings, so the meaning of words can only be found in their *use*—as opposed to in a fixed definition. Or in other words: an at least temporarily valid definition of a word would simply describe its current use or uses in a speaker community. It is of some doubt that Rittel had read Wittgenstein's (1953) last publications. However, his colleague in Ulm, Tomás Maldonado had and the two were in conflict in the 1960s. Rittel's intent at that time was to strengthen scientific approaches in design education, while Maldonado, who already had introduced a lot of scientific approaches to design education in Ulm, began to see the problematic aspects of a subcomplex over-scientification of design praxis (Bonsiepe, Maldonado 1964). Maldonado and Ulm's co-founder Otl Aicher soon understood that Rittel's mathematical approaches were too simple and linear to address the multi-faceted messy problems of real-life design decisions. An insight that Rittel was eventually to adhere, but only after a long delay of roughly a decade, when Ulm had already closed and Rittel was teaching in Berkeley. At this point Rittel saw the "Dilemmas in a General Theory of Planning" and a "Planning Crisis" (Rittel 1972). In Berkeley, Rittel made several attempts to get a methodological grip on complex problems in urban planning. He had learned that there was a limit to simple and linear problem solving, and attempted developing adequate description methods for complex multivariate problems—still with the aim to solve these problems by mathematical algorithms ("issue-based information system"). Or if classic

"solving" was impossible, to at least find relative optimums in the solution space. By the early 1970s at the latest, Rittel formulated that a category of problems exist, which will never be solvable in an objective way, problems that are even impossible to describe in a clear and objective way. (Skarburskis 2008) However, late it came, the effect that Rittel's concept of "wicked problems" had and still has on design theory should not be underestimated.

## 4 Ulm, cybernetics and the Cybersyn project

In the 1970s Bonsiepe led the design team of the Cybersyn project in Chile. The goal of this project was to control and steer the country's industrial sector, which had been widely nationalised, or rather socialized, by the socialist Allende government (Medina 2011). In contrast to the dogma of liberal economy, which postulates that a healthy economy can only be achieved by the forces of the "invisible hand" of an uncontrolled market, Cybersyn was based on the belief that economy is also human made, that "the laws of a free market" are not unchangeable natural laws. Therefore, the economy has to be understood as *designed*. In addition, it should be designed, especially if the aim is for a just and more equal society. It was hoped Cybernetics would be a "best of both worlds" solution eliminating on one hand, the injustice of capitalistic economy and on the other, avoiding the disadvantages of the Eastern Bloc's rigid and inflexible planned economy. Cybersyn was to become the control centre of a cybernetically controlled planned economy, informing in real time about production data, allowing dynamic control and real time adaptation of steering measures—instead of laying down fixed production target figures in a 5-year plan. In the late 1960s, these concepts had also been discussed in the GDR (German Democratic Republic, socialist eastern Germany). One of the key figures in this discussion had been the philosopher Georg Klaus, professor at the Berlin Humboldt University in East Berlin. He had been a communist already in the 1930s and a survivor of the Dachau concentration camp. Klaus had earned his doctorate at Jena University in the late 1940s with Max Bense as doctoral adviser and had become an expert in Semiotics and Cybernetics about which he had published several books. In "Kybernetik und Gesellschaft" [Cybernetics and Society] (1964) he describes his "sociocybernetics", a merger of Marxism, direct democracy, and Cybernetics. To accumulate live data, he proposed installing a set of three voting buttons in every household of Eastern Germany: Yes, No, and Abstention. Unsurprisingly, the cybernetics discussion was soon silenced by GDR officials who strictly followed Moscow's directives in the early 1970s (Eckardt 2005).

In recent years, Cybersyn has been rediscovered as an example of a utopia-driven project, based on speculation that

it may have provided a working alternative to both neoliberal capitalism and the communist "dictatorship of the proletariat". The timing suggests that such interest was a reaction to the financial crises and increasing doubts about neoliberal narratives. The prevailing illustration in these features, articles, and dissertations is the single colour photograph of the Cybersyn's ops room, which Gui Bonsiepe was able to save in the turmoil of the military coup and his hurried migration to Argentina. However, there was more to the design part of the Cybersyn project than the styling of a set of conference chairs, wooden veneer on the walls, and a set of display boxes depicted in this iconic image. Sometimes the ops room design has been ridiculed as a knock-off of sci-fi film sets or cinematic "war room" depictions. This superficial view, probably typical for art historians, who are trained in analysing and comparing artefacts on a visual level, omits the decisive aspects of use processes, team interaction, and communication. The Cybersyn design goal was to enable a team to make informed decisions. To this end, information and collaboration is essential. For a designer with an Ulm background it was a matter of course that a room layout, its arrangement of chairs and their specific design, influence or even mould the way groups of people work together—just consider how power relations are reflected and moulded in the layouts of a hierarchically organized courtroom and by contrast the setup of a round table discussion. In addition, of course, there are similarities with war rooms and spaceship navigation bridges. For these similarities do make sense, or may even be considered "natural", since there are also a lot of parallels in the use processes these rooms should facilitate. Steering a spaceship, developing strategies in war, controlling a national economy—all are complex decision-making processes. That the ops room displays a distinct 70s style, for its colour scheme, fibreglass tulip chairs, etc. is neither surprising nor worthy of great discussion. These formal aspects are the least interesting. Far more interesting, and discussion worthy, are the interfaces integrated into the chairs controlling the information displays and decision-making, to enable or rather enforce a completely paperless process. Bonsiepe had prior experience in developing sign systems for computer-controlled interfaces, e.g., the Olivetti ELEA computer he developed in Ulm with his mentor Tomás Maldonado in 1961 (Maldonado and Bonsiepe 1963). Another often overlooked aspect is the design system of the info displays. The team did not simply develop diagrams, but a "visual grammar" with defined rules of how to visualize numeric data and processes. Most of the documentation has been lost, but the fact that this part of the project is rarely revealed is also down to the lack of knowledge and interest of journalists, historians, and computer scientists in rule-based visual design systems. To summarize, Bonsiepe was certainly not hired for the product design experience he had. The job was not about interior decoration

and a suite of seating accommodation. Many other designers could have done such a job just as well. However, beyond that, Bonsiepe had an understanding that products and the artefactual environment influence a social process such as decision-making—an obvious fact for Ulm alumni. A circle of seven equally designed chairs encourages somewhat different discussions than that offered by a rectangular table with the "chairman" seated at its head.

In addition, Bonsiepe had had experience with early "interface design" for computers. He was versed in systemic design approaches in information design. He also had an understanding of Cybernetics. Beyond the confines of Ulm, such expertise was not common for an early 1970s designer. This explains Fernando Flores', (Cybersyn project head representing the Chilean government), surprise upon the discovery of Stafford Beer's books in Bonsiepe's bookshelves at their first meeting. Until then, Flores had considered artists and designers as "confusionistas" (Gui Bonsiepe, E-Mail to the author, 25 Feb 2021). Therefore, at least in retrospect, with his studies in the Information Department, his teaching experience in product design and visual communication, his product design and design management experience at INTEC (see Fernández 2006:10), Bonsiepe seemed to be a natural fit for the Cybersyn project.

Also the name "ops room" was not an accident. Short for "operations room", it connotes the tradition of Operations Research, the 1960s discipline that would offer methods of rational business decision-making for enterprises, balancing and managing cost, demand, production, human and material resources, distribution and the like. As with Cybernetics, Operations Research has its roots in warfare. Its first application was on mathematical problems related to the optimization of area bombings with multiple variables, such as the "width of the bomb carpet", "density", "precision", and "dispersion". In addition, this may explain some structural similarities of an economy control room and a war room. And last, but most importantly, Stafford Beer, lead scientist of the Cybersyn project, was a pioneer of dynamic Operations Research methods and what today is called enterprise software or business intelligence software (such as SAP, SAS, Oracle etc.)—this was the core of the project. Once more, Operations Research was part of the Ulm curriculum: in the third year, Bonsiepe's study records list a course in "Mathematische Operationsanalyse" with Horst Rittel in 1958–1959. (Bonsiepe 2015, p 63).

#### 4.1 From cybernetics to interface design

Another aspect of Cybernetics is worthwhile looking at. Alongside mathematics, philosophical logic, and electrical engineering, Cybernetics are a predecessor of today's computer science. As a result, Bense's introduction of Cybernetics to the Ulm curricula forms part of a thin line of tradition

leading to interface and interaction design. The Stuttgart School, Bense's "home base" at Stuttgart Technical University, had certainly more impact on German computer sciences than the Ulm School of Design had. Some alumni of Bense in Stuttgart became pioneers in Computer Graphics (Computer Graphics in a computer science sense, i.e., generating images by code—not in the sense of computer aided graphic design), and Computer Art, first and foremost Georg Nees and Frieder Nake. The Ulm equivalent is Gui Bonsiepe, who studied in Bense's "Information Department", and crossed the line from Cybernetics to computer sciences to interface design several times in his professional career. He does the same in his writings, a path that eventually lead to a design theory that puts the concept of *interface* at the very centre of the question of what design actually is, and what a designer actually designs: interface as the central domain of design, in contrast to artefacts, systems, interactions, experiences, services or the like. (Bonsiepe 1999).

## 5 Naturalization of information, communication, and human behaviour—a conclusion

Nowadays, the idea that everything in the world is controllable and steerable by cybernetic principles, appears quite megalomaniac. After several decades of reduced interest, Cybernetics have a revived interest as a subject of technological and cultural history. (Hörl and Hagner 2008) However, it has always been the case that trending sciences have a dominant aspiration to explain "everything". Similar forms towards an underestimation of complexity can be found in the Artificial Intelligence concepts of the 1960s (and in the opinion of this author, present in some of today's Artificial Intelligence concepts). In the 1960s, perfect translation machines had been announced to be available "within a few years". Today, with 40 years of delay, it is astonishing how good translation software works, but it remains far from perfect. The reason for this is again simple: a severe underestimation of the complexity, fuzziness, and ambiguity of human languages, or semiotic processes and meaning construction in general. In the 1990s the relay baton was taken on by Genetics that would solve all kinds of health problems through gene therapy and agricultural problems via bioengineered crops and pesticides. Today, Neuroscience has become the alpha science for the entirety of questions about humankind. Questions of human behaviour, which have been a subject of philosophy, sociology, psychology, and cultural studies, are nowadays often reduced to "brain activity patterns" technically measured and visualized. Of course, neurosciences produce a lot of valuable insights. The danger lies in the temptation to claim them as the sole interpretation of what humans are, and the sole explanation of

their behaviour. A look at the inflation of neuro-something derivatives (Neuro-Management, Neuro-Leadership, Neuro-Psychoanalysis, Neuro-Sociology, Neuro-Marketing and even Neuro-Web Design ...) suggests that we witness a classic hype, that must end at the very least in temporal delusion (Falkenburg 2008; Hasler 2011).

The parallel to Bense's concepts of the 1950s and 1960s is apparent: questions of human behaviour are interpreted as sole questions of the natural sciences, which can only be answered by means of the natural sciences. This "naturalization" comes with an obvious devaluation of the humanities and the liberal arts. (Janich 2006) In everyday language, the cybernetic equalisation of human, animal, and machine, seems to be generally accepted. We speak of "sensors" and "actuators"—as if a machine could sense something or as if it could act. However, in philosophical action theory, to "act" is strictly bound to an intention. Do machines have intentions? Probably not. In addition, if not, they also do not act. (Dretske 1999) Shannon and Weaver talked of machines that "communicate" to exchange "information". Of course it is a question of definition, of how we define terms, such as "sensing", "acting", and "communicating". Nonetheless, a great deal of technical descriptions and cybernetic steering mechanisms use a generous amount of anthropomorphic metaphors to describe processes that could as well be described using solely physical parameters, without the use of a single cognitive term (Janich 2006, p 50).

Whether the Cybersyn approach would have worked in Chile, or resulted in a cybernetic tech frenzy and an underestimation of the complexity of economic interdependencies—we will never know. The project was ceased by the US-supported anti-socialist military coup in 1973 before it could get properly off the ground. Ironically, comparable methods, systems and algorithms have a determining influence on today's capitalist economy—in business informatics, especially business intelligence software, in the highly automated financial market, and in stock exchange trading. In this sense, cybernetic control of business and economy does not necessarily have a natural bias towards "left" or "right" economic policies. Looking at Cybernetics' origins in anti-aircraft defence, it becomes clear that Cybernetics are comparable to an unblameable tool like a knife. Handy for peeling an orange, but just as handy for stabbing a person to death.

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