Circulation: a Theoretical Toolkit

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Circulation: A Theoretical Toolkit

ABSTRACT: This paper introduces a framework which we believe has the potential to become a relevant toolkit for researchers involved in the analysis of design history and practice. We show how design can be understood as a circulation process, and how design elements can be understood as forms identified by design studies scholars, which can be followed as they circulate from one instance to another, being either created, conserved, or dissipated. Using the example of the evolution of the iPhone calculator, we illustrate how this framework facilitates a dynamic understanding of how design elements are transported and transformed when traveling through human and nonhuman entities.

KEYWORDS: design research, design history, design theory, circulation, meme

Introduction

Design studies, design research, design history, and other subfields related to the study of design have now been through a few decades of reflection to clarify their specificities in terms of theory and methodology. Several publications that summarize the current state of the art have been published recently, where authors discuss how to understand, define, and analyze design processes, the use and consumption of design, or the possibility for their fields to function as academic disciplines (see for instance, Clark and Brody 2009; Highmore 2009; Fallan 2010; Lees-Maffei and Houze 2010; Koskinen et al., 2011). While these authors present in detail their experience of the transfer of concepts and models from various disciplines such as history of art, cultural studies, philosophy, semiotics, cognitive psychology, or science and technology studies (STS), and provide an increasingly coherent theoretical grounding, the question remains as to what kind of theoretical background and methodological approaches are better suited to the needs of design scholars.

In this paper, we introduce a framework which we believe has the potential to become a relevant toolkit for researchers involved in the analysis of design history and practice. Among the questions facing the field of design studies[1], we will approach those of *what* is design, and *where* is it located? As discussed by Tim Ingold, what people call "design" sometimes seems to come from the past (typically from the work of previous designers, famous or anonymous), sometimes from the work of someone who conceives it anew, and sometimes it can even be imagined ex post facto from observations, as when we see something and we believe

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[1.] We use here "design studies" as an umbrella term to embrace the analysis and discussion of fundamental aspects of design activity, from design processes to reception and use.

someone had this design in mind before it became a real thing (Ingold 2013). In a similar way, in his paper about the application of Artificial Intelligence to design, Schön (1991 discusses what designers borrow: is it features from previous products? Or is it more abstract elements (what Schön calls patterns and rules)? In other words, it is difficult for design scholars to differentiate between design as something that comes from previous design works, design as something new that is the output of a creative act by one or several people, and design as an imagined object or a thing that has a material reality.

Since existing debates are presented and analyzed in the aforementioned books and in the references they discuss, we do not review in detail here the arguments and difficulties faced by design studies at the moment, but rather concentrate on describing the specificities of the theoretical toolkit we suggest and on illustrating it with a case study. For clarity's sake, we will rely on a design object that most readers should be familiar with: the iPhone calculator application.

In short, the idea is to leave aside abstractions or general constructs and focus on a reduced set of elements that describe the way "design" circulates in human and nonhuman entities. We start with the difference between deductive versus inductive research procedures in the social sciences (as discussed in grounded theory, for instance, Glaser and Strauss 1975 [1967]; Corbin and Strauss 1998) and then connect with the emphasis on the so-called "materiality" of the last decade in various scholarships in the humanities and social sciences (see for instance Callon 1986; Pinch 2003; Latour 2005; Bennett 2010). Part of our argument is that we believe design studies needs to find a specific way to deal with the heritage of postmodernity. As illustrated above with the issue of the locus of design, questions that researchers face are how to work with concepts and definitions while knowing that these are socially constructed and therefore somewhat unreliable. Instead of problematizing the concepts used "from above" and discussing why and when they do not apply, we suggest approaching design issues "from below."

Complexity as a Starting Point

We will give the framework we describe in this paper the name "Circulation." One of its core ideas is to take the complexity of situations considered by design researchers not as a conclusion but as a starting point. We will build on a previous contribution, in this journal, *Design and Culture*, from the first author (Zimmermann 2010), where the general concept of "culture" is broken up into smaller parts. Since the first publication, this conceptualization has been refined (see Zimmermann 2013; Zimmermann 2015), and for this reason we briefly summarize its main components before showing its relevance for design studies.

The framework is based on the idea that the data that scholars in the humanities and social sciences are dealing with is made of matter and that it usually has a shape (here in the metaphorical and general sense of "matter" and "shape"). The idea of shape, or form, is the most important point. It describes here, to use a metaphor from Aristotle, who is one of the main proponents of this old debate in the history of philosophy, how wax may take the form of a seal without taking the materials that the seal is made of (*De Anima*, 424a, Book II)[2]. In

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[2]   See the review by Tim Ingold (2012) on how Aristotle's "hylomorphic" (to describe compounds of matter and form) approach

the same way that people speak about atoms to deal with the complexity of "matter," one considers lower-level entities of shape – called *waves* – which are used to deal with the complexity of "shape."

The word "waves" here is derived from the term "sound waves" and its use in the context of sound engineering. Where a sound can be considered as being made of sound waves (variations of air pressure), the idea of waves is used to describe any kind of displacement of matter. For instance, if one is sitting on a beach and writes a few words in the sand, and then builds a sandcastle, both the words and the sandcastle are made by displacing the grains of sand. A related concept called *forms* is used to speak about aggregates of waves (e.g. entities such as the words written in the sand or the sandcastle are forms made of waves). Consequently, a picture, a sound, a word, and any other entity considered for the operational needs of a study, becomes a form. As such, a form is always made of waves (in a similar way to how a physical object is always made of atoms), and the notion of "waves" is used to explain how the contents of "forms" sometimes disappear, or how new content is created.

It is worth noting that the concept of form is close to the one of *meme*, as defined by Richard Dawkins (Dawkins 1976). The word "meme", although today rarely seen in academic papers, is widely used in the cybersphere to describe phenomena such as when a cute picture of a cat is spread all over the web, or the various uses of the Obama "Hope" poster during the 2008 presidential campaign in the United States in restaurant menus, graffiti, t-shirts, and so on (e.g. people refer to "the Obama meme"). The advantage of using the framework of waves and forms instead of the one of memes is that it solves the two main unsettled issues of what is sometimes called "memetics": the discrete unit of memes, what memes are physically made of – they are made of waves; and how to account for their insufficient copying fidelity, why memes sometimes change when moving from one medium to another – because waves can be dissipated or can be created from nothing, as in the example above with the words and the castle made of sand (see Bloch 2005, for a discussion on the concept of the meme and its limitations from an anthropologist's point of view; see also the discussion in Zimmermann 2015).

In a nutshell, the framework relies on the following terms:

Wave: The smallest level of shape matter can take.

Form: Aggregate of waves that is identified by a human being. Heuristic device for ordering and classifying the empirical material human beings deal with.

Circulation: The movements where waves are being transferred from one material support to another. These movements are characterized by the *conservation*, *dissipation*, or *creation* of the waves that a form is made of.

Here is an illustration of how the circulation framework can be used to describe design phenomena: one considers a picture of a tree taken outside a home in Switzerland, then sent by e-mail to a friend in China. Let us imagine that the friend likes the photograph, prints it using a black-and-white printer, and sticks it on a wall in front of his desk. Then, his ten-

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was used and then later abandoned by scholars.

year-old child notices the picture and makes a drawing of it, where she decides to add a few limbs to the original tree. In the end, if we consider the tree outside the window and compare it to the drawing (we assume that the child draws well), we will see an obvious link between the beginning and the end of the circulation process: some sort of imprint has been transferred from one place to another. At the same time, if we follow the path that goes from the tree to the child's drawing, we note several steps and transformations: the shape of a natural element – the tree – became digital data, then probably at some point an analog signal, and later ink marks on a sheet of paper coming out of a printer. Then it went through a ten-year-old child's eyes, brain, and hands, before it was finally turned into other ink marks on another sheet of paper. In such movements, we will say that the *form* that is the shape of the tree has *circulated* from Switzerland to China. The general shape of the tree – the part that is recognizable – has been *conserved*. The color of the tree, which disappeared when the image was printed in black and white, has been *dissipated*. The limbs of the tree that have been added by the child have been *created*. And so on.

As illustrated with this example of the tree, the circulation framework does not provide answers about *why* things happened that way (why the child might want to draw a tree, why our friend bought a printer, why people use e-mail, and so forth), but its descriptive power says much about *how* things happened that way: how the shape of tree circulated from Switzerland to China, and how it went through the various steps that lead to the drawing on the piece of paper. In this sense, waves and forms are mainly sensitizing concepts; they are not theories that explain or predict the structures of people, things, and the interactions between them, but methodologies that allow one to flesh out relevant points[3]. Viewed from this perspective, since the concept of form is quite broad and encompasses entities which go beyond the needs of design scholars, in the context of this paper we will also sometimes refer to forms as design elements (i.e. forms that are relevant to the needs of design scholars).

If we go back to the top-down versus bottom-up methodological issue mentioned earlier, we see how the circulation framework allows the researcher to start from concrete observations and move toward abstract entities. For instance, instead of considering "modernism" and then discussing how the concept is used in architecture, or the works of Le Corbusier and discussing his influence on later architects' works, one may study the way long, dynamic lines circulated among the works of architects in Europe at the beginning of the twentieth century.

As the imaginary example with the tree illustrates, or in the previous paragraph with modernism in architecture, the circulation framework does not make things simpler. On the contrary, it starts with the idea that things, people, and the interactions between them are overwhelmingly complex. The main advantage of starting with a form, such as "long dynamic lines in architecture in Europe at the beginning of the twentieth century," is that it gives the analysis a physicality and a specific, limited scope, while at the same time keeping it open to different sources of authorship. For instance, it can relate to human or nonhuman entities – a famous or anonymous designer, artifacts such as tools, techniques, software, or other design works. Moreover, if, during the analysis, the researcher realizes that one of the forms s/he has decided to focus on is too vague, it will always be possible to split it into

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[3]. In the sense discussed by Herbert Blumer between definitive and sensitizing concepts: they do not provide descriptions of what to see but suggest directions along which to look (Blumer 1993 [1969]: 147–8), quoted in Clarke and Star (2008).

smaller forms.

In the next section, we will illustrate how the circulation framework can be used in a case study. As stated earlier, for the sake of clarity, we rely on a simple situation that involves both real-world and software design materials, and we select a design object which we believe most readers are already familiar with.

The iPhone Calculator Application

In order to circumscribe the study and also because of space limitation for this article, we retain one material object and we formulate one simple research question. Here we select as our object of study the calculator application on the version iOS 6 of the iPhone by Apple Inc., and the following question: "Which parts of the interface come from former existing devices, and which can be considered as newly designed by Apple employees?" In this short section, we will identify and describe forms that we believe have circulated from former design objects and have been conserved, and also elements which have been dissipated or created for the calculator designed by Apple.

Figure 1: iOS 6.1 calculator: (a) vertical mode.

Figure 1: iOS 6.1 calculator: (b) landscape mode.
Photos: Nicolas Nova (CC licence BY-SA 3.0).

Figure 1 shows two images of the calculator application on the iOS 6.1, in vertical (a) and then landscape (b) modes. Based on what we imagine to be the range of user interface decisions made by the designers of this calculator, we choose to pay attention to the following forms:

- Horizontal display located at the top of the screen
- Arrangement of the memory features in the first row
- Arrangement of the mathematical symbols in the upper row and the column on the right
- Arrangement of numerals 0 to 9 (with numbers going up from bottom to the top)
- Coexistence of two calculators in one software, through the vertical and landscape modes[4]
- Arrangement of more elaborate mathematical functions on the left side of the screen in landscape mode
- Colors in clusters based on similar functions (background and numerals in black; mathematical symbols in brown; memory features in green; "equals" in a striking yellow tone)
- Semi-spherical keys
- Rectangular keys with rounded corners
- Four vertical columns
- Size and location of the "equals" key

[4.] We consider here the iPhone calculator as software. The switch between vertical and landscape mode is therefore a *form* in the sense that it is part of its code (rather than considering it as, say, a function). Another way to understand how the code physically relates to the final software is to imagine the calculator as double-sided, with the vertical and landscape interfaces located on one single material object.
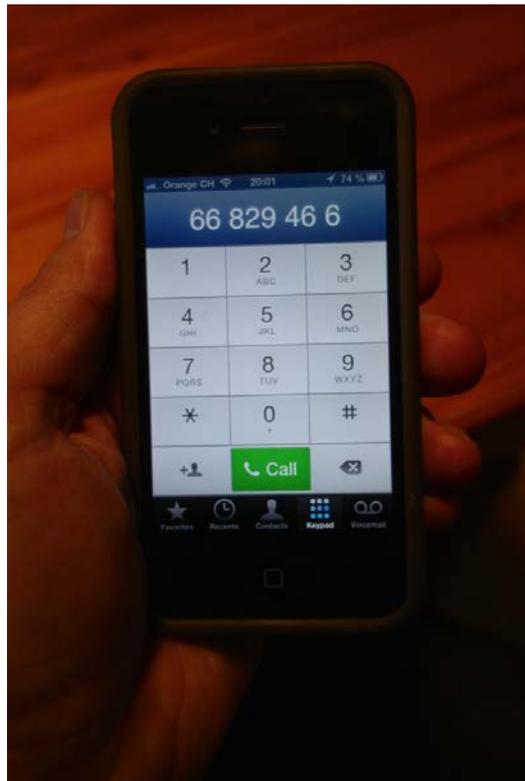
Figure 2 : iOS 6.1 telephone keypad. Photo: Nicolas Nova (CC licence BY-SA 3.0).

In order to provide additional data for the analysis, we compare the forms of the list above with four other interfaces: (a) the iPhone numerical keypad used for phone usage (Figure 2); (b) the first version of the calculator on the iPhone operating system (iOS 1) represented in Figure 3; and (c) the hardware calculator ET33 by Braun, the German consumer electronics company (Figure 4).
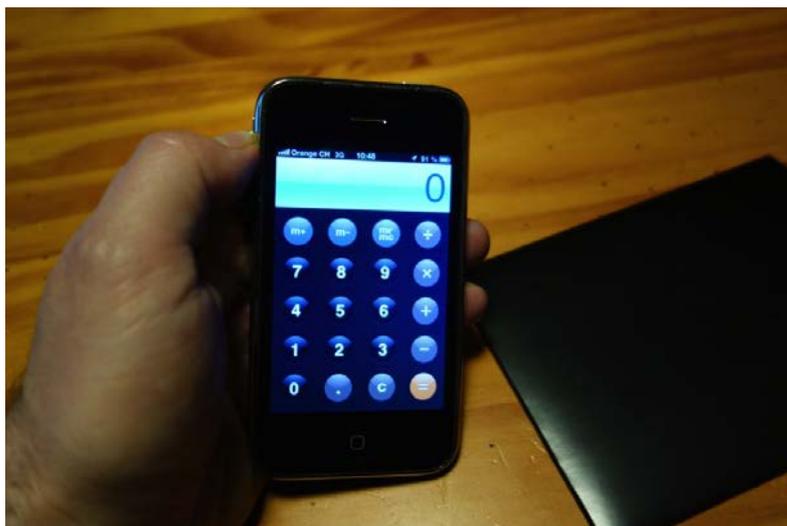

Figure 3 : iOS 1 calculator. Photo: Nicolas Nova (CC licence BY-SA 3.0).

Figure 4 : ET33 (Braun) calculator. Photo: Nicolas Nova (CC licence BY-SA 3.0).

Firstly, a comparison between Figure 1 and Figure 2 reveals the different layouts of numeric keypads on the iPhone. In Figure 1, the numbers for the iPhone calculator application are arranged from left to right, and from the bottom to the top (i.e. lowest numbers at the bottom). Interestingly, things change when the user of an iPhone switches to the phone application to dial a number – see Figure 2. In Figure 2, number keys are also arranged from left to right, but this time from the top to the bottom of the screen (i.e. lowest numbers at the top).

How can one account for two different configurations for a basic issue such as the interface to input numbers from 0 to 9? According to Jacomy (2002), both types of keypads come from two different "technical traditions" which have used them as a standard over time. On the one hand, there is the "calculator layout," which has been used for computing machines since 1887 (starting with the Comptometer by Felt & Tarant Manufacturing Company). On the other hand, there is the phone keypad designed by John E. Karlin, an industrial psychologist at Bell Labs at the beginning of the 1960s. The dual presence of these two configurations highlights the circulation of keypad layouts up to the iPhone, and the importance of design decisions taken for prior instances of a similar object (Jacomy 2002: 58–60).

Let us now move to a comparison between the iOS 6 calculator (Figure 1), the previous version on the iPhone (Figure 3), and the Braun ET33 calculator (Figure 4). Our choice of these illustrations for comparative purposes, if arbitrary, is of course not completely random either. Figure 3 shows a former version of the calculator application by Apple Inc., therefore it makes sense that it presents similarities to its successor. Also, we had read that Apple's Senior Vice President of Industrial Design, Jonathan Ive, expressed admiration for the design work of Dieter Rams from Braun, which he said inspired his work (we will come back to this later). Similarities between the two series of products can easily be noticed even by an untrained eye.

If we come back to the list we made at the beginning of this section, we notice that the following forms can be found in each of the three images:

• Horizontal display located at the top of the screen
• Arrangement of the memory features in the first row
• Arrangement of the mathematical symbols in the upper row and the column on the right
• Arrangement of numerals 0 to 9
• Semi-spherical or rounded corners of the keys
• Arrangement of more elaborate mathematical functions on the left side
• Colors in clusters based on similar functions (background and numerals in black; mathematical symbols in brown; memory features in green; "equals" in a striking yellow tone)

If one focuses on the forms we listed for the images above, the main differences between the Braun calculator (Figure 4) and the earlier version of the iPhone calculator (Figure 3) interfaces, besides the fact that one is hardware and the second software, seem to be the number of vertical columns and the location of the "equals" key, while some of the mathematical symbols have been moved from the vertical column to a horizontal row. Also, the key shapes with a semi-spherical appearance (shaded to imitate the look of a rounded 3D button on iOS 1, as on the Braun calculator) have been replaced by rounded-corner buttons. The shift from vertical to landscape mode is specific to Apple's software device, and it cannot be compared to features of the Braun calculator.

We note also that the iPhone's calculator interface in iOS 6 shares forms with its predecessor in iOS 1 (e.g. key colors and order), itself sharing forms with the electronic calculator from the ET series released by Braun (which includes the ET33 model of 1977 up to its successors until 1987). Interestingly, this series has been designed by Dieter Rams and Dietrich Lubs with a minimalistic spin that is considered characteristic of Rams' touch (Klemp and Ueki-polet 2010). It seems obvious that part of the similarities between Apple's calculator and Rams' work on the Braun device were intended by the designers of the iPhone application[5].

We are not aware of official statements by Apple regarding the borrowing of Braun calculator features (not exactly a surprise, since the company is famous for its policy of secrecy), but we know that, on several occasions, Jonathan Ive mentioned his interest in Dieter Rams' minimalist style and how it influenced his own work. For instance, discussing the semi-spherical keypad shapes listed above, Ive highlighted the cleverness of Rams' proposition: "The concave button top, necessary to stop your finger from slipping as it made the long travel necessary for earlier mechanical switches, does not point to obsolete mechanisms. Instead, it reminds us how immediately and intuitively form alone can describe what an object does and suggest how we should use it" (Ive, quoted in Lovell 2010: 13).

According to Bernd Polster, the relationship between Rams and Apple's designer can be described as a contemplative one: Rams was a role model to Ive, who learnt from him and even "sent his idol in 'good old Germany' an iPod" (Polster 2011: 66). Referring to common

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[5] For instance the calculators ET33, ET44, ET66, ET88. See also the similarities between the Braun T3 pocket radio and the Apple iPod, or the PowerMac G5/Mac Pro and the Braun T1000 radio. We are indebted to the discussion by design pundit Jesus Diaz on Gizmodo for part of this discussion: http://gizmodo.com/343641/1960s-braun-products-hold-the-secrets-to-apples-future (last accessed 3 March, 2013).

traits between the ET calculator and the iPhone version, Dieter Rams also made the following comment: "There are common elements, but he has developed my design. It is a huge compliment to be mentioned alongside him" (Rams 2010).

The interface that appears in landscape mode, when the 2007 version was updated in 2008 (from OS 1 to OS 2), is probably following the scientific calculator archetype brought forward by Hewlett Packard, then followed by Texas Instrument, Casio, and Sharp (Mikesell and Ames 2003). Although we did not research the specific evolution of button design, other changes seem to correspond to the addition of new features on the iPhone. It is also worth noting that the rounded corners are known to have been an important design issue for Steve Jobs and may originate from this tradition at Apple (Isaacson 2011: 83, 130, 470, 491–2). To our knowledge, these new features do not correspond to a model formerly released by Braun.

To go back to the theoretical framework discussed in this paper, what we suggest is to rely on the notion of circulation in order to describe situations where forms are conserved while traveling. In the example above, what we observe are design elements of Braun calculators circulating to Apple iPhone's calculators. Keypad layouts, the key shapes and color and the background, have been transferred from one physical object to another. Their journey was a complex one, involving many human and nonhuman entities, and was certainly not limited only to Dieter Rams' and Jonathan Ive's agencies (who play here the role of the "genius designer" traditionally present in the press about design). A complete study of the calculator interface in the iPhone would imply paying attention to the many other circulations that occurred in its making.

The square keys with rounded corners mentioned earlier could be considered as other circulations with conservation – if one manages to show how Apple has imported the design from other objects. If it hasn't been imported but newly designed, then it should be considered as a creation specific to this application. Similarly, if we return to the calculator application, we can consider that the key shapes with a semi-spherical appearance have been dissipated in the move from iOS 1 to iOS 2, as well as the positioning of certain mathematical symbols (e.g. plus and minus). Finally, the switch between vertical and landscape mode since the iOS 6 version, as well as the size of the "equals" key on iOS 6, is a creation by Apple designers.

In a nutshell, the framework of waves and forms allows both for a concrete, somewhat positivist approach through its focus on waves and the physical structures and processes that host them, and for a relativist approach through the use of the concept of forms and the operational, subjective choices made by the researcher through describing a design phenomenon. Moreover, it suggests a way to pursue the research process further by looking for more circulation paths that ended up in the iOS calculator, or paths that move further ahead in time.
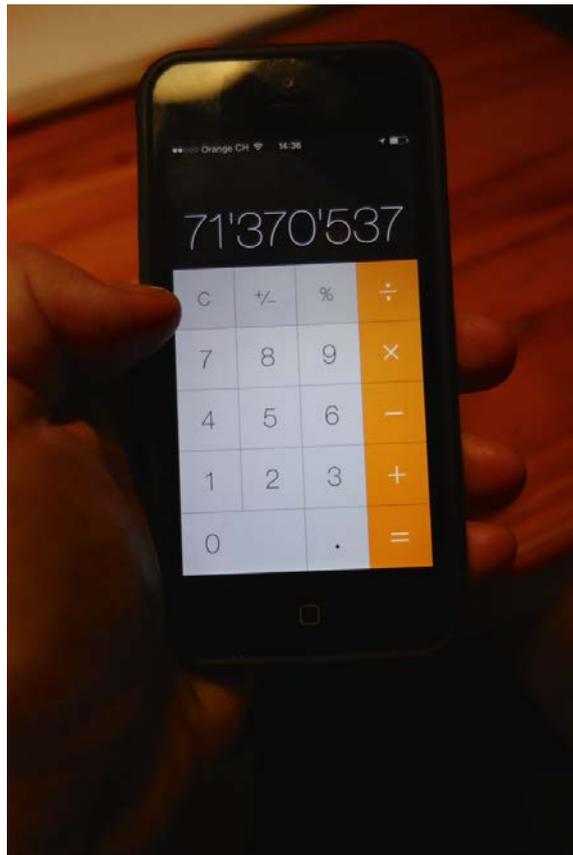
Figure 5: iOS 7 calculator.
Photo: Nicolas Nova (CC licence BY-SA 3.0).

For instance, the release of the iOS 7 version of the calculator could enable us to extend the analysis. As represented in Figure 5, the visual design of this new operating system reflects a shift in the company's strategy[6] – three colors of the calculator interface (black, gray, orange), as well as textures and shadows, were dissipated when it circulated from iOS 6 to iOS 7. Such changes follow the recent wave of "flat design" that corresponds, for instance, to the visual representation chosen by Microsoft with their "metro design language" applied first on the Win7 phone operating system[7]. Using the circulation framework, one may say that forms of the "Braun calculator" are still circulating: design elements such as the orange color of the equals sign have been conserved (and extended to the other mathematical operators), while the key shapes with rounded rectangles, as well as the brown and black keys, have been dissipated. Additionally, one can also consider the circulation with conservation of the design elements of the flat/uni-color background and the sans-serif font, which circulated, possibly, from Microsoft's metro design language.

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[6] See technology blogs such as Fast Co.design (www.fastcodesign.com/1670760/will-apples-tacky-software-design-philosophy-cause-a-revolt). It seems to highlight the tensions between two factions of Apple designers who defended different levels of ornamentation and mimicking of physical devices in their design (a practice referred to as "skeuomorphism" in design circles).

[7] "Design language," in designers' parlance, refers to the set of guidelines that define the design of an interface or a product.

Our findings with regard to the OS 6 and 7 calculators are summarized in Table 1.

Design element chosen by the researcher	Current state of the circulation analysis	Source of the analysis
Horizontal display located on top of the screen	Conserved?	*ongoing*
Arrangement of the memory features on the first row	Conserved?	*ongoing*
Arrangement of the mathematical symbols in the upper row and the column on the right	Dissipated?	*ongoing*
Arrangement of numerals 0 to 9, calculator layout (with numbers going up from bottom to the top)	Conserved	Jacomy, 2002: 58–60
Switch between vertical and landscape mode since the iOS 6 version	Created by Apple Inc.?	*ongoing*
Arrangement of more elaborated mathematical functions on the left side of the screen in landscape mode	Conserved?	*ongoing*
Colors with clusters based on similar functions	Conserved	Lovell, 2010, 13–14
Semi-spherical keys	Conserved from the calculator to the iPhone OS 1 version, then dissipated after iOS 2	Lovell, 2010, 13–14
Rectangle keys with rounded corners	Conserved from Steve Jobs observations of various other similar design objects (car windows, billboards, street signs, etc.)	Isaacson 2011, pp. 83, 130, 470, 491–2

Table 1 : Different circulations, creations, and dissipations discussed in the article in relation to the OS 6 and 7 versions of the iPhone calculator application.

Conclusion

In this paper, we introduced a framework for design studies which we suggest labeling with the word "Circulation." By relying on the concepts of waves and forms (Zimmermann 2010, 2013, 2015), and on a single case study of the interface of the iPhone's calculator application, we have shown how design can be understood as waves circulation processes, and how design elements can be understood as forms identified by design studies scholars, which can be followed as they circulate from one instance to another, being either created, conserved, or dissipated.

In the above example of the iPhone calculator, which we used as an illustration of how the framework can be used by design scholars, we discussed how design elements of the Braun calculators, designed by Dieter Rams and others, circulated to Apple's smartphone. While some were conserved through the process of circulation (such as the clusters of colors), others were dissipated (such as the semi-spherical appearance of the keys), and others seem to have been created (such as the landscape mode). It is these movements of circulation, dissipation, and creation in which design studies are mostly interested.

Specifically, the notion of circulation facilitates a dynamic understanding of how design elements are transported and transformed when traveling through human and nonhuman entities. The concept of waves allows the researcher to break down a design, as needed, into ever smaller parts (i.e. the forms), to trace back its past instances, and to consider its various origins in earlier generations. To talk about circulation does not make things simpler, but it provides methodological and theoretical tools for a nuanced and enhanced understanding of the phenomena on which design researchers work.

Our goal here is to go beyond categories of various kinds of users, designers and artifacts, humans and nonhumans, by allowing for a conceptualization of change: design elements (forms) can be either created, conserved, or dissipated, be displaced or stay immobile, while at the same time remaining strictly related to their physicality. The concept of circulation accounts for movements that can be localized regionally, moving inside a network, changing shapes or not, and maintaining shape constancy while depending upon discontinuities.

As typically discussed in design history (a discipline often interested in objects that cannot be attributed to a single author), the circulation framework allows the researcher to consider the general evolution of a design object, its "genealogy,"[8] and the collective processes involving the human and nonhuman entities that gave birth to it. It can include, through the concept of waves, the dissipation and creation of other design elements that are either removed or added during the design process. It takes into account various phenomena such as economic constraints or intellectual property issues (e.g. that facilitate, or restrain, the circulation of a design element), the failures in the design process or in the diffusion of the innovation (which lead to waves' creation or dissipation, either directly or indirectly, in the product or in the way it is communicated to the users), or the creative agency of designers, be it through pragmatic decisions based on ergonomic issues or through interaction between people and artifact, such as in Ive's tribute to Rams.

[8.] On the concept of artifact genealogy, see Simondon 1958; Steadman 1979; Basalla 1988; Stiegler 1998; Eldredge 2002.

To give but a quick comparison with other frameworks, we see that waves circulation differs from existing theories about evolutionary perspectives on design on different levels. Firstly, our framework concurs with Steadman's critique of the biological metaphor of evolution in the context of design (1979). He basically argues that the notion of evolution sometimes "removes the human designer and replaces him with the 'selective forces' in the 'functional environment' of the designed object". (Steadman 1979: 201). The circulation framework takes this issue into account by stating that forms are effectively set in motion by designers in their creative work. However, our perspective goes beyond Steadman's because we move away from the evolution metaphor and describe the core movements that enable the circulation of design features, which he only alludes to in his book. The notion of form can indeed correspond to what Steadman expresses as a complex object made of different traits; but his model only focuses on alterations. In effect, it does not consider the variety of cases we discussed above (conservation, creation, and dissipation). Moreover, the model we describe here expands Basalla's notion of continuity and novelty (1989) by providing a finer-grained description of what circulates over time. Basalla, indeed, mostly discusses artifacts in general (e.g. the continuity between transistors or steam engines) and not necessarily the smaller components that can be addressed with the notions of waves and forms.

Lastly, while Langrish (2004) tackles similar issues about the "memetics of design," our perspective addresses it from a different angle. He delineates three types of categories of "ideas" that can be "replicated": (a) Recipemes or "recipe ideas" ("transmittable ideas about how to do things"); (b) Selectemes ("ideas about what sort of thing designers want to do"); and (c) Explanemes ("ideas that provide the basis for answering 'why' questions"). Such typology, although valuable for explaining phenomena similar to the ones we described with the calculator example, focuses more on abstract matter than the circulation framework. The latter, as a set of most reduced design elements closely connected with materiality, provides a concrete approach and also has the specific strength of encompassing both narrower and broader categories: Langrish's categories, and further ones which may include issues related to the use, or consumption, of design from users, consumers, dealers, distributors, managers, or product testers can all be dealt with by relying on the circulation framework. While design objects often act as intermediaries located between production and use, the concept of waves circulation allows researchers to bridge the two spheres and consider how design elements shape and are shaped from one side to the other of this interactive process.

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