Visual Anatomy of Frame Creation in Abductive Reasoning by way of the Semiotic Square

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Abstract

Background Although the importance of dealing with paradoxes in frame creation in abductive reasoning has been discussed in design research (Dorst, 2011, 2015b), a logical approach to deal with paradoxes in problem solving has been lacking. We raise the following questions: If design reasoning is not random, what is a logical method that could be useful for designers to engage with paradoxes in the problem-solving process? What is a logical principle behind the interplay among complex meanings?

Methods We attempt to respond to these questions by proposing "the semiotic square" as a logical method to cope with paradoxes in frame creation in abductive reasoning (Greimas, 1987; Greimas & Rastier, 1968). It is assumed that since meaning is grasped in the relations of difference (Floch, 2001; Greimas, 1983; Greimas & Rastier, 1968), the semiotic square involving contrary, contradictory, and implicative relations may be useful to deal with complex meanings in design reasoning for problem-solving. We present the analysis of a design case based on the semiotic square with a diagram. We attempt to describe a logical principle behind the interplay among complex meanings in frame creation in abductive reasoning by use of the semiotic square.

Results The analysis of a design case shows that it is in the logical relations of contradiction, contrariety, and implication that working principles, paradoxes, themes, assumptions behind concrete practices from the problematic situation, and proposals for design solutions may be arranged and better grasped. We found that using the semiotic square in frame creation in abductive reasoning may facilitate the logical development of reasoning about the potential possibilities of design directions because a given meaning may be expanded upon the semiotic square.

Conclusions Using the semiotic square in problem-solving does not produce the solution directly, but it might help materialize the abstract process of frame creation in abductive reasoning. By following a logical path of the semiotic square while questioning the logic behind "WHAT + HOW = VALUE" (Dorst, 2011) and abductive reasoning that infers possible preconditions (WHAT + HOW) for the consequence (VALUE), one might find a simpler and easier way to deal with complex meanings from the problematic situation than managing the process without it.

Keywords Semiotic Square, Framing, Paradox, Abductive Reasoning, Meaning

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1. Introduction

There is a space between problem and solution where a paradox exists. It is not rare for designers to face a complex situation that includes a paradox in the problem solving process. A paradox in design practice appears when two or more statements that are true in their own right consist of a complex statement, but they “cannot be combined for logical or pragmatic reasons” (Dorst, 2015b, p. 51). For example, Dorst (2011) states it is true that the law enforcement is meant to reduce crimes and violence for public safety. However, a paradox emerges when security measures do not improve public safety, but rather produce a grim, forbidding environment, not an aspired result. However, Dorst (2011) argues that searching for the central paradox is one of experienced designers’ key design practices to read a problematic situation in a new way, to create a novel frame for the problematic situation, and to propose a solution.

Framing is defined as a design reasoning process that creates a new viewpoint to tackle a problematic situation; specifically, “framing in response to paradoxes in the problem situation” consists of the core of abduction in design practice (Dorst, 2011, p. 527). It is then in that space that involves paradoxes that design reasoning plays a role to engage with a solution. Schön (1983) also emphasizes that “frame analysis” is important because it provides possibilities for understanding the reality of the practice by helping practitioners become aware of their tacit frames that are bound up with approaches to problems, the values that have been prioritized or omitted, and the strategies for changing the situation. Further, with frame analysis, practitioners may move from being aware of previous tacit frames to exercising the perception of the possibility of different ways of framing the reality of their practice that practitioners would construct in their practice.

Although the importance of dealing with paradoxes in design reasoning has been discussed (Dorst, 2011, 2015b), a logical approach to deal with paradoxes in problem solving has been lacking. We raise the following research questions: If design reasoning is not random, what is a logical method that could be useful for designers to manage paradoxes in the problem-solving process? What is a logical principle behind the interplay among complex meanings? We attempt to answer these questions by proposing Greimas’ semiotic square (Greimas, 1987; Greimas & Rastier, 1968) as a logical method for design reasoning with which to perceive paradoxes from problematic situations and reframe in abduction toward possible solutions.

Articulating the design reasoning may be significant, in that making the process accessible could make it available to anyone who would like to use the process when necessary (Cross, 2007), especially to those who are interested in frame creation in abductive reasoning (Dorst, 2011, 2015b). We first review frame creation in abductive reasoning. We then analyze practices from a design case (Dorst, 2011, 2015b) by the semiotic square. Then, we attempt to describe a logical principle behind the interplay among complex meanings from the problematic situation in frame creation in abductive reasoning by use of the semiotic square. We present the analysis with a diagram. Finally, we discuss the usefulness of using the semiotic square in design practice.

2. Frame creation in abductive reasoning

Cross (2011) argues the logic of design reasoning is essentially abductive: "according to Peirce, 'deduction proves that something must be; induction shows that something actually is operative; abduction suggests that something may be.' It is this hypothesizing of what may be, the act of producing proposals or conjectures, that is central to designing" (p. 27). Since design reasoning produces "a composition or product," it is called "productive reasoning"; it also is called "appositional reasoning" because solutions are responses that are juxtaposed to or matched to the problem (p. 28). Since the relationship between working principles for solutions and results is not clear (Hahn, 2013), abduction in design necessarily involves a guessing act that proposes new relationships between how to deal with problems and solutions to achieve expected results.

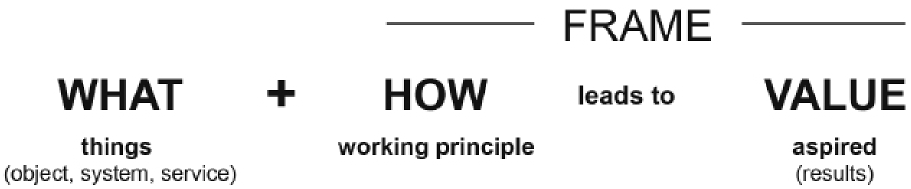

Figure 1 Frame creation in abductive reasoning (adapted from Dorst, 2011, pp. 523–525)

Dorst (2011), in the critical work, "The Core of 'Design Thinking' and its Application," presents the formula for frame creation in abductive reasoning as in Figure 1. Further, Dorst differentiates conventional problem solving that involves Abduction-1 from Abduction-2. Whereas designers propose only "what" in the equation based on the known working principle during "Abduction-1," they create both "what" and "how" for the aspired "value" during "Abduction-2." The "what" in the equation may be "an object, a service, or a system" (Dorst, 2011, p. 524). However, Dorst (2011) argues that experienced designers approach the challenge of Abduction-2 very differently from novice designers; While novice designers are likely to randomly create "what" and "how" toward "aspired value," experienced designers use a deliberate strategy of framing with the following logic: "IF we look at the problem situation from this viewpoint, and adopt the working principle associated with that position, THEN we will create the value we are striving for" (p. 525). Once a promising frame is proposed, the next step is to design the "what." A rigorous process for testing and forming the equation then follows to see if the "what" plus "how" would really produce the aspired "value." Therefore, it is important to note that experienced designers' framing for Abduction-2 operates at a meta-cognitive level that mediates reflection on the perception of the problematic situation and solutions for the aspired outcome simultaneously. Framing in Abduction-2 constructs the open condition for interacting with possible solutions, including proposals of things, working principles, and their combinations, without losing designers' awareness of the aspired value.

3. Paradox as an object of design reasoning

Dorst (2011) argues that "framing in response to paradoxes in the problem situation" is the core of abduction in design practice (p. 527). He also shows that finding themes from the problematic situation and exploring them is a method to analyze the problematic situation, which is then linked to reframing. We view that if paradoxes demand reframing of a problematic situation, then paradoxes are critical objects of design reasoning that requires a specific analytical reasoning skill. If designers have a method to analyze paradoxes in a problem situation in a logical way, reasoning about possible solutions might be easier. How to deal in a logical way with paradoxes from the problematic situation seems to be significant because this is precisely where design reasoning plays a role to engage with possible solutions.

4. The semiotic square

The semiotic square, originally proposed by Algirdas Julien Greimas (1966), has been used in diverse research such as advertising (Cian, 2012), marketing (Oswald, 2015), and visual communication design (Craib & Imbesi, 2014). However, its usefulness as a logical method for design reasoning, especially in frame creation in abductive reasoning, has been discussed little.

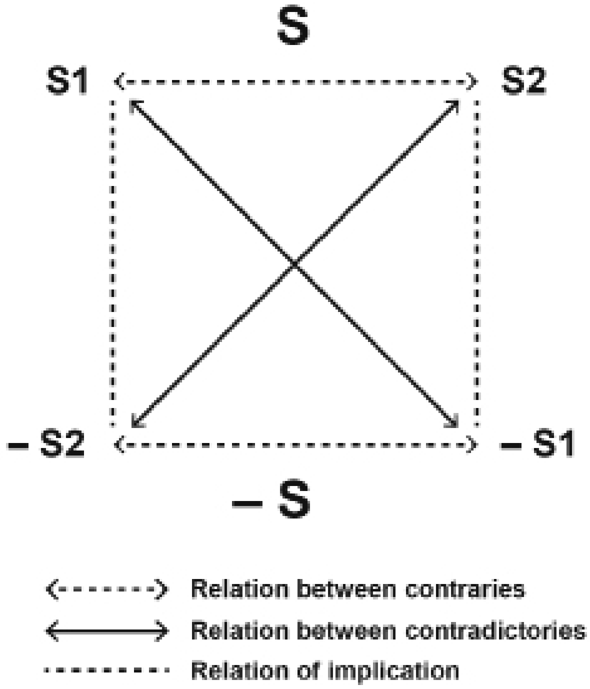

Figure 2 The semiotic square (adapted from Greimas, 1987, p. 49)

The basic idea of the semiotic square is that following Saussure, meaning is understood in the relations of difference (Floch, 2001; Greimas, 1983; Greimas & Rastier, 1968). By taking two operations, the contradictory and contrary relations, a given concept is understood in its differential relations (Greimas & Rastier, 1968). In Figure 2, Greimas (1987) describes that a binary opposition of S1 and S2 consists of a semantic axis S when S presupposes an absolute absence of meaning, taken its contradictory –S. Also, S1 and S2 presuppose their respective contradictories –S1 and –S2; –S2 and –S1 implies S1 and S2, respectively. Thus, the semiotic square visually captures "the relations that exist between the distinctive features constituting a given semantic category" (Floch, 2001, p. 145).

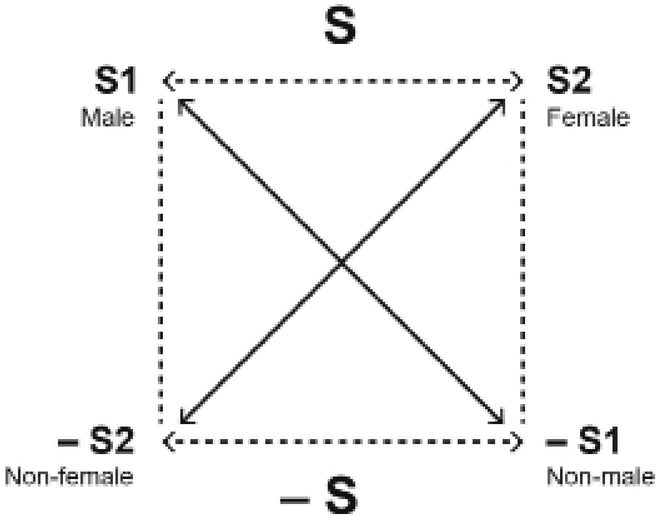

Figure 3 An example of the semiotic square (Kwon & Shin, 2003, p. 143)

In Figure 3, the semiotic square visually arranges a concept male in its relational structure and presents its presuppositions in a logical way so that male is understood in the relations of difference. A meaning male presupposes its contradictory term non-male, its contrary term female, and its complementary term non-female. From a semiotic viewpoint, meaning of a concept is grasped in relation to something that it is not (Kim, 2003). Male is understood in this way; male is not female, male is not non-male, and male is not non-female. The four positions in the semiotic square are not material, physical positions, but conceptual positions that reveal a meaning (Kim, 2003, p. 286).

Also, the semiotic square visualizes systematic dimensions of logical meaning relations and the structure of presuppositions in which the meaning of an element belongs. It must be emphasized that the logical quality of the semiotic square may enable us to anticipate "both of the ways in which meaning may unfold, and of positions of meaning that are logically present but not yet in force. Above all, the themes, images, concepts and expressions 'positioned' on the semiotic square always exist in defined logico-semantic relations" (Floch, 2001, p.145).

5. The semiotic square as a logical method for design reasoning

We contend that the semiotic square may play a role in design reasoning, especially in frame creation in abductive reasoning, as a logical method to structure and reveal meaning relations for the following reasons. First, since the semiotic square objectifies distinctive relations of a semantic category in the logical structure and logically organizes meaning relations, it may help with the logical analysis of meaning relations of complex design problems. In particular, using the semiotic square may facilitate a logical approach to build logical meaning relations in the phase between exploring a working principle and themes that emerge from a problem situation and creating a new frame to see the situation from a different viewpoint while problem-solving. Employing the semiotic square may form the condition of reflective modes of design reasoning because it is a logical framework with which to quickly separate meaning relations from the content.

Second, the arrangement of the four elements on the semiotic square shows logical transformations of a given meaning (Kwon & Shin, 2003, p. 146) because one can obtain the logically differential three meanings by taking the contradictory and the contrary (Greimas & Rastier, 1968). That is, the semiotic square maps the potential possibilities of the element, which may be something that is not yet in force, but that we could foresee. This suggests that a given concept may expand on the semiotic square. Finally, mapping the possibilities of meaning elements may contribute to flexibility of thought from the viewpoint of framing and abductive reasoning.

6. Method

We ask, if design reasoning is not random, what is a logical method that could be useful for designers to engage with paradoxes in problem solving? What is a logical principle behind the interplay among complex meanings? We attempt to respond to these questions by proposing the semiotic square as a logical method for design reasoning, especially frame creation in abductive reasoning.

Our assumptions behind the proposal of using the semiotic square in frame creation in abductive reasoning are as follows: the role of framing is to generate a new viewpoint for the problematic situation from which designers move forward to the solutions; before framing for solutions, it is essential to perceive a working principle that has underpinned concrete practices from the problematic situation (Dorst, 2011). However, if paradoxes are found in the problematic situation, they may be associated with a specific frame involving a working principle that failed. But paradoxes might not be established under the different condition with a different frame involving a different working principle.

Further, since we view that concrete practices may be found around or constitute “what component (things: object, system, service)” in the equation and “how (working principle)” is implied in workings of “what” component, we locate concrete practices under a concept of a working principle in the S1 position in Figure 4.

However, when designers intend to overcome paradoxes stuck to a working principle in a failed frame, they develop a new viewpoint to tackle the problematic situation. In this frame creation, what is needed is a transition of a concept for a working principle. However, we view that the transition of a concept of a working principle might be facilitated with the semiotic square because one can obtain the logically distinctive three other concepts using any of the four conceptual positions in the semiotic square. The semiotic square can be repurposed to examine logical possibilities of a given concept because by taking two conceptual operations, the contradictory and the contrary, the arrangement of the four conceptual positions in the semiotic square may reveal at a glance logical transformations of a given concept. If meaning of a concept is grasped in relation to something that it is not, i.e., meaning is grasped in the difference, from the semiotic viewpoint (Kim, 2003), a concept of a working principle that has been used, whether consciously or unconsciously, in the problematic situation might be better understood around what has not been meaningfully dealt with.

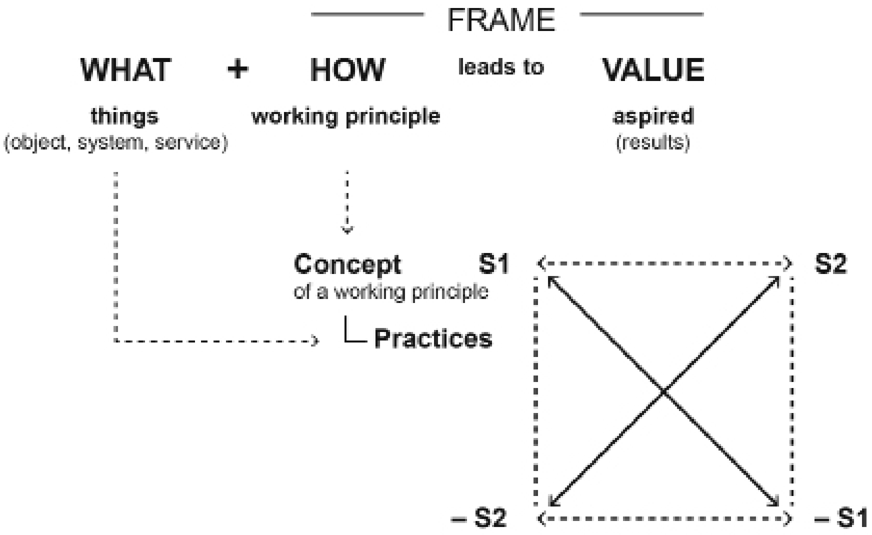

Figure 4 Frame and the semiotic square

For example, if we locate a failed working principle on the S1 position in Figure 4 and move from S1 to –S1, we can obtain the absence of meaning of a failed working principle on –S1 position, taken as the contradictory of S1. It might be noticeable that while we take a logical transition from the failed concept on S1 position to –S1 position, paradoxes stuck to a failed concept might be released because –S1 position means the absence of the failed concept and paradoxes might not work in the absence of the failed working principle. That is, paradoxes might not work under the different condition.

Although the four positions of the semiotic square do not explicitly represent the relationship between a working principle and the aspired value, if a concept on S1 position is not compatible with the aspired value, a concept on –S1 and S2 position might be compatible with the aspired value because the quality of a concept on S1 position is absent in the two concepts on –S1 and S2 position.

But if a concept on the S1 position associates with paradoxes in relation to the aspired value, a concept on –S2 position might be still linked to the paradoxes because a concept on –S2 position implies a concept on S1 position. Therefore, it seems that intentionally applying the two conceptual operations, the contradictory and the contrary of the semiotic square, to a working principle from a paradoxical problematic situation allows us to distance ourselves from a way of viewing the problematic situation and to come up with logical transitions from a failed working principle. This may lead us to a possibly compatible concept in relation to the aspired value that could be tried in the problematic situation. Table 1 shows the possibilities of utilizing the semiotic square in design reasoning.

Table 1 Possibilities of utilizing the semiotic square in design reasoning

Possibilities	Descriptions
Logical analysis of meaning relations	With the semiotic square, one can quickly separate meaning relations from the content because the semiotic square objectifies distinctive relations of a semantic category in the logical structure and logically organizes meaning relations.
Mapping the potential logical possibilities of a given concept	Using a concept as a point of departure and taking the contradictory and contrary relations with regard to the concept, one can generate the logically distinctive three other concepts and arrange them in the semiotic square. The three concepts are logical transformations of the concept. They may be something that is not yet in force, but that we could foresee.
Reasoning about the potential possibilities of design directions	Intentionally applying the contradictory and contrary relations to a concept of a working principle from the problematic situation may allow us to distance ourselves from a failed working principle and to come up with a possibly compatible concept for the aspired value.

In order to see the role of the semiotic square in design reasoning, especially in frame creation in abductive reasoning, we analyze a design case of Kings Cross, the entertainment district (Dorst, 2011, 2015b) using the semiotic square (Greimas, 1987, p. 49). Dorst provides detailed descriptions of the design case in the materials (Dorst, 2011, pp. 528-530, 2015b, pp. 31-34 and in other several pages in the book) that are specific enough to access to what was a paradox, themes, frames, practices, and values. From the paradox, the themes found in the problematic situation, both failed and successful frames, concrete practices, and specific constituents for the equation (What + How leads to Value) in the materials, we were able to apply the method of the semiotic square to the design case. The questions we had at the beginning of this research were how the designers came up with a metaphor of a music festival for solutions in the design case. The transition of frames required an explanation simply because we could not describe the process.

7. Analysis of a design case based on the semiotic square

In this section, we analyze a design case of Kings Cross, an entertainment district, by means of the semiotic square to see if there is not a random but logical principle behind the interplay among complex meanings in design reasoning.

First, let us provide a summary of the design case's problematic situation based on the materials (Dorst, 2011, 2015b).
An entertainment area located in a metropolis visited by about 30,000 people on a good night was having problems of "drunkenness, fights, petty theft, drugs dealing and, later in the night, sporadic violence" (Dorst, 2011, p. 528). The local government's solution was "'strong arm tactics', increasing the police presence, putting in CCTV cameras," [and] requiring clubs to "hire security personnel" (Ibid.). Paradoxically, efforts to solve the problems worsened the situation, causing "not getting a good experience at all," "a grim public environment" by the "visible extra security measures," and "becoming increasingly bored and frustrated as the night progressed," which was far from the aspired value, "have a good time" (Dorst, 2011, pp. 528-529). In contrast with the local council's failed frame of the situation, which was "law-and-order problems, needing law-and-order solutions," designers successfully reframed the situation involving a new viewpoint of "organizing a good-sized music festival" from which design directions were developed.

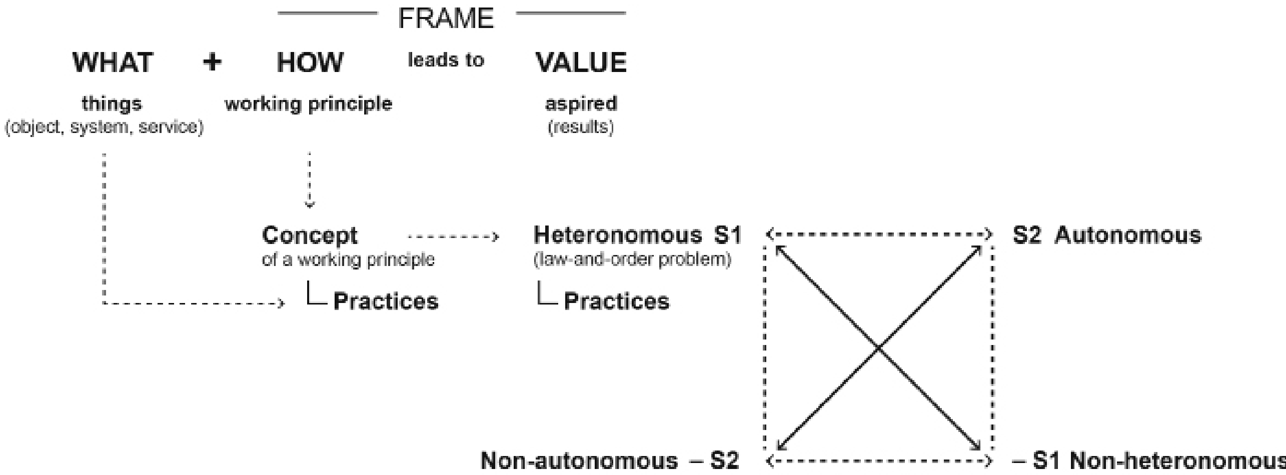

Figure 5 A concept of a working principle expanding on the semiotic square

Second, in order to analyze the design case by the semiotic square, we transformed the failed working principle of "law-and-order problems" into a concept "heteronomous" because a law manifest in the security measures external to people influenced or governed people's actions in the problem situation.

Using a concept "heteronomous" as a point of departure and taking the contradictory and contrary relations with regard to "heteronomous," we developed the logically distinctive three other concepts and arranged them in the semiotic square as in Figure 5: 1) since contradictory relations in the semiotic square are privative relations (Greimas, 1987), "non-heteronomous" on –S1 position means an absence of meaning heteronomous, taken as the contradictory to "heteronomous;" 2) the opposite of heteronomous, "autonomous" on S2 position means self-governed or acting independently or having the freedom to do so; and 3) "non-autonomous" on –S2 position means an absence of meaning autonomous.

As a result, the contrary pair, "heteronomous" versus "autonomous," consisted of the upper part of the semiotic square while "non-autonomous" versus "non-heteronomous" made the lower part. Also, it might be noticeable that "non-heteronomous, autonomous, and non-autonomous" are logical transformations of the concept "heteronomous" because we obtain the three others by taking the contradictory and the contrary relation.

We may see that non-heteronomous, autonomous, non-autonomous are meaningful elements that could be logically foreseen because they are potential possibilities even if they are not in force or even if they are not observed in the reality of the practice. For example, we might perceive the absence of autonomy in absolutely heteronomous situations and imagine autonomous situations.

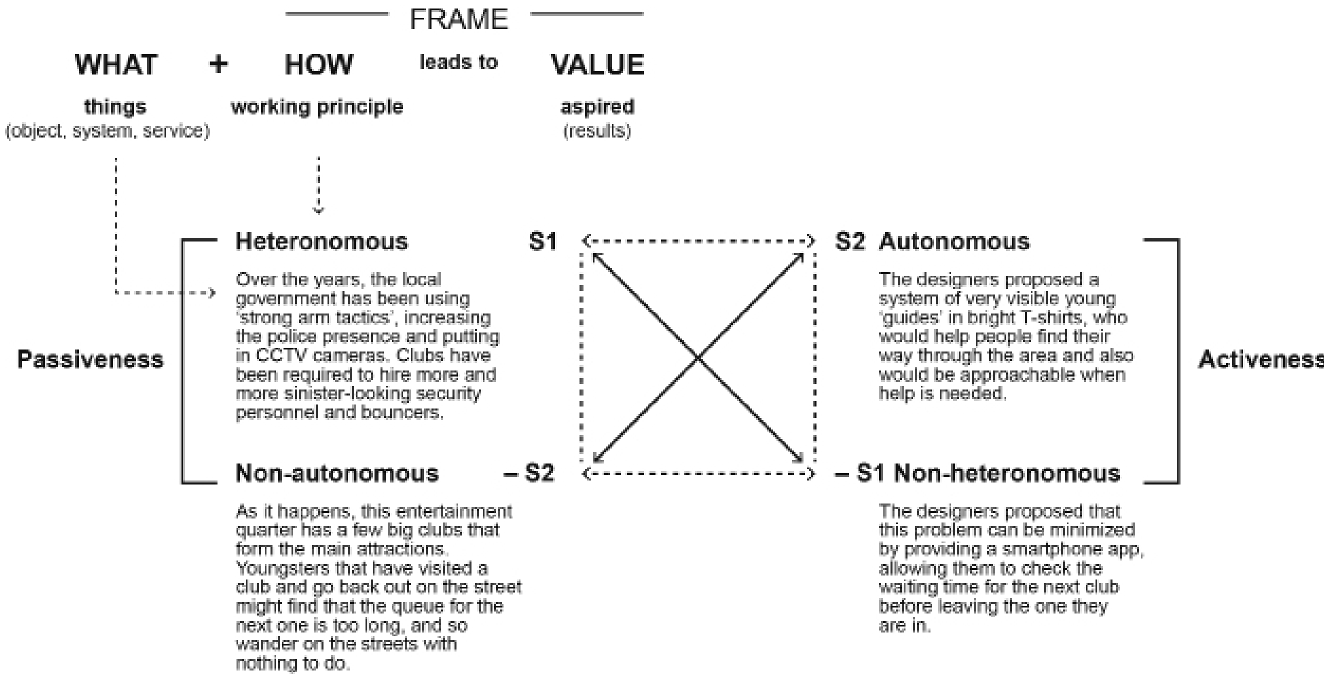

Figure 6 Projecting a working principle and practices onto the semiotic square

Third, after we logically expanded a meaning “heteronomous” (the failed working principle) into the four logically possible types of experience on the semiotic square, we projected concrete practices from the design case in the materials (Dorst, 2011, pp. 528-530) onto one of the four conceptual positions (heteronomous, non-heteronomous, autonomous, and non-autonomous) in the semiotic square as in Figure 6.

However, in this process, we examined if each practice was compatible with a meaning on a given conceptual position. For example, we located concrete practices such as “increasing the police presence, putting in CCTV cameras, and hiring more sinister-looking security personnel and bouncers” under a concept “heteronomous” on position S1 rather than “autonomous,” because what is implied in the practices is to act in accordance with the external rule, not to act in accordance with a self-governed rule.

On the other hand, a solution for wayfinding, such as proposing a system of visible guides to help partygoers find their way, may belong to the type of “autonomous” on position S2 rather than “heteronomous.” What the proposed system implies is that people have freedom to use a system of ‘guides’ depending on their needs, not a law forced on them.

The practices of “increasing the police presence, putting in CCTV cameras, and having more sinister-looking security personnel and bouncers” seem to be conceptually opposite of practices of “a system of guides.” Whereas possible behaviors may be reduced around a law that sorts out behaviors, some to be legal and some to be illegal in the first practices, possible behaviors may be increased around the infrastructure or the system proposed at the level of needs in the latter practices. The first practices negatively work through the mode of law and order simply to sort out crimes or not crimes, while the latter practices positively work through the mode of production to generate what could be right for a partygoers’ particular situation. Further, on the part of “What” component (things: object, system, service) in the equation, practices under “heteronomous” type may be described as “public space control,” while practices under “autonomous” type may be seen as “public space service.” What do people experience in the public space: the public space control by strong-arm tactics or public space service by options that suit their needs?

Moreover, the practices that are dependent upon situations, such as the partygoers’ wandering on the streets with nothing to do, belongs to the type of “non-autonomous” on position –S2 because there is nothing of object, system or service that people could use independently. However, regarding the type of “non-heteronomous” on position –S1, a solution for crowd control includes a smartphone app to allow people to check the waiting time for the next club; this is recognized in the absence of features of “heteronomous” experience and constructs a contradictory relation (S1 and –S1). Therefore, this analysis shows that it is in the logical relations of contrariety, contradiction, and implication that the practices emerging from the problem situation and proposals for the problem solving may be arranged and better grasped.

Further, mapping the elements from the problem situation by the semiotic square seems to be useful because it allows for reflective modes of logical reasoning in relation to assumptions behind concrete practices. The logical relation structure as in Figure 6 clearly shows that the failed methods framed by "heteronomous" (law-and-order problems) are found in the axis of partygoers' passiveness, and the successful methods exist in its opposite axis, activeness. Specifically, while partygoers' passiveness is assumed in the failed working principle of "heteronomous," partygoers' activeness is presupposed toward the aspired value of having a good experience in the successful working principle of "autonomous." What matters is the moving path from passiveness to activeness that reframing the problem solving involved. That is, the solutions are not shown in the same position of logical relations, but rather in the contrary axis.

This research does not solve the problems by using the semiotic square. However, the analysis of the design case by means of the semiotic square shows that operating a seemingly simple relational logical structure, the semiotic square, by taking contradictory and contrary relations on top of relevant issues may be a powerful logical method for design reasoning, especially in the logical expansion and transition in frame creation. Logical relations inherent in the semiotic structure reveal the arrangements of the potential possibilities at a glance. Conversely, following the logic may generate new viewpoints.
Therefore, the critical usefulness of adopting the logic of the semiotic square in design reasoning lies in the development of reasoning about the potential possibilities of design directions.

8. Visual anatomy of frame creation in abductive reasoning by way of the semiotic square

In this section, we attempt to describe a logical principle behind the interplay among complex meanings in frame creation in abductive reasoning (Dorst, 2011) for problem solving by way of the semiotic square (Greimas, 1987).

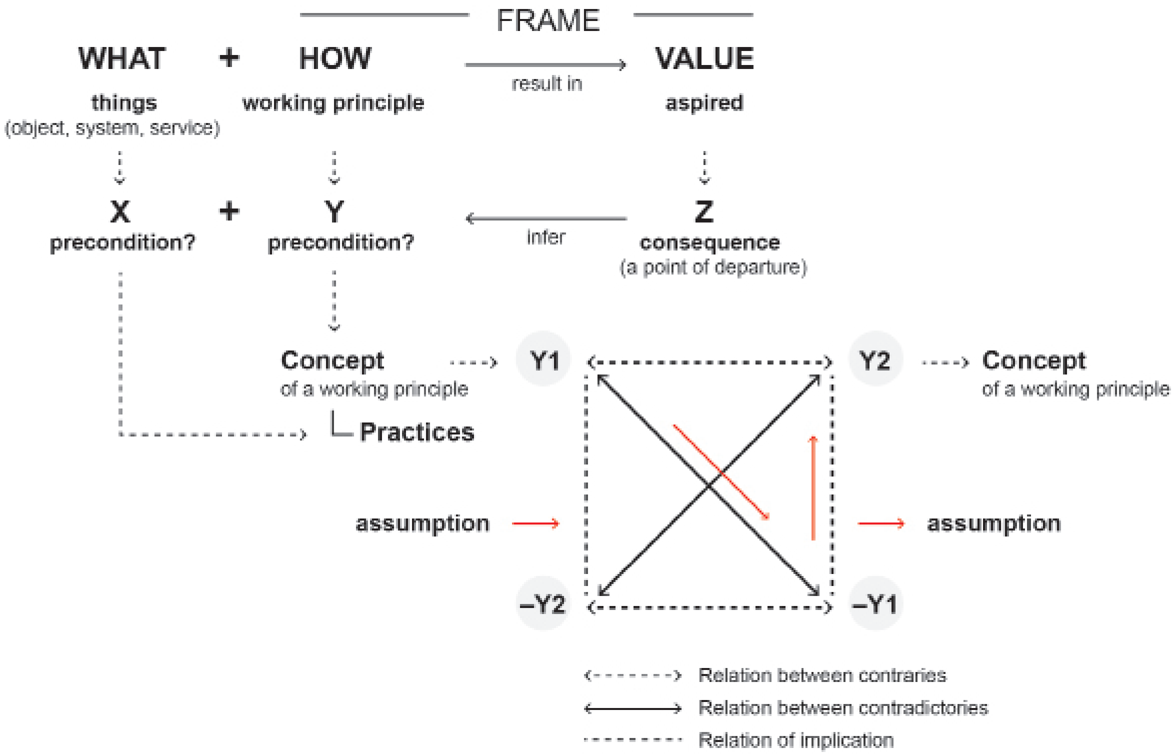

Figure 7 Frame creation in abductive reasoning by the semiotic square

Using the semiotic square seems to be especially relevant to "framing in response to paradoxes in the problem situation" in abductive reasoning (Dorst, 2011, p. 527) in that it helps examine the logic behind a working principle and paradoxes in relation to consequence.

The core challenge of abductive reasoning is that one needs to "think from consequences (value) back to causes (what) and working principles" (Dorst, 2015a, p. 3); in Figure 7, VALUE is the aspired consequence that designers intend to achieve in the future, but it is a point of departure to solve the problem in abductive reasoning. The black arrow (←) in Figure 7 shows that inferring possible causes or preconditions (X and Y) starts from the aspired value (Z). In this process, it is essential to ask what would result in Z? Under what conditions will Z be possible? Once the aspired consequence (Z) is determined, the next step is to hypothesize what may be of preconditions (X + Y) for the consequence (Z). In the equation, WHAT (object, system, service) and HOW (working principle) are preconditions for the consequence of VALUE, which needs to be proposed. The logic is that if an X based on an assumption Y is preconditioned, consequence Z may follow.

However, if X plus Y worsens the problematic situation, the abduction equation will be X + Y = –Z (not the value). In this case, Y is not compatible with the solution, and the paradox between methods framed by working principle Y and the consequence Z is formed. The paradox produces tensions such as "not getting a good experience at all and a grim public environment by the security measure in place, boredom, and frustration" in Dorst's (2011) design case.

How can we then release the tension? In a logical dimension, if Y is not compatible with Z and if X + Y produces what is not Z, then it would be necessary to transform the incompatible relation into the relation that is not incompatible with Z. If paradoxes are found in the problematic situation, they may be associated with a specific frame involving a working principle that failed. But paradoxes might not be established under the different condition that is structured by a different frame involving a different working principle. In order to remove the paradox in the case, abductive reasoning would involve inferring what is not Y (–Y) as a possible precondition or a cause to the consequence (Z). One may then imagine what is opposite to Y toward generating possible causes for Z.

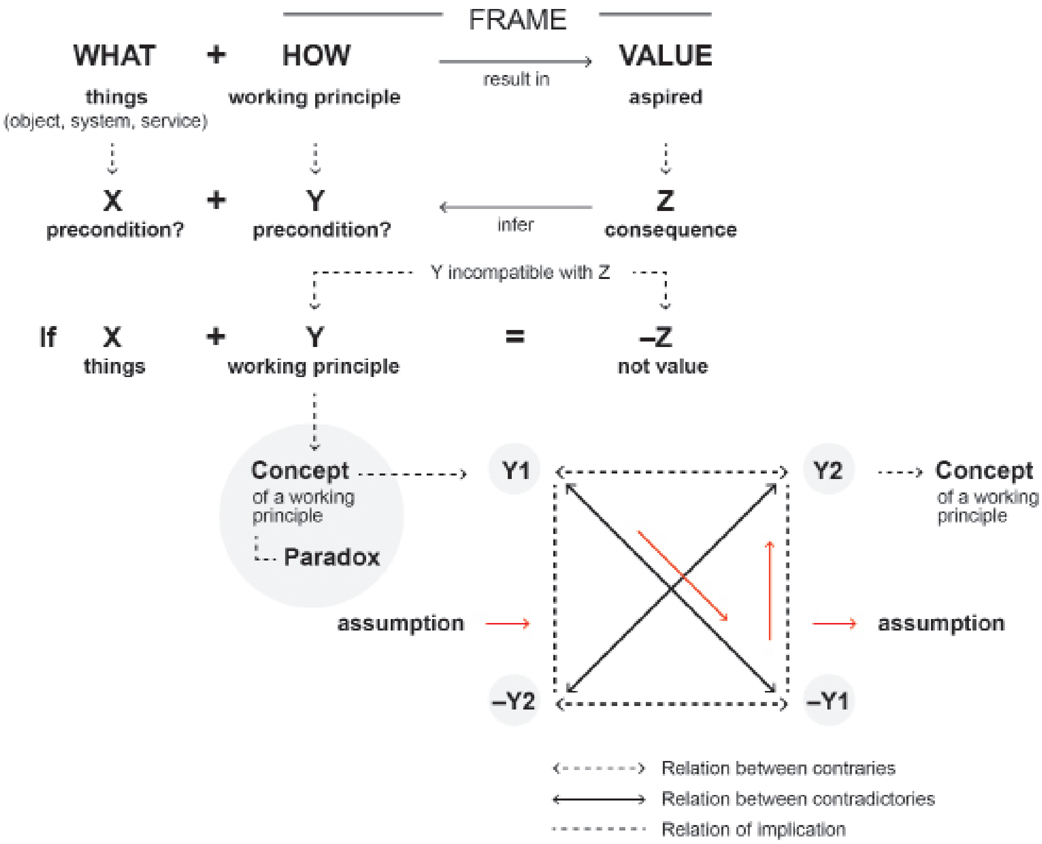

Figure 8 Frame transition in response to a paradox by the semiotic square

Using the semiotic square might facilitate this process, helping question the logic behind a working principle Y in relation to consequence Z. For example, let us say that a working principle Y1 is found in the problematic situation. We may project a working principle Y1 onto the S1 position of the semiotic square and follow its logical path. In Figure 8, by taking contradictory and contrary relations on the semiotic square, we may transform working principle Y1 to non-Y1 (–Y1) to the opposite of Y (Y2). If Y1 transforms into non-Y (that is contradictory to Y), then non-Y is not incompatible with Z. The paradoxes that are found in a frame with a working principle Y1 would not be established under the different condition that is logically contradictory to Y1, –Y1 and that is logically opposite to Y1, Y2. Thusly, the tension between Y and Z will be released.

In Figure 8, this process is expressed by the direction of red arrows, from Y1 to –Y1 to Y2. Y2 is contradictory as well as contrary to Y1 because –Y1 implies Y2.

Importantly, when we imagine other possible working principles that are not Y1 as well as that are opposite to Y1, what is implied is a shift of assumption: an opposite assumption behind working principle Y1. For example, in Figure 6, it was assumed that "having a good experience" (VALUE or Z in Figure 7 and Figure 8) would be possible under the assumption of partygoers' passiveness and preconditions of heteronomous behaviors, which turned out to be not true. If the solution was found in the contrary axis on the semiotic square, it would not merely be an accident.
Rather, this analysis suggests that the solutions are logically grounded on a different assumption. Using the semiotic square in problem solving does not produce the solution directly, but it might help materialize the abstract process of frame creation in abductive reasoning.

9. Conclusion

The point of departure for the approach of frame creation in abductive reasoning by way of the semiotic square was that we encountered the problem of explaining how to generate alternative frames that could solve the problematic situation in parallel with dealing with already complex paradoxes. Generating alternative frames rather than being buried under the previous frame while dealing with already complex paradoxes seemed to be a challenge for novice designers because the process seemed complicated. However, we thought if design reasoning is not random and if framing solves the problem of paradoxes intertwined with the problematic situation as the design cases (Dorst, 2011, 2015b) illustrate, then there might be a principle that works in dealing with paradoxes and reframing the problematic situation.

We have paid attention to "framing in response to paradoxes in the problem situation" in abduction (Dorst, 2011). If paradoxes from the problem situation demand the reframing of a problematic situation, then paradoxes against the aspired value are critical objects of design reasoning that requires a specific analytical reasoning skill. However, there has been little logical approach to how to deal with paradoxes and reframe the problematic situation, although frame creation is understood by a metaphorical understanding of a problem situation (Johnson, 1987).
We ask what is a logical method that could be useful for designers to engage with paradoxes for the aspired value, in the problem-solving process. We then propose the semiotic square (Greimas, 1987) as a logical method for design reasoning. It is assumed that since meaning is understood in the relations of difference (Floch, 2001; Greimas, 1983; Greimas & Rastier, 1968), the semiotic square's involvement of contrary, contradictory, and implicative relations may be useful to design reasoning for problem solving.

Based on the analysis by projecting a design case that involves frame creation in abduction onto the semiotic square, we found that in the logical relations of contrariety, contradiction, and implication, a working principle and practices emerged from the problem situation and proposals for problem solving may be better understood. Mapping of elements from the problem situation by the semiotic square seems useful because it logically facilitates reflective modes of reasoning in relation to assumptions behind concrete practices. Further, we found that the logic of the semiotic square might be very useful in design reasoning because it allows for the logical development of reasoning about the potential possibilities of design directions, and it reveals the logical structure of meanings.

Using the semiotic square in problem solving does not produce the solution directly. However, the advantage of frame creation in abductive reasoning by way of the semiotic square is that by following a logical path of the semiotic square while questioning the logic behind “WHAT + HOW = VALUE” (Dorst, 2011) and abductive reasoning that infers possible preconditions (WHAT + HOW) for the consequence (VALUE), one might find a simpler and easier way to deal with complex meanings from the problematic situation than managing the process without it. This way might produce more logically possible directions.

However, the limitation of this research is that since our method was to apply the semiotic square as a logical method for design reasoning to a single case that was completed successfully, the approach of design reasoning by the semiotic square needs more case studies to determine the validity of the method. Using the semiotic square in problem solving from the outset might be useful for the limitation. Also, in order to further progress the approach, more theoretical discussions about meaning in relation to frame creation in abductive reasoning would be essential.

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