Chapter 4

NOR: Truth Table, True Distinction

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> Oh, cried Humboldt, so what was science, then? Gauss pulled on his pipe. A man alone at his desk. A sheet of paper in front of him, at most a telescope as well, and a clear sky outside the window. If such a man didn't give up before he reached an understanding, that, perhaps, was science. (Daniel Kehlmann, *Measuring the World*)

In his 1926 life-size poster "Der Mensch als Industriepalast" (Man as Industrial Palace), physician and infographics pioneer Fritz Kahn draws on the state of the art, science, and technology of the second industrial revolution to depict core processes of the human organism as if it were a factory: tubes filled with chemicals, a metabolic division of labor in assembly lines, a mechanical pump for the heart, a camera for the eye, and a telephone switchboard for the central nervous system. The higher brain compartments, however, are still Gutenberg Galaxies of books and humans, devoid of any industrial technology. At the time, computers were clearly wetware.

At the turn of the next industrial revolution, George Spencer Brown was one of these human computers in a brain compartment of a British radio transmission equipment manufacturer, Mullard Equipment Limited, whose Technical Publications Department features as sponsor and potential publisher of his typescript *Design with the NOR*. This 1961 typescript shows that Spencer Brown's 1969 book *Laws of Form* adds a veritable piece of hardware to the libraries of industrial man, whose updated wetware can now think like a transistor.

The *Norigin* of the Form

George Spencer Brown's distinct form of distinction is a notoriously elusive concept and has, therefore, motivated different attempts at drawing it.

While the "mark" or "cross" clearly is the perfect token of perfectly condensed "continence," it is equally clear that its complexity must be unfolded if it is to act as the famous difference that makes a difference (cf. Bateson, 1972).

George Spencer Brown's "Design with the NOR": With Related Essays, 33–39

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One particularly comprehensive depiction of the form is Louis Kauffman's (2001, p. 98) *Planar Graph of the Rhombic Dodecahedron*, which integrates the different states the form can enter. In this volume, Divyamaan Sahoo's figures illustrate "that the primary distinction is drawn in the context of a current, or more generally in the context of a flow." The form has also been associated with the tetralemma, an ancient matrix structure used in traditional Indian logic (Roth, 2017). Other forms of representation include an unnamed figure by Boris Hennig (2000, p. 166), which may be deciphered as a model of the white cross (Roth, 2017, p. 1473).

In the "Annex 2. The calculus interpreted for logic" to his Laws of Form, however, Spencer Brown (2015, p. 90) implicitly concedes that his calculus of distinctions did not emerge from the unmarked space, but rather was inspired from his wanderings in the fields of logic; and the 1961 typescript *Design with the NOR* shows now that these fields were located in the realms of his work on "the transistor NOR unit."

This transistor and its various models represent, therefore, early forms of the form. Inasmuch as transistors implement and are correctly represented by truth tables, a NOR truth table might be the original image of the form.

True Forms

If the NOR transistor, and thus the original form of the form, may be confused with a NOR truth table, then the relationship between truth and distinction is as obvious as complex. An example of a binary and digital NOR truth table is given in Table 1.

In the truth table for this NOR gate, 1 stands for true and 0 for false. More classical tables use the capital letters T and F for true and false, respectively. In either version, we see that a NOR defines as true only those cases where both A and B are false.

Truth, therefore, is inherent to the form or, at least, the original form of the form. If we take "the form of distinction for the form" (Spencer Brown, 2015, p. 1), then we find that its original form is the distinction between true and false distinctions. Moreover, NOR seems to appear twice as both the only true distinction in row one (0,0) and the distinction distinguishing the true from the false distinctions (see also Fig. 1).

Table 1. Example of a Binary NOR Truth Table.

Input		**Output**
A	**B**	**A NOR B**
0	0	1
0	1	0
1	0	0
1	1	0

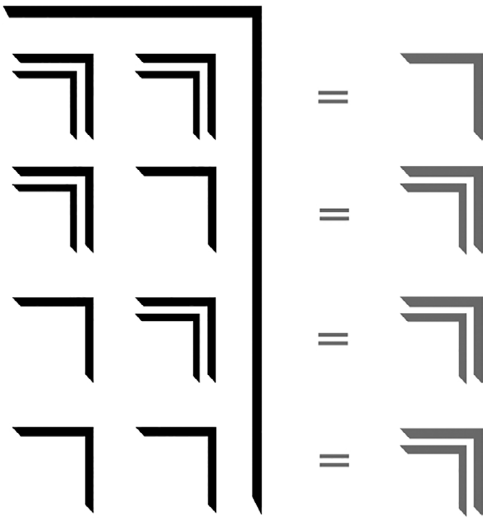
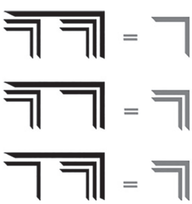


Fig. 1. A NOR Transistor as Arrangement of Crosses.

Fig. 1 shows the NOR transistor as an arrangement of crosses. The arrangement is somewhat unorthodox in that it seeks to maintain aspects of the basic design of a truth table or punch card and thus implies that the "outer" cross left of the equals signs applies to each of the four "inner" states, which, therefore, are,



And

respectively. That said, a black cross may be confused with a 1 (or "true") and a "white" double cross with a 0 (or "false"). In the absence of input, therefore, the NOR transistor truly is what it is. This is also the case with row one in Table 1, when the state of the transistor may be safely be confused with its outer border when a NOR transistor "is" the state of NOR. In all other cases, the transistor detects something that it is not and is therefore false.

Thus, a design with the NOR makes it possible to distinguish two different forms of true distinctions from false ones: the indication of its default distinction and the distinction that makes this indication come about. Note that the remaining rows below the NOR default state contain two cases of NOT and one of AND, which are default states of different forms (of transistors). NOR, therefore, is a true distinction that contains both true and false distinctions.

Continence, however, is a delicate matter because it must be perfect to define a distinction: "Distinction is perfect continence" (Spencer Brown, 2015, p. 1). To be true by this definition, a distinction must, therefore, split the entire space of reference into separate sides or states that are mutually exclusive and jointly exhaustive. As Spencer Brown (1961) demonstrates on p. 3 of Part I of the NOR typescript, this perfect split is rendered possible by a digitalization of inputs that makes it possible to transcend the limitations of binary thinking, as discussed on p. 1 of Part II. The example on the previous page states that a NOR unit can perform its sole operation "neither A nor B nor C nor…" precisely because the unit ultimately does not discriminate between these input variables anymore. This digital design, however, works only if the distinguished variables are (a) mutually exclusive and (b) jointly exhaustive; that is, only if (a) there are no overlaps, and thus no short circuits, between the variables, and if (b) all relevant inputs have been wired to the digital unit.

In this sense, the NOR, and hence Spencer Brown's cross, is a true distinction by these measures. Paradoxically, however, it also contains distinctions for which this judgment does not apply. Fig. 1 shows that NOR is functionally complete in that it contains AND and NOT. Yet "in" the NOR, these false distinctions are expressed by true distinctions.

This "logical" reading of the NOR typescript leads to the conclusion that the original form of the form is a true distinction (truth table) that distinguishes between true and false distinctions. As a true distinction, the cross splits the world into mutually exclusive and jointly exhaustive sides or states and is functionally complete insofar as it can simulate the functions of other distinctions.

Forms of Truth

The NOR typescript suggests that George Spencer Brown's cross as well as his laws of form were inspired by his work on "the transistor NOR unit." Paradoxically, however, it is hard, if not impossible, to draw a proper model of the NOR unit using the crosses it inspired. Inasmuch as transistors implement or correspond to truth tables, this problem amounts to the challenge of imagining the cross-tabulation that inspired both the crosses and the laws in ways other than as arrangements of "white crosses" or (()).

This problem corresponds nicely to Spencer Brown's observational switch from unit(y) to difference. Yet it might also point at a blind spot that results from his chosen strategy to deparadoxify the paradoxes he encountered in his work with the new transistor. Much like the fictional Carl Friedrich Gauss in the above motto, Spencer Brown, as a wetware computer sitting in a *Mullard Equipment Limited* brain compartment, had little more than paper and pencil to report on his journeys through a realm as dynamic as is a transistor, which required him to map time onto space. In this sense,

Or

Are states of the NOR transistor and, as such (and like any arrangement of crosses), time frozen in space.

As fascinating as this approach is, it remains an ingenious exercise of "one man, one sheet, one pencil," an exercise that is blind to the social context in which it is performed. This is not at all to deny the heroism of the discovery of either the cross or the later laws, but rather to point at the circumstance that the discovery of even the most universal mathematical operator takes place in a context of communication. Communication, therefore, is also the context of the original NOR transistor and the corresponding truth table.

From a communicative perspective, both a transistor and a table constitute forms of communication. Moreover, they – like all forms of tabulation – constitute communicative forms that translate from one form of communication into another.

Table 2 shows that this digital truth table translates between two different forms of communication, and thus also two different forms of truth.

In the first two columns from the left, "1" means "true" and "0" means "false" in the sense of the absence or presence of the two variables "A" and "B." In social systems theory, on which Spencer Brown's work had decisive influence (Luhmann, 2013a, p. 43), *interaction* is the term that applies if the difference between absence and presence guides our observation (Luhmann, 2013b, p. 113ff). From this perspective, the two left columns refer to an interactive concept of truth.

The right column, by contrast, presents the result of a conditional program: *if* "neither A nor B" is present, *then* the table reports a "1" or "true." In social systems theory, conditional programs are a variety of decision programs (Luhmann, 2018, p. 213), which in turn, belong to the decision premises, and more generally to decisions as forms of communication that communicate their own contingency. The program extends across all columns as it translates interactions into

Table 2. A "Socialized" Example of a Binary NOR Truth Table.

Interaction		**Decision**
A	**B**	**A NOR B**
0	0	1
0	1	0
1	0	0
1	1	0

the decision reported in the right one. In this translative sense, decisions contain interactions and make truth appear as a matter of *decision*.

The cross refers to the NOR transistor or the corresponding truth table. The cross, therefore, refers to a communicative device that acts as an interface of interaction and decision (and, to some extent, other forms of communication, too).

In fact, the question whether this device works properly cannot be answered without knowledge of its function. If this function is truth, then the device refers to the function system called science, whose medium is truth and whose code is true/false.

As noted earlier, however, his "Annex 2. The calculus interpreted for logic" to the *Laws of Form* shows that Spencer Brown (2015, p. 90) took the device from its original context and defunctionalized it so that it can now perform other functions beyond the fields of logic and truth.

Still, for science in general and social theory in particular, the original function of the cross is more than sufficient. This is even more true for a social theory in which science is defined by distinctions between true and false drawn in the medium of truth.

Thus, a challenge worthy of the wetware computers in the Gutenberg galactic brain compartments of the social sciences departments of the fourth industrial revolution would be to think of how crosses, tables, or transistors must be arranged to allow for what has recently been dubbed the digital transformation of social theory (Roth, 2019; Roth, Dahms, Welz, & Cattacin, 2019).

If social systems theory is to play a role in this transformation, then it must help solve the puzzle of how arrangements of crosses can capture or at least relate to the original form of the form that inspired the design of its own theory architecture: the NOR transistor and the corresponding truth table.

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References

Bateson, G. (1972). *Steps to an ecology of mind: Collected essays in anthropology, psychiatry, evolution, and epistemology*. Chicago, IL: University of Chicago Press.

Hennig, B. (2000). Luhmann und die formale Mathematik. In M.-B. Peter-Ulrich & G. Wagner (Eds.), *Die Logik der Systeme. Zur Kritik der systemtheoretischen Soziologie Niklas Luhmanns* (pp. 157–198). Konstanz: Universitätsverlag Konstanz.

Kauffman, L. H. (2001). The mathematics of Charles Sanders Peirce. *Cybernetics & Human Knowing*, *8*(1–2), 79–110.

Luhmann, N. (2013a). *Introduction to systems theory*. Cambridge: Polity Press.

Luhmann, N. (2013b). *Theory of society* (Vol. 2). Stanford, CA: Stanford University Press.

Luhmann, N. (2018). *Organization and decision*. Cambridge: Cambridge University Press.
Roth, S. (2017). Parsons, Luhmann, Spencer Brown. NOR design for double contingency tables. *Kybernetes*, *46*(8), 1469–1482.
Roth, S. (2019). Digital transformation of social theory. A research update. *Technological Forecasting and Social Change*, *146*, 88–93.
Roth, S., Dahms, H. F., Welz, F., & Cattacin, S. (2019). Print theories of computer societies. Introduction to the digital transformation of social theory. *Technological Forecasting and Social Change*, *149*, 119778.
Spencer Brown, G. (1961). *Design with the NOR*. Crawley, Sussex: Mullard Equipment Limited.
Spencer Brown, G. (2015). *Laws of form* (6th ed.). Leipzig: Bohmeier Verlag.