Chapter 3
Cybernetics and Design: Conversations for Action

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Abstract Ranulph Glanville came to believe that cybernetics and design are two sides of the same coin. The authors present their understanding of Glanville and the relationships they see between cybernetics and design. They argue that cybernetics is a necessary foundation for 21st century design practice: *If design, then systems*: Due in part to the rise of computing technology and its role in human communications, the domain of design has expanded from giving form to creating systems that support human interactions; thus, systems literacy becomes a necessary foundation for design. *If systems, then cybernetics:* Interaction involves goals, feedback, and learning, the science of which is cybernetics. *If cybernetics, then second-order cybernetics:* Framing wicked problems requires making explicit one's values and viewpoints, accompanied by the responsibility to justify them with explicit arguments; this incorporates subjectivity and the epistemology of second-order cybernetics. *If second-order cybernetics, then conversation:* Design grounded in argumentation requires conversations so that participants may understand, agree, and collaborate on effective action – that is, participants in a design conversation learn together in order to act together. The authors see cybernetics as a way of framing *both* the process of designing *and* the things being designed – both means and ends – not only design-*as*-conversation but also design-*for*-conversation. Second-order cybernetics frames design *as* conversation, and they explicitly frame "second-order design" as creating possibilities for others to have conversations.

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3.1 A Conversation about Conversations-for-Action

This paper began as a conversation with Ranulph Glanville about the relationships between cybernetics and design.

Some background: Glanville studied architecture and taught at the Architectural Association for many years. He also studied with cybernetician Gordon Pask, who developed "Conversation Theory" [33] and was among the first to recognize connections between cybernetics and design. Pask was involved with designers – working with Cedric Price on the Fun Palace, contributing to Nicholas Negroponte's *Soft Architecture Machines* [25], and participating in an early design methods conference. Also, Pask's approach to science and theory might be described as "designerly": he was a "maker" throughout his most prolific period from the 1950s through the 1980s [26], experimenting with "machines for conversation" including, among many others, Musicolour, Self-Adaptive Keyboard Instructor, and Colloquy of Mobiles, [34]. Pask's student Glanville saw the deep connection between cybernetics and design in Pask's work and was among the first to forefront that cybernetics and design are not just connected, they are two sides of the same coin.

This paper is not a review of Glanville's extensive writings, and we may not fully understand his views. However, we would like to report on points he made to us, sometimes quite vehemently – and we would like to comment on the many places where we feel we concur and the few where we do not.

The catalyst for our conversation was Glanville's masterful presentation at the RSD3, Relating Systems Thinking and Design 2014 Symposium in Oslo [15]. Glanville argued that first-order cybernetics, far from being mere mechanics or calculation, provides a necessary alternative to linear causality: it brings us circular causality, critical to understanding and realizing (making) interactive systems that evolve through recursion, learning, and co-evolution. Second-order cybernetics is fundamental to design because it gives us an epistemological framework for designing. Second-order cybernetics moves us from a detached, "objective" pose, where we can duck responsibility, right into the messy middle of things, where we must take responsibility for our actions.

Second-order cybernetics frames design *as* conversation. This creates the conditions for learning together and thus better-directed, more-deliberate actions: hence the second half of our title, "Conversations for Action." And because it is conversation that leads to learning and effective action, the key focus for designers must ultimately be to design *for* conversation.

Sadly, Glanville's passing cut short our conversation with him. We strive to present his views as best we understand them, quoting him when possible. We appreciate his gifts, and we miss him. We invite continued conversation, especially with others who have collaborated with him and who may see his intentions differently. Together let us learn and evolve the field.

3.2 The Context for Cybernetics and Design

To connect design with cybernetics is not new.[1] Both Christopher Alexander (in 1964) [1] and Horst Rittel (in 1965) [36] acknowledge the influence of cybernetician Ross Ashby's *Design for a Brain* (written in 1952) [2]. Rittel notes in his "Universe of Design" lectures, "The explicit view of Ashby is of the designer as regulator." [36, p. 91]. Rittel explains, "Design has been defined as a purposeful and goal seeking activity" [36, p. 124].

Framing the design process as a single feedback loop can be a useful first approximation; it emphasizes several key aspects of the process – iteration; error correction; information flowing from designer through environment and back again; and perhaps even convergence on a goal, as Simon suggested (in 1969), "changing existing situations into preferred ones." [39, p. 111].

Yet, framing the design process as a single feedback loop is a gross simplification. Even simple design situations involve multiple levels of structure, meaning, and goals – nested components and subcomponents, networks of signs (in the semiotic sense), and hierarchies of goals and means for achieving them. While the design process may seek a sort of homeostasis, it is less like the self-regulation of a thermostat and more like autopoiesis, the self-generation of a living organism. Far from being unitary (controlling a single variable, e.g., heat), the system is "fractal", in the sense that feedback loops operate across a range of scales, in the large and in the small, and these feedback loops are connected in a vast web.

Framing the design process as a feedback loop also raises questions at another level. Feedback measures difference from goal. So: Where does the goal come from? Who sets the goal? Who controls the system itself?

What is more: Outside of classes in design schools, very few design situations present with clearly defined goals. Fundamentally, the designer's main challenge is to understand the situation, its constituents, and their context, and from that understanding help facilitate agreement on shared goals. A peculiar aspect of designing is that the process of formulating (and reformulating) goals proceeds not only by explicit discussion of possible goals, but also by making artifacts related to the possible goals. In other words, as designers act to achieve a goal, they often discover the need to change the goal. (Separating goal-formulation from action is also misleading.) Designing requires making goals explicit, otherwise they cannot be examined, critiqued, or improved. This distinguishes design from many other forms of human activity because the "why" – the goals of design – must be transparent so that the intentions and values of the designers are available for review and response, which may come from other designers or from anyone else affected by the outcomes of the design process.

Thus we see that connecting design to feedback raises the questions: By what process are goals examined, critiqued, improved? As we will argue below and as Rittel well knew, the answer is: through conversation.

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[1] We acknowledge a broader history of associating design and cybernetics but cannot offer a thorough survey here.

3.3 Conversations for Action

"Action" is inherent in what historian of science Andew Pickering [35] calls the cybernetic ontology – what we might call the "frame" of cybernetics:

> Since Descartes, it comes naturally to us to think of the brain as the home of the mind, and the mind as a centre of knowledge, reason, thought and cognition – the cognitive brain, we could call it. And part of the singularity of the cybernetic ontology was that it had a very different account of the brain. The cybernetic brain was a performative rather than a cognitive organ, understood as geared directly into doing and performance rather than cognition. 'The brain is not a thinking machine,' Ashby wrote in 1948, 'it is an acting machine.' As far as conceptualising the human is concerned, this shift of referent from cognition to performance was a defining aspect of the singularity of cybernetics. – Andrew Pickering [35]

"Design" is what this acting machine "performs", the process by which it proceeds, the process by which it learns – which is to say, the process by which it understands distinctions; agrees on goals and means; and enacts them – and then, based on the results, iterates with "improved" actions.

For those reasons, we construe design as a conversation for action – that is, as cybernetics. Action may either conserve or change a situation. In other words, design is a conversation about what to conserve and what to change, a conversation about what we value [20]. Both the design process and cybernetic systems involve observing a situation as having some limitations, reflecting on how and why to improve that situation, and acting to improve it. This follows the circular process of observe→reflect→make that is common to the recursive and accumulative process of learning in service of effective action, as is found in science, medicine, biological systems, quality management, and everyday living [7].

We construe cybernetics as a process for understanding [42] as well as a practice for operating in the world that focuses on systems that contain loops that enable the attaining of goals [35]. The term cybernetics comes from Greek roots meaning to pilot or to steer; on moving into Latin it becomes to govern. Some erroneously construe cybernetics to be mechanical. Some even hear in the word "system" the march of jackboots – unthinking, mechanical control. What interests us is quite the opposite – the messy chaos of natural and social systems, which cybernetics can help us begin to understand. We believe there is huge range for variation and possibility while applying the cybernetic frame to designing objects, interactions, services (increasingly driven by data), and more.

We also believe it is a misunderstanding to construe cybernetics as requiring a reductive stance or a focus on engineering. Glanville himself makes the point that Norbert Wiener ought to have published his most famous book *Cybernetics: Communication and Control in the Animal and Machine* after he had published *The Human Use of Human Beings* – because the former left an imprint of cybernetics as engineering grounded in mathematics, while the latter explains cybernetics as "a way of thinking and a way of being in the world" [15, p. 3]. The flowering of cybernetics in the 1940s came from conversations among a vast range of world-experts from both the hard sciences and the social sciences, who celebrated the field as uniquely focused on a new way of seeing systems [40].

3.4 Connecting Design to Cybernetics and Conversation

The structure of our argument is:

- If design, then systems
- If systems, then cybernetics
- If cybernetics, then second-order cybernetics
- If second-order cybernetics, then conversation

We now traverse that path and offer rationale and implications.

3.4.1 If Design, Then Systems

> [A] building cannot be viewed simply in isolation. It is only meaningful as a human environment. It perpetually interacts with its inhabitants, on the one hand serving them and on the other hand controlling their behavior. In other words structures make sense as parts of larger systems that include human components and the architect is primarily concerned with these larger systems; *they* (not just the bricks and mortar part) are what the architect designs.
> – Gordon Pask [29, p. 494]

Many of today's design challenges are complex problems, where an appropriate formulation of the situation is neither already agreed-to nor easy-to-characterize. However, through conversations within a design team, an agreeable characterization may be defined (the "problem" formulation) and then tackled by defining actions to improve the situation (the "solution").

The industrial era changed the nature of design from design-for-making (insofar as there were any explicit design steps before making) to design-for-manufacturing. Beginning in the 20th century, design-for-systems becomes necessary, as evidenced from World War II when operations research as a field of practice and cybernetics as a systems discipline arose [18]. As argued in depth elsewhere [9, 11], designers of digital systems are faced with the challenges of product-service ecologies. (Later we will widen the scope beyond digital and see that design-for-systems still applies.) This new design challenge is often exemplified by the iPod or iPhone, but the same points could be made for any networked device (even the original telegraph). While the user interacts with an iPod as physical device, its software connects to a network of communication systems (internet) and databases (music archive) and marketplaces (music for sale), which has relationships to other actors (social community members, artists) and related aftermarkets. The complications of this system of systems must not be exposed in ways that confuse a user; and the designer must know enough about the system-to-system relationships to produce an effective outcome. Hence, designers must be conversant with this end-to-end mesh of systems in order to design for a tractable set of rich choices from which the user lives her experience.

The rise of design-for-systems has further consequences. Good form-giving is largely table stakes – necessary but not sufficient to ensure the success of new ventures. Beginning in the 20th century and accelerating in the 21st, new value-creation

has moved to the development of systems. The term platform is often invoked [43] in reference to complex, distributed interactions of hardware and software, networks and users, transactions and markets, for which primary examples are Alibaba and Amazon; Facebook and Google; Apple and Samsung [9][2]. Our definition of platform includes the capacity for others to build systems within it, no matter the medium.

Therefore, we wish to distinguish two levels of design: 1) design of things to be used, including tools used to make other things, and 2) the design of situations in which others can create, that is, the design of platforms, including languages. Level 1 we may call first-order design; level 2 we may call second-order design – that is, design-*for*-conversation.

Design for complex problems that bridge product-service ecologies requires new skills:

> Looking at a specific system, recognizing the underlying pattern, and describing the general pattern in terms of the specific system constitutes command of the vocabulary of systems, reading systems, and writing systems – that is, systems literacy. – Hugh Dubberly [10, p. 3]

3.4.2 If Systems, Then Cybernetics

> One of the things I should do is try to make a little difference between cybernetics and systems, or see if there is one. – Ranulph Glanville [17, 2'28"]

From the 1960s, The Club of Rome [22] popularized systems dynamics (SD) as a modeling language for complex systems, and since then Donella Meadows' and others' work have brought SD to a wide range of populations, including design students [23]. Conceived as a toolkit for explaining ecologies and economies, the vocabulary of SD – resource stocks and their flows – is well suited to its original application. However, we see limitations in SD for modeling systems for interaction. Meadows only briefly mentions regulation. SD does not clearly differentiate system behaviors that are the result of variations in levels (stocks as well as flows of material things) from system behaviors that are the result of feedback (flows of information). Perhaps most limiting is SD's lack of distinction between the effects of changes of levels (for example, an increase in population) and a deliberate act to effect an outcome (for example, a change of course of action as a result of new information, as when a comparator flips action from heating to cooling in a thermostat). Goals require agency, and agency implies actions taken intentionally based on data interpreted as feedback to the system's goals. (Of course we may attribute agency to a mechanical system when it behaves as if it has purpose, see Pask [30].)

Goals and information are about the immaterial aspects of systems while stocks and flows are very much the materiality of them. The originators of cybernetics sought to make a clear distinction between the material and the immaterial. Ashby

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[2] The platforms mentioned are grounded in digital technology and therefore incorporate hardware/software infrastructure, but not all platforms are digital (see later example of the Schiphol Airport signage system).

goes so far as to say "the materiality is irrelevant" [3, p. 1] in order to further distinguish cybernetics as a discipline focused on information in purposive systems. As Glanville states while invoking Ashby, cybernetic systems are "not subject to the laws of physics and energetics, but subject to the laws of information, of messages" [15, p. 4].

Because design involves human beings – what we want and how we might act to get what we want – systems literacy for designers must go beyond SD and incorporate goals and agency. Designers must therefore understand the workings of systems with agency. Cybernetics offers both language and models for understanding and describing such systems.

A cybernetic viewpoint on design also invites (if not demands) consideration of the capacity of a given system to achieve goals (whether imbued by a designer or inherent in the system itself). This of course is the concept of "variety" [3]. When the system is a team of designers, the question need be asked: Do we have the requisite variety to successfully design and construct an outcome that will achieve our goals?[3] This question raises other issues, already raised above: How do these goals arise, and whose are they? To answer requires a shift to second-order.

3.4.3 If Cybernetics, Then Second-order Cybernetics

I have also developed the analogy between second-order Cybernetics and design so as to give mutual reinforcement to both. Design is the action; second-order Cybernetics is the explanation. – Ranulph Glanville [14, p. 22]

Today's most critical (design) challenges are global in scale and have direct impact on quality of life – and its very existence. They include the future of the climate, water, food, population, health, and social justice. They are characterized as wicked problems [37] because the challenge to be addressed appears irredeemable. Even defining "the problem" is itself elusive, subjective, and controversial. Calling these situations problems is misleading; a better term might be "mess" or "tangle".

What is worse: Wicked situations are impossible to solve fully; rather, we work as hard as we can to minimize their negative effects, but we cannot eradicate them. In part this is because these situations operate across complex systems of systems, with emergent and unpredictable behaviors, including unintended consequences, even when well-intended actions are taken. And furthermore, some of the systems employed are human networks, comprising ecologies of language and conversation, with concomitant ambiguity, conflict, and human defects at play.

In sum, describing a wicked situation so that actions may be identified, whose execution has some likelihood of effectiveness, is a design challenge of great difficulty and greatest importance for our future.

Rather than speaking of "solving" in the context of wicked situations, the convention is to speak of positive change as "taming". Taming wicked situations requires

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[3] For elaboration of design for variety, which is beyond the scope of this paper, see [12].

framing – the subjective look at situations from a perspective that is only one possibility of many. Often stakeholders see a wicked situation from very different points of view; finding a new frame – "reframing" – is necessary for progress. The value of one frame above another is guidance to an effective path forward, usually through a frame's power to explain why the system behaves as it appears to behave. This is a form of taming complexity through language [41, 12]. Framing must support objective facts but only by being explicit about the values that forefront some "facts" above others. Fundamentally, it must create an argument for some design approaches above others – the "design rationale". Neither systems dynamics nor first-order cybernetics are enough (emphasis added):

> The systems-approach "of the first generation" is inadequate for dealing with wicked problems. Approaches of the "second generation" should be based on a model of planning as an argumentative process in the course of which **an image of the problem and of the solution emerges gradually among the participants**, as a product of incessant judgment, subjected to critical argument. – Horst Rittel in [37, p. 162]

The shared goal or problem definition emerges from the interactions of the participations as much as the solution does. We interpret this to mean that the problem and its solution are "emergent", in today's jargon – co-emerging as an image, that is, a characterization or (re)framing. Thus Rittel and Webber themselves reframe design-as-problem-solving to design-as-problem-finding or needs-finding. Rittel is important in part because he is among the first to frame design as politics – as discussion and argumentation – as opposed to design-as-art or design-as-science [36, p. 144]. Similarly, Buchanan [4] later framed design as a branch of rhetoric.

Rittel points out that the stance of designer as expert problem-solver is largely a myth. There are few design problems with clear solutions. Design is not objective; it's subjective. It's messy. The designer never stands outside the situation. The designer is always part of the situation – and other stakeholders also have necessary roles to play in the design process.

Thus design becomes centered in an argumentative process that involves "incessant judgment, subjected to critical argument" [37, p. 162]. Rather than existing outside the design situation, judgment and argument appear inside when the stance is that of second-order cybernetics. For the shift from first-order to second-order occurs when the observer – the designer, the modeler, the problem-framer, the participant in design conversations – is aware of her observing.

In sum, design for wicked problems, and the required (re)framing, calls for second-order cybernetics, which makes the role of the observer explicit, which in turn makes explicit the subjective position of every design rationale.[4]

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[4] For an eloquent exposition of the emergence and practitioners of second-order cybernetics along with a glossary, Glanville [14] is highly recommended.

3.4.4 If Second-order Cybernetics, Then Conversation

> Conversation is the bridge between cybernetics and design. – Ranulph Glanville [15, p. 8]

> Design is a circular, conversational process. – Ranulph Glanville [14, p. 22]

Reaching judgments and making arguments are, of course, forms of conversation. Glanville further tightens his assertion about the relationship of design and conversation by stating that conversation is a requirement for design, even when the conversation is with oneself, perhaps just using pencil and paper. (Schön [38] makes a similar point.) There is the person who draws and the (other yet the same) person who looks. The difference between these personae – between making and observing/reflecting – is, in and of itself, a major source of "novelty", Glanville claims. (We prefer the terms "variation" or "invention". Our position on the role of novelty in design is given below.) Engaging multiple perspectives is a necessary condition for conversation, and without conversation, he writes, "You're not doing design, you're doing problem-solving."[5] Design, instead, is "to do something magical" and "to find 'the new'" [15, p. 10].

With compatible meanings, Rittel, Buchanan, Glanville, Negroponte [24], and Pask [32] describe design as conversation, which can be modeled as two (or more) second-order systems interacting, which in part can be a discussion of goals. We state elsewhere [8] that conversation is required in order to converge on shared goals. To share goals is to agree on (re)framing a situation in order to act together. We see the development of arguments in the course of designing (for or against different ways of framing situations) and the derivation of different choices or actions as the same as conversation. Thus we concur with Glanville's eloquent, albeit general, statements about conversation, cybernetics, and design.

However, we find some of Glanville's stated positions to be assertions without an accompanying rationale. For example, he was clear and even adamant that design knowledge is tacit, not explicit. We take this as part of his argument that design knowledge exists only in relation to action. If design is conversation, however, and if conversation is learning – very often, or at least consistently so in relation to design – then is not both the goal and the effect of the design conversation to make its subject explicit? We assert that for the major (design) challenges of today, making design knowledge explicit is a necessity. Form-givers may have the luxury of working alone, but designing systems and designing platforms require teams – and thus goals and methods must be made more explicit so that the resulting artifacts are coherent and actions are coordinated. Just as design is different than problem-solving, making choices in designing is different than making choices in creating a work of art. When designing, fit-to-purpose is the rationale for one choice above another; the question, of course, is do we agree on the purpose? When designing for systems, articulating

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[5] While we accept the distinction between design and problem-solving, we can imagine typical cases of problem-solving that require conversation. For example, a team might discuss how best to break down a problem into more manageable components. Likewise, much of education involves discussion of strategies for recognizing problem types and appropriate strategies for each type.

that rationale is an irreplaceable component of the design conversation that takes place across the individuals, disciplines, and languages that comprise a design team.

A retort might be that a given design conversation is about some specific situation or artifact – not about design. But then, a design conversation about design must be the subject of design education, and we arrive at the same point – making the tacit explicit is a requirement for effective design. Not doing so leaves design stuck in its medieval master-apprentice craft tradition, where change is slow, and innovation is difficult.

But any dive into specifics may lose sight of the universal need for conversations in order to design. Design conversations discuss goals, means, context (itself a conversation, not a state [5]), how-to-frame-the-situation (and who-advocated-for-what-position), what-to-conserve (what-we-value), what-to-try, how-to-evaluate-it, what-happened-when-we-tried, and what-to-try-next.[6]

3.5 The Responsibility of Designers

We have argued that 21st-century design requires conversation, as well that (in complete alliance with Glanville) design *is* conversation. When we say "conversation" we mean it explicitly in the second-order sense of recognizing our (subjective) participation in the process of framing and justifying our choices, and therefore our responsibility for it all.

> We human beings can do whatever we imagine if we respect the structural coherence of the domain in which we operate. But we do not have to do all that we imagine, we can choose, and it is there that our behavior as socially conscious human beings matters. – Humberto Maturana [20]

If designers are to be responsible for the process of design, we must seek the most effective tools and methodologies – and to document, evolve, and disseminate them into the community of design and into the world of wicked situations.

Therefore, designers must themselves be responsible for systems literacy as a foundation for design; for working within a second-order epistemology where they take responsibility for their viewpoints; for processes of collaboration through conversation; and for articulating their rationale as an integral part of their process. This has deep implications for the development of new design curricula.

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[6] Further work is needed to more carefully dissect and characterize the types of design conversations. One approach suggests that design for innovation requires four broad classes of conversations for these purposes: to agree on goals; to agree on means; to create new language, as required for innovation; and, in an over-arching conversation, to design the conversations required for design, from the perspective of requisite variety [27].

3.6 Implications for Teaching Design

Glanville was influenced by his experience of design methods during his time as a student at the Architectural Association in the 1960s. Perhaps it was in rejection to the "expert stance" of the first generation that he came to prefer to say that design is "at once mysterious and ambiguous" [16].

We agree that when narrowly interpreted in its first-order form, cybernetics as engineering may suggest a sort of problem-solving which accepts or even assumes goals rather than inviting conversation about what our goals should be. But in its second-order form – with subjectivity, values, and responsibility explicit – teaching design as cybernetics is more common sense than straight-jacketed engineering, more about possibility than determinism, more emergent than mechanical. Teaching vocabulary and grammar does not deny poetry. Quite the contrary: A knowledge of vocabulary and grammar, if not a prerequisite, seems at least a more fertile ground for the emergence of poetry, and her sister, delight.

Thus, we argue that "systems" – systems dynamics, first-order cybernetics, second-order cybernetics, and conversation theory – should be a series of courses in all design school programs [6].

The value of teaching systems to designers is that it will help them do better work. It will provide language and models for talking about (and thinking about) the world in which they work, the systems they design, and the process by which they design. It will make them more effective and more efficient. That is, introducing cybernetics to designers will make the design process more "rigorous", in the sense of "stronger" or "more compelling" – *not* more "correct".

3.7 Novelty, Design, and Second-Order Design

> For me, one of the most important things is how to find novelty, and that I don't think can be done by specification or purposeful action, it needs wobbly conversation and deep speculation. After it's found, it can be specified. – Ranulph Glanville [16]

While not presuming too much about Glanville's possible elaborations on the relationship of novelty and design, we want to be clear about ours: Novelty is *not* the primary goal of design. (There is a risk that traditional designers will hear the pursuit of novelty as the pursuit of new form for its own sake.) Like Glanville, we embrace conversations for design, specifically as a way of discovering new goals and new opportunities, as we co-construct our shared frames and persuading arguments. But as yet under-developed in our argument is the role of value and values. Design is a particular set of conversations, which explicitly and implicitly (to oneself alone or with others) embody what we value and what we seek to conserve. Maturana's framing of "possible change" in the context of "what we do not wish to change" is directly useful and actionable:

> Every time a set of elements begins to conserve certain relationships, it opens space for everything to change around the relationships that are conserved. – Humberto Maturana and Ximena Dávila Yáñez [21, p. 77]

Of course we must be aware of what we are conserving, to open the possibility of change. Unstated but what we hear implied in Glanville's position is the notion that the results of design should not be fixed – that is, that designers create possibilities for others to have conversations, to learn, and to act.

This idea is transformational – a paradigm shift. Le Corbusier's publication of *Le Modulor* [19] may be a fulcrum point, the visible signal of the new paradigm. Another signal of the new paradigm was Karl Gerstner's publication of *Designing Programmes* [13], "Instead of solutions for problems, programmes for solutions." (Much earlier, moveable type with its inherent reuse sets the stage for what comes after modernism, even as moveable type creates the revolution of modernism itself.) To single out one example in practice, the Schiphol Airport signage system from 1967 by the Dutch firm Total Design and Benno Wissing is one of the first and most famous examples in practice – creating not a complete system, but a system in which others can create. As a platform for creating – in our terms, a platform for conversations for designing – a signage system is quite limited, but still the outlines are there. The relationship of designer to outcome is changed: The signage system is never completely finished, never completely specified, never completely imagined. It is forever open. "Second-order design" has emerged. Design-*for*-conversation is born.[7]

Pask saw this potential and began to explore it through his experimental machines, which sought to engage people in conversations [31]. Influenced by Pask, Negroponte went so far as to imagine an "architecture machine" able to collaborate with designers in designing spaces, physical and virtual, literal and metaphorical. Such a machine embodied design-*as*-conversation to enable design-*for*-conversation. In 1967, the idea of the architecture machine gave rise to a research group co-founded by Negroponte. Amid the convergence of digital content, digital communication, and computing (including the PC revolution), MIT's Architecture Machine Group set the stage for the MIT Media Lab, which opened in 1985 to house an assortment of research directions. Yet, the original idea of the architecture machine was set aside and remains unrealized.

We see design-for-conversation as the emergent space of design for the 21st century and aim for it as our goal. Whether designing interactive environments as computational extensions of human agency or new social discourses for governing social change, the goal of second-order design is to facilitate the emergence of conditions in which others can design – to create conditions in which conversations can emerge – and thus to increase the number of choices for all.

> I shall act always so as to increase the total number of choices. – Heinz von Foerster's Ethical Imperative [41, p. 282]

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[7] Chatbots, such as Elisa and her many spawn, e.g., *Mattel*'s Hello Barbie, which follow pre-defined script trees, are not examples of design-for-conversation. Nor are voiced agents, such as Siri and Alexa. Indeed, the current fad for so-called "conversational interfaces" misses the point of conversation [28].

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