Synthesis of Forms: Integrating Practical and Reflective Qualities in Design

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Synthesis, or the integration of hitherto separated elements, is a prominent concept in theories of design processes. Synthesis often happens when there is a need to make a decision, though it is often the result of a combination of different alternatives, instead of deciding in favor of one and eliminating another. In many design studies, synthesis has been investigated in the contexts of everyday design—bicycle frames, sewing machines, commercial architecture. We were interested in how it might apply in contexts of reflective design, whose pragmatics often depend on different interrelationships between users and technological products. In this paper, we argue that designing everyday use objects for reflection requires a synthesis of two apparently opposite forms: conventionally practical forms, since they are everyday use objects, and evocative forms, since they make users think. We provide two examples of everyday objects for reflection that we believe synthesize both conventionally practical and evocative forms, analyzing the design processes that led to these forms, and discussing how these reflective designs embody different forms of synthesis.

CCS Concepts: • **Human-centered computing** → Interaction paradigms; *Human computer interaction (HCI)*; Interactive systems and tools;

Additional Key Words and Phrases: Form-giving, Design process, Research through Design, Design Theory

ACM Reference Format:
Maliheh Ghajargar and Jeffrey Bardzell. 2021. Synthesis of Forms: Integrating Practical and Reflective Qualities in Design. In *CHI Conference on Human Factors in Computing Systems (CHI '21), May 8–13, 2021, Yokohama, Japan.* ACM, New York, NY, USA, 21 pages. https://doi.org/10.1145/3411764.3445232

1 INTRODUCTION

Designing the features of computing and interactive artifacts in a way that can foster thinking and cognitive development has been the subject of research in cognitive and learning science areas since the advent of artificial intelligence and software developments in the 70s and 80s, continuing through more recent research on supporting learning, creativity, and reflection [25, 27, 29, 35, 44, 48, 53, 61, 66]. For instance, Pea's concept of "cognitive technology" is an early example of such artifacts [45]. This concept employs the use of computing technologies to transcend limits of the mind alone in activities of thinking, learning and problem solving. These technologies are designed and adapted to learner environments to engage to a deep reflective thinking and higher-order of critical and meaningful learning. Further, the cognitive tools' form, behaviors, interactions and affordances are the factors that are determined by the design of the tool and are mentioned as crucial factors that enhance their functionality as cognitive technologies [33].

Similarly, one of the functions of everyday use objects for reflection is to evoke thinking. Therefore, as with any other design, it needs to deliver its intended function, and it will be imbued with specific characteristics, forms and structures to achieve that purpose. While the purpose of objects for reflection is to evoke thinking and reflection in users, they are

Manuscript submitted to ACM

also everyday conventionally practical products with their own basic and somehow traditional functionalities – e.g. coffee tables, cups, lamps, vases, etc. That is, their function is two-fold: to serve in some pragmatic capacity and also to evoke. Now, sometimes pragmatic functionality and evocativeness are positioned as though they were in opposition to each other (see, e.g., [18]), and therefore resolving this apparent opposition in a single object is a challenging design problem. Hence, in designing everyday use objects for reflection, it is crucial to explore ways through which the distinct functionalities and characteristics can be synthesized in a coherent and single design form.

In this work, we begin with the observation that most objects do not have a single, simple meaning, but rather a layered and complex set of meanings. An everyday coffee maker might not only make coffee, for example, but it might also fit (or clash) with the visual decor of the kitchen in which it is located; it might have sentimental value; it might reflect a loyalty to a brand; it might be made of a preferred material; and so on. Accordingly, our research seeks to understand how objects synthesize a multiplicity of meanings and forms, and more specifically, how a single design form (e.g., an artifact, or a feature of an artifact) might achieve a synthesis of design qualities that we tend to view as logically exclusive (e.g., practical functionality vs. evoking critical reflection) and yet which we argue are not exclusive when manifest in actual designs.

In pursuing such an inquiry, we (1) summarize relevant HCI and design theory on forms and form-giving practices,; (2) situate the concept of objects for reflection in relation to established design practices in HCI, such as ambient displays, eco-feedback technologies, and critical design objects; by doing so we aim to bring into view their conventional practical functionality and evocativeness; (3) reflect on a research through design project led by the lead co-author in which the form-giving of simultaneously practical and evocative design artifacts was central to the research goal of the work: Sóle and Kucheh (Figure 1); (4) discuss how through form-giving, it is possible to synthesize practical functionality of everyday use objects with the evocativeness.

In this work, we question the apparent contradiction between practical and evocative objects sometimes asserted in design theory, for example, Dunne and Raby's famous A/B list [16] or Forlizzi et al.'s proposal that practical and critical design get a "divorce" [18]. We do so both as a matter of design theory and also as a practice-based investigation of a certain kind of form-giving. In doing so, we hope to advance design theory's account of the relationships between apparently practical vs. evocative design purposes and also to provide practical support for designers engaged in form-giving in pursuit of both practical and evocative design outcomes. Key to our contribution is the notion of synthesis, by which we mean a coherent integration of two or more separate elements into a third element. Specifically, we consider how forms associated with practicality in design (e.g., everyday functional objects such as kitchen appliances or text editors) are synthesized with those associated with evocativeness (e.g., critical designs, design fictions, and reflective designs). We further argue that the synthesis of practicality and evocativeness in design form-giving can manifest in two archetypal relationships: seamless synthesis and complementary synthesis. In seamless synthesis, the practical forms and evocative forms are not distinguishable and they create one coherent functional whole, in which the evocative forms are part of the practical forms. In complementary synthesis, two forms are functionally independent, but they together shape the ultimate form of the object as a whole.

2 BACKGROUND AND RELATED WORKS

Objects for reflection share qualities with two kinds of design that are otherwise quite distinct from each other: eco-feedback technologies and critical design objects. Eco-feedback technologies are practical everyday objects that also seek to call attention to their own resource use, for example, an electric appliance that visualizes how much electricity it is using. Critical design objects also seek to prompt reflection and even debate, though they are often circulated

in media and museums and seldom used (or even usable) in everyday life. Their differences notwithstanding, both design approaches seek to prompt reflection and awareness. We provide a background and related work, to situate this research in relation to eco-feedback technologies [20, 21] and speculative and critical objects [15, 16] focusing on their forms and synthesis.

Fig. 1. Sóle (right), Kucheh (top-center).

2.1 Forms and Synthesis in Design

Design history in general, and industrial design in particular, has a long tradition in craft and form-giving practice, that is the engagement with and manipulation of materials to shape objects, buildings, spaces, etc. in order to meet specific needs or desires [30, 47, 50].

Form-giving is the phase in which design ideas and intentions are concretized and manifested as designed objects [51] that fit into contexts, situations, environment, practices, etc. Form-giving includes giving shape, color, material,

weight, function, scale, and similar qualities to objects, as well as composing and synthesizing them into coherent wholes.

Although forms are often influenced by their contexts - for example, a seaside building will be constructed to handle heavy winds or to afford desirable views - contexts do not determine forms. Further, the boundary between the form and the context can be moved. For example, Alexander [1] imagines designing a tea kettle, only to propose that a tea kettle is the wrong way to heat domestic water, and thereby to redesign the kitchen – in this case, changing the boundaries of the design problem. Alexander notes that such boundary play can be pushed to the extreme of "designers who want to redesign entire cities and whole processes of manufacture when they are asked to design simple objects" [1]. Forms are also considered the outcome of the design process and the result of the synthesis of complex problem-solving and decision-making processes, in design processes [1, 31].

Similarly, Miller [39] identifies the moment of the "form-creation" phase as a moment when "any conceptualization about the material form emerges, and ends when a definitive design is established. In this phase, the ideas are externalized, explored iteratively, and represented tentatively in a visual form, using a variety of media and materials. The form-giving process is not only concerned about determining the forms and shapes to fulfil the function of the product, but is also aimed at establishing the product's desired emotional, semantic, and aesthetic qualities in relationship to its intended experience, meaning, and use [32, 42]. Miller refers to these holistic qualities as the form-giving's "synthesis" [39]. In The Semantic Turn, Krippendroff even defines Industrial Design as "the creative activity that lends form and meaning to industrially manufactured objects, both for mass and limited production" [32]. Further he affirms that form and meaning are correlated: "Something must have form to be seen but must make sense to be understood and used".

In HCI and interaction design, form-giving has been further defined as the process through which not only physical forms and attributes, but also temporal and interactive forms such as task sequences, are identified and designed to convey meanings, and to create sensorial and aesthetics experiences [58]. For example, a smart watch has its own physical elements, which are created according to the user's needs, specific materials and production techniques. But the watch also manifests other kinds of forms when users interact with it. For instance, the smart watch alarm clock shows the time through the graphical user interface, and it changes the default or home user interface according to the new functionality. It also notifies the user through the sound notification or vibration. Therefore, the user experience is shaped by a combination of all of those qualities and forms. The temporal or the interactive forms do not modify the original physical form; along with the physical form, they create a composition that is perceived by the user as a whole.

Form-giving in HCI has further been informed by philosophical aesthetics, including analytic, pragmatic, and phenomenological traditions, to stimulate interaction design research and practice. Bardzell [9, 10] suggests that the form of an artifact is one of four primary considerations of aesthetics, along with intentionality/the act of creation, the individual's experience with or reception of a work, and the sociocultural context in which it was produced/consumed. Artifact form has a unifying principle (sometimes known as "significant form" after Clive Bell) that composes the work's disparate parts ways into a whole that is replete with meaning. Gross et al. [28] argue that the materiality of seemingly immaterial entities, such as information, is manifest through physical forms – e.g. Tangible User Interfaces. Löwgren [37] highlights four concepts that characterize the experience qualities of interaction: Pliability, Rhythm, Dramaturgy and Fluency. Petersen et al. [46] offer a pragmatist aesthetics for interactive systems design that focuses on the aesthetics of everyday use.

HCI has also introduced its own aesthetic concepts. For example, computational composites [62] foregrounds form in its conception of interactive artifacts. Computational composites are experienced as wholes by better understanding three constituting elements: physical form, temporal form and the "form" of interaction. While a physical form is

perceptible through its three dimensional and tangible shape, a temporal form is a pattern of the state-changes that a computer can produce over time [63]. The "form" of interaction, or 'interaction gestalt', is another concept that defines what is being created and designed as the user experience, when the user interacts with and experiences an interactive artifact with its constituent forms [36].

As even this brief summary demonstrates, "form" is a complex concept that features centrally in design processes and products; in physical, temporal, interactive modalities, contributing to meaningful, emotional, and tactual experiences. Forms are not simple tokens pointing to single meanings, but instead are semantically, materially, and interactionally dense. All of this applies to designs whether they are functional, evocative, or some combination of the two. In the two following subsections we will present eco-feedback technologies and critical design objects and will analyse and compare their practical forms and evocative forms.

2.2 Eco-feedback Technologies

Eco-feedback technology has seen a growing interest within HCI and Ubiquitous Computing research, since environmental issues (e.g. climate change, air pollution, energy and water scarcity) became salient and global [14]. Eco-feedback technologies aim to provide feedback regarding individual or group consumption behaviours, with the goal of raising awareness and prompting behavior change that reduces environmental impact. The concept is inspired and informed by environmental psychology mechanisms [21]. One common formal tactic of eco-feedback technologies is to use attention grabbing features, such as bright and saturated light colours (typically red and green), sound notifications and, vibrations. Another formal tactic is to have their own independent functionality and design intention as an eco-feedback technology, such as ambient displays and ambient orbs. These two tactics are not, of course, exclusive: it is possible for a single object to deploy both.

2.2.1 Practical functionality and evocativeness. Eco-feedback technologies certainly aim to provoke, that is to grab the attention of users to some specific human consumption behaviours, with the ultimate goal of changing or altering them. They often do so by presenting and delivering the information regarding the activity or behaviour, in time and place of that specific activity. For example, the Waterbot is an eco-feedback device that is connected to a faucet and aims to reduce water consumption by presenting resource use information at the time and place of water consumption [5].

The forms of the eco-feedback technologies are often shaped and informed by environmental psychology models and theories of behaviour change, even not always explicitly. Froehlich et. al [21] present two models –rational choice and non-activation– as two prominent pro environmental models imported from environmental psychology that are used for designing eco-feedback devices. For example a rational choice model-driven design would rely on the fact that people opt into pro environmental behaviors if they are economically advantageous (e.g., to maximise rewards and minimise costs – to show the user how much they can save money if they reduce the consumption, or how many trees they can plant by reducing the consumption). Further, the act of provoking users to adopt sustainable behaviours is the practical functionality of eco-feedback technologies, distinguishing them from everyday useful objects. That is because such technologies, even where they are added as a feature to an everyday use object, are not serving users to address an immediate or an expressed need; instead, they are intended to educate, to reward, or to discourage users to do certain activities (e.g., over consumption of water in the bathroom).

2.3 Critical Design objects

Critical design objects are often situated in opposition to commercialised and everyday use objects, since they are designed with the intention of provoking debates and discussions [12, 17]. Dunne and Raby introduced an oft-cited A/B table, listing design qualities and intentions of affirmative design (column A) in binary opposition to design qualities and intentions of critical design (column B): design as process (A) vs. design as medium (B), in service of industry vs. in service of society, consumer vs. citizen, and so on. Critical designs are claimed to be a medium for evoking political public debates [15], a means to evoke debates and critiques around behaviour change design methodologies [28], or as a critical product to evoke reflection on political issues around contemporary technology design, or issues that pertain to feminist concerns, such as diversity, gender and identity [13].

Critical design treats designing as a mode of critique, grounded in critical theory, STS, feminism, and political philosophy, yet manifest through artful and craft-based expressions and forms. Critical designs often feature many of the forms of conventional consumer products, with one or more provocative twists, which is intended to prompt critical perception and critical dialogue. For example, Dunne and Raby's Teddy Bear Blood Bag Radio [12, 16] is a future consumer radio for children that is powered by electricity generated from decomposing blood stored in a teddy-bear shaped blood bag. The teddy bear, blood bag, and radio are all conventional consumer design forms; it is their juxtaposition into a shocking overall product ("significant form") that calls attention to how the device is powered, which is what serves its critical purpose–to raise awareness of the social costs of powering consumer devices. Critical design objects elicit contemplation by reworking the familiar; Auger argues that the critical design process can first create the familiar, then by creating contrasting signs that defamiliarize, they can elicit reflections on users. He brings up the examples from cinema and literature – e.g. The creation process of Shelly's Frankenstein, where the feature of the body was first defined as natural and familiar, later adding a layer of unfamiliarity [7].

2.3.1 Practical functionality and evocativeness. The practical functionality or the usefulness of critical design objects lies often within their ability to raise questions and critique. In other words, just because they do not open tin cans, keep water off our heads during rain, or allow light in a building while protecting interior temperatures, does not mean that critical designs are not practical. Critical design objects still have intended uses - to prompt such discourses and shifts in consumer values - but those uses are not subordinate to the narrow goals of industrial production and consumer needs; Dunne and Raby refer to their practical value as their "social usefulness" [16]. Although eco-feedback technologies and critical design objects historically arose out of two very different schools of thought—eco-feedback's scientific positivist and behvioralist approach vs. critical design's artistic and critical approach—they share a similar design intention, in that both are designed with the intention of raising awareness, and so raising awareness is their practical functionality.

2.4 Everyday use objects for reflection

Everyday use objects for reflection are often physical, interactive, familiar objects, which are able to log, sense, collect data and provide feedback to the users, thanks to the computing and sensor technologies. The interaction with such interactive technologies and objects has proved to be effective in triggering thoughts and reflection in users about their behaviors and actions. That happens mainly through providing users with haptic, sonic, visual feedback– e.g., for the purpose of sustainable behavior change in the home environment [23, 25, 53]. Further as they are designed for a specific context –e.g. home environment– they are formed to fit it, and reflect the specificity of their use context [25, 29, 40]. The everyday-ness of such objects is simply referred to the fact that they are first and foremost designed with the intention of addressing users' needs, hence they are practical and functional objects. Accordingly, many of

our daily use objects can be considered as such: coffee tables are used to support objects, door handles are used to open doors, calculators are used for mathematical calculation, GPS-based mapping software is used to search for and find routes to places, etc. The concept of objects for reflection aims to provide the opportunity to augment all forms of everyday use objects with forms that evoke reflection and thoughts. Hence, most of them are designed to be both socially and practically useful, and to serve both people's utilitarian needs and those that belong to the reflexivity and thoughtfulness practices.

2.4.1 Practical functionality and evocativeness. The practical functionality or usefulness of objects for reflection integrates their traditional functionality as everyday use objects into evocatively augmented forms. In our practice of designing such objects, we first design them as everyday use objects, and then we augment them with evocative forms. That means firstly they have usable, functional and understandable forms, and are designed to meet a specific and often utilitarian user need. For example, in designing Sòle, which we will describe in following sections, we first designed an everyday use lamp, which has a physical structure and form, appropriate material, light bulbs and electricity. Later, some of the forms, either included within the main functionality or as complementary forms, are shaped in order to evoke reflection in everyday settings. In the case of Sóle, we reworked the physical forms and the modular structure and the light bulbs so that they could dynamically and interactively show the changes in urban mobility behaviors (cycling, driving, etc.) Yet, related to their everyday practical functionality, the information is often presented to the user in the context of the use – which is the home environment for Sóle –rather than during a specific user activity – cycling or driving a car.

The design of such objects is often inspired by a diverse set of theories with their own diverse epistemologies (e.g. technical rationality of eco-feedback technology, critical design's phenomenology, user experience design's pragmatism, etc.) [24]. HCI has long turned to empirically grounded psychological theories and models to aid design and to deliver a measurable outcome. In contrast, reflective design considers reflexivity a core principle embedded in the design of computing artefacts grounded in critical approaches to computing [57]. Reflective design accordingly emphasizes the importance of cultural values and quality of life in technology design. It attempts to bring the hidden into view – for example how technologies perpetuate unbalanced power relations at the workplace.

The design of everyday objects for reflection often draws from both empirical psychology and the sociocultural theories underlying reflective design. That is, it often draws upon reflective design approaches and critical approaches to computing, but it materialises the design in an everyday setting in a pragmatic way. That resulting form must not only evoke reflection, but it must be socially acceptable and, in many cases, commercialised (or commercialisable). By leveraging scientific models of human behaviour and the sensitivities of a reflexive approach to the design, it seeks to maximise its success as a reflective design. In other words it synthesizes both "ordinariness" and the "enchantment" of technology as a pragmatic approach to experience design for everyday life [38]. That is the enchantment of a reflective design is presented through the ordinariness of commercially and technologically available structure.

3 METHODOLOGY

The present research has as its point of departure the question of the relationship between practical and critical design. Throughout design theory, and on diverse sides of the debate, pragmatic and critical design are often presented as though in opposition. Forlizzi et al., [18] propose even a "divorce" between practical and critical design. Dunne and Raby, who coined the term critical design, distinguish between "affirmative" and "critical" design, leaving little doubt in readers' minds about what they think of the former. And although at a level of logic, the distinction feels intuitively

correct, as we considered our own reflective design practices, we could not square this theoretical distinction with our own practice.

We turned to two intentionally different accounts of designing for reflection: eco-feedback technologies and critical design, in part because each is informed by different epistemologies: eco-feedback by post-positivist social science and engineering and critical design by postmodern critical theory [24]. Then we reflected on the first author's design work, specifically Sóle and Kucheh, which were reflective design that had forms and purposes that seemed to integrate the two design practices. That is, the two designs borrowed forms from both design traditions without compromising the coherence of their final forms. The designs synthesized both practical and reflective qualities of design. They were practical because they are everyday use objects which apply similar types of interaction modality that eco-feedback technologies provide, but they have forms that evoke user reflections. We offer an account of the form-giving processes that led to each of these two designs. The account is simultaneously descriptive–offering a historical account of what happened roughly in chronological order–and also interpretive, that is, pursuing significances of the design by engaging the relationships between forms and meanings and their reception by an engaged subject. In this way, the account of the design processes moves among theoretical inspirations for the designs, how the designs make use of existing patterns found in product and interaction design, how visual and spatial explorations via sketching and prototyping contributed to their forms, how product semantics were developed using metaphor, and how subjectively felt consequences of all of the above were shaped.

4 FORMS OF SÓLE AND KUCHEH

Informed by HCI and design literature on form-giving practices, which accounts for diversity in forms and materials –including, physical, digital and interactive forms and materialities [6, 65] - we present two interactive prototypes developed as objects for reflection for home environments. Both designs followed a concept-driven approach to interaction design research [59], which is similar to research through design [22, 67]. Zimmerman et al. [67] show how interaction design artifacts and activities can be integrated within the HCI research process, defining four criteria, including "extensibility," which help the HCI community evaluate design contributions. Gaver [22], critiquing scientism as a basis for RtD, questions "extensibility and verifiability" as appropriate criteria of evaluating RtD. While this and many other debates continue in the RtD research literature, nonetheless, the community generally agrees that RtD is an iterative process, which is informed by relevant theories while employing design skills, processes, and methods; and the outcome of which is a contribution towards design theory and/or knowledge generation (as opposed to, say, a commercially viable product). We return to these issues in the Discussion to ask how evocative and practical features of design can be synthesized. In doing so, we argue, the outcome can be a design pattern, as Alexander defines it [3]. Design patterns can be replicated (i.e., they are extensible or generalizable) in a sense appropriate to design, rather than the norms of scientific positivism. Such a formulation helps to capture what is common to both Zimmerman et al.'s and Gaver's respective understandings of RtD.

The Sóle and Kucheh projects were informed by Schultz's theory of "implicit connections with nature," which is based on the Aron's et al. 's Inclusion of Other in the Self scale (IOS). The IOS scale is a social psychology theoretical model that originally was developed as a model to measure the closeness and the sense of togetherness between intimate partners [4]. The "implicit connections with nature" model adapts the IOS model and applies it to the intimate relationship between human and nature and asserts that "attitudes about environmental issues are rooted in the degree to which people believe that they are part of the natural environment" [54, 55]. Schultz' theory emphasizes the importance of people's understanding of their ties with the natural environment, so foregrounding the inclusion of humans within

the biosphere helps to encourage people to act in a more sustainable, responsible and inclusive way. This theory further discusses the crucial role of the understanding of the sociological relationships between individuals and the community that foster the altruistic actions and social sustainability [60].

Together, Schultz' and Aron's models focus on two relationships: that between humans, and that between humans and the natural world. Jointly (Figure 2), they gesture towards the care for others in the natural world that characterizes an intimate relationship and the commitment to environmental responsibility that we were hoping to stimulate in our designs as objects for reflection. These theoretical models became the central concept that guided the concept-driven design process for both the Sóle and Kucheh designs. The design goal was "to help people reflect on their degree of closeness and intimacy with nature as a way to self-care." It should be clear that there was no expectation that users of the designs would engage the theory as such, as if they might exclaim, "Oh, this lamp embodies Schultz's appropriation of Aron's Inclusion of the Other in the Self scale!" Rather it was to provide the designer with a sufficiently granular understanding of the psychological problem space to be actionable for design. The design was intended to encourage users to experience a certain degree of closeness and intimacy through reflective qualities of designs' forms.

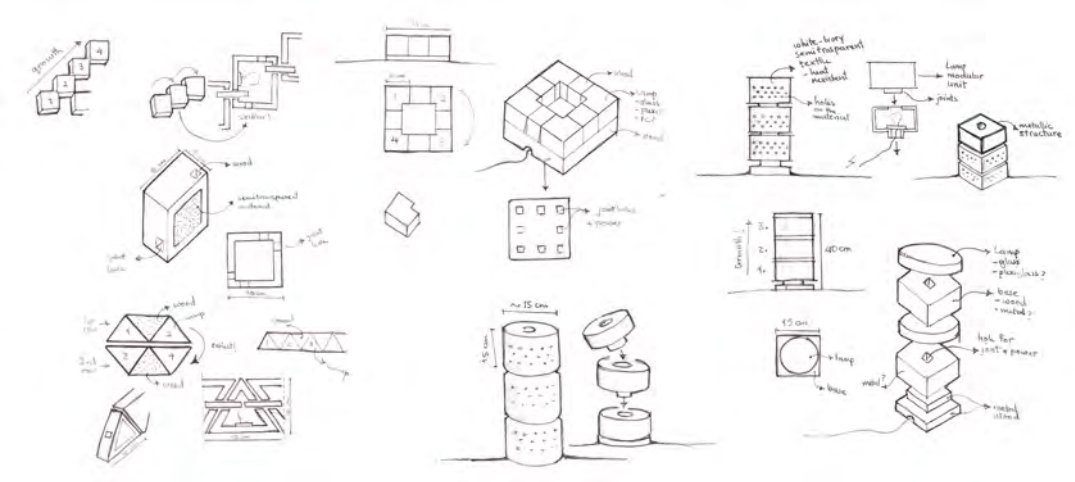

Fig. 2. Design sketches for Sóle exploring forms that are linked together, presenting connections with nature

4.1 Sóle (An Interactive Table Lamp)

Sóle [1] is an interactive table lamp for home environments. It is a functioning everyday lamp that is also designed for the purpose of triggering sustainable urban mobility behaviors in users. It achieves the latter through interaction, by providing light-based responses to user behaviors that mostly follow design patterns of other eco-feedback technologies. The lamp receives data collected by an urban mobility mobile application called NiuGo (developed by TIM) [23]. The app was designed to motivate users to change their urban mobility behaviors in the city of Turin (Italy), by encouraging them to use more sustainable means of transportation. Users create profiles on the app and set goals to achieve with a given amount of time. The application measures the distance travelled by a given means of transportation through an

[1]Sóle is the Italian word for the sun. Beyond its literal meaning, it has been also used as a symbol of wisdom, clarity and beauty in various literary works (e.g. Dante's).

embedded accelerometer sensor in combination with the user specifying which means of transportation they use. The app then calculates the total distance and time travelled by the user, by each kind of means of transportation (bike, public transportation, personal car).

In designing Sóle, the designer considered three common types of lamps that are used in home environments: wall lamps, table lamps and floor lamps. Additionally, their components, ergonomics, functionalities and dimensions, possible forms and structures have also been studied. During sketching, the designer explored the forms that can represent Schultz' theory of "implicit connections with nature," a theory that modeled connection in three parts (myself, my community, and my planet). Accordingly, she envisioned the lamp structure in three distinctive yet interconnected parts. But she also wanted the parts to function as objects for reflection [25]. Accordingly, she began sketching lamp forms that met these criteria (Figure 2): The interlocking units visible in the sketches not only present the functional connection among three modules—each representing myself, my community and my planet units—but also a symbolic connection and closeness among self, community, and planet. That closeness in forms intends to represent further the inclusiveness of the attitudes, which is inspired by Schultz et al.'s theory of "implicit connections with nature" [54, 55]. The block-like structures recall building blocks used in childhood, featuring many of their visual and tactual affordances, helping to extend an invitation to play - physically or mentally - with the lamp's configuration.

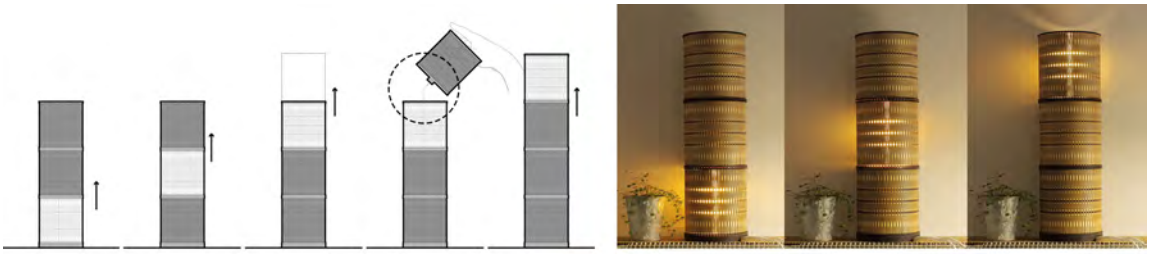

Fig. 3. The behavior and interactivity of Sóle: to arise modality

As functioning lights, the units reinforce their structure using light two different modes: to arise (Figure 3) and to accumulate (Figure 4). In the to accumulate modality, more light bulbs will be turned on as a result of a successful behavior, whereas in the to arise modality, the light bulbs will turn off in lower units and turn on in the upper units sequentially, which shows visually a raise of the position of light alongside of the lamp structure.

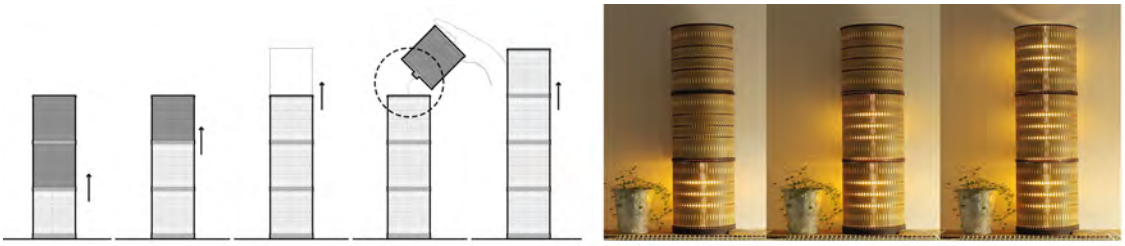

Fig. 4. The behavior and interactivity of Sóle: to accumulate modality

Although Sóle shares its design purpose with ambient displays in that both are designed to foster sustainable behavior change, Sóle's white color lamps, instead of red-green lamps commonly used in ambient displays, is one way

to distinguish it from traditional eco-feedback technologies, moving it closer to the category of everyday use object. Incorporating natural white lights makes it usable as an ordinary useful lamp for home environments. In addition, Sóle's non-intrusive, and calm light behaviors enable it to blend into a typical living environment, without disturbing the ongoing and daily activities carried out in the place [8, 29, 64].

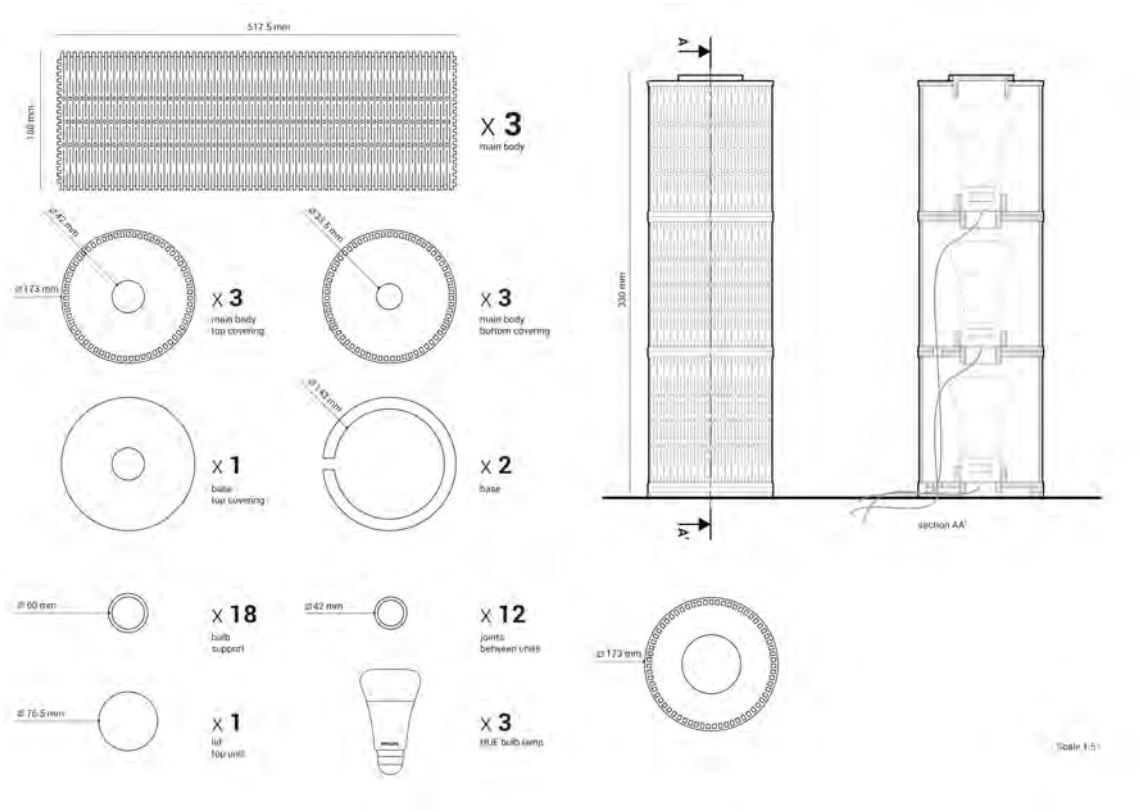

Fig. 5. The behavior and interactivity of Sóle: to accumulate modality

4.2 Kucheh (An Interactive Keyhook)

Kucheh [2] is an interactive key hook, designed for home environments, specifically the home entrance. Similar to Sóle, it is linked to the same mobile application described above (section 4.2), from which it receives data regarding user's daily urban mobility habits. As with Sóle, Kucheh is also inspired by Schultz's three-part notion of implicit connections with nature: myself, my community, my planet. Through the sketching process (Figure 6) the designer sought to visualise forms that represent inclusiveness, that is forms that are able to include some other forms within their boundaries, in a coherent manner and whole. Early drawings show different efforts to arrive at forms that manifested this concept. She entertained two ideas in particular. In one, three circular forms in different sizes move towards each other until they overlap each other, and in the other, they are concentric and are assembled and rotate upon each other.

[2]Kucheh is a Persian word, and it is the name of a specific narrow alley commonly used in Persian architecture..

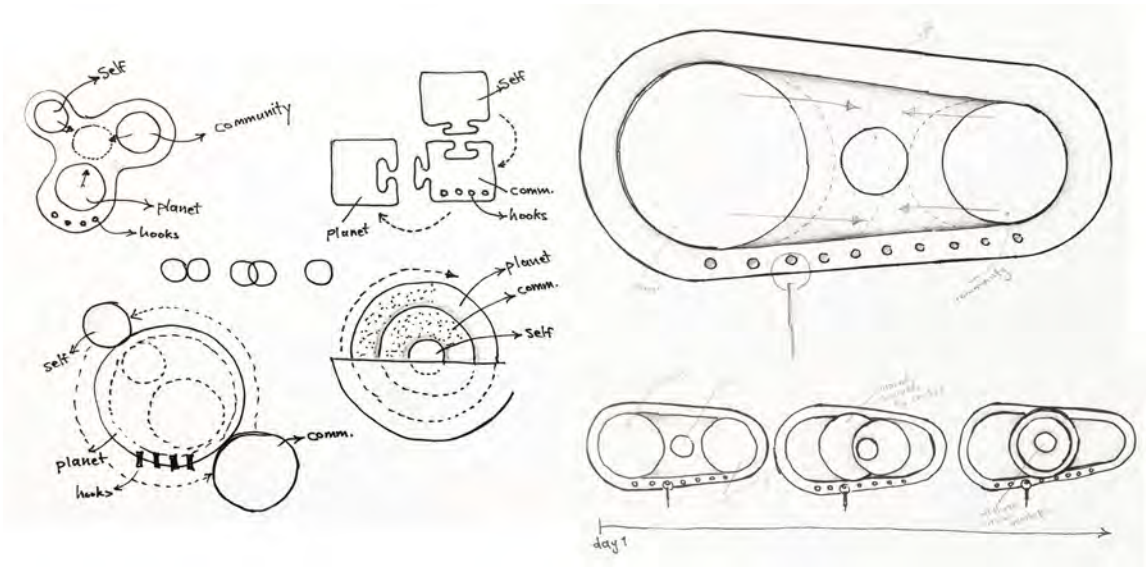

Fig. 6. Early drawings exploring Kucheh's possible form.

The designer chose the second option - the concentric rings form - because it was closer to Schultz's original theory, which asserts that humans are already included within the biosphere, but they are not always fully aware of it. Figure 7 shows the overall form. The inner circle represents the self; the middle circle represents the community; and the largest circle represents the planet. Thereafter, she sketched the behaviors of the object, and sought to understand how those forms can actually interact with each other, showing the degree of inclusivity in user's behaviors. She decided to use the circles' rotation to represent progress towards sustainability goals. The circles can rotate 180°, and half each circle is marked with dots, which shows the degree of rotation. At the beginning of each month, those dotted surfaces are initially hidden behind a cover over the lower half of the circles, which functions also as a place for key hooks (Figure 8). As the user attains sustainability goals, the circles rotate to reveal the marked (dotted) portion of the circle, not unlike progress bars. The center circle, representing self, does not move. The middle circle, community, moves when the user achieves sustainability goals in excess of his or her community's. The outer circle, representing the planet, rotates when the user meets his or her own sustainability goals. Figure 8 shows Kucheh in different states over the course of a single month. More precisely, the movement of the circles is calculated based on the distance travelled by the user as measured by the smart phone's embedded accelerometer sensor. The circles' slow rotating behaviors continue on a daily basis based on the user's urban mobility actions – e.g., if the user sets a goal to move each day 10 percent more than the previous day by bicycle, and if s/he achieves that goal, then the environment circle rotates 6 degrees (so as to complete the 180° semicircle after a month). Similar calculations determine the movement of the center circle, which not only calculate movement based on the user's behaviors, but also those of her or his community.

Similar to Sóle, also Kucheh is entirely made of 4mm plywood sheets and used a 20cm long, 6mm diameter wooden stick for key hooks (Figure 9).

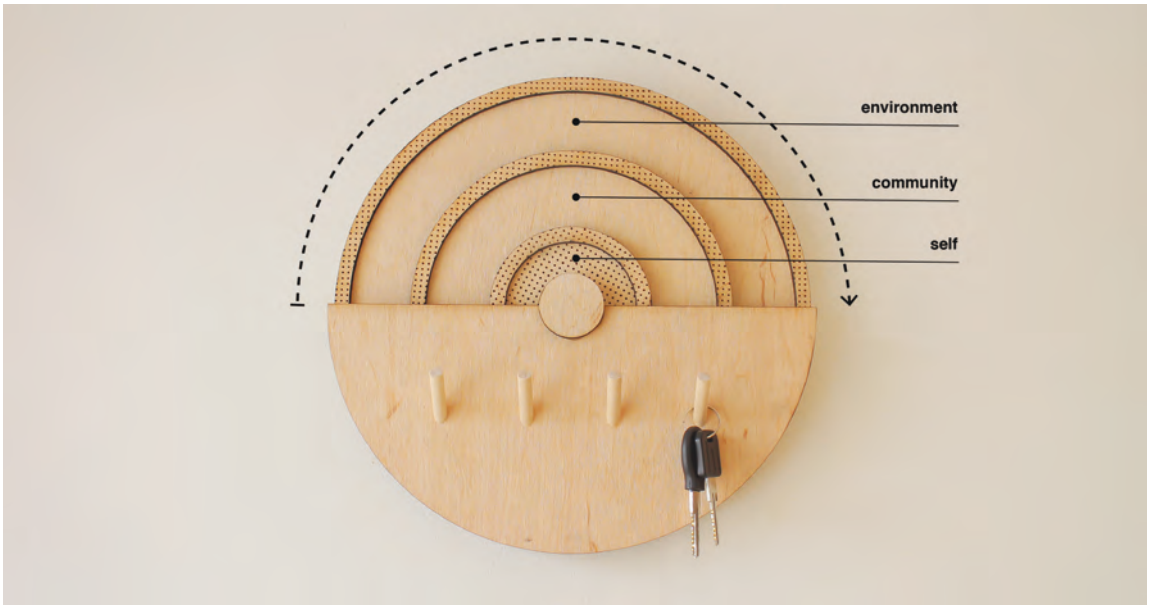

Fig. 7. Kucheh's three concentric circles.

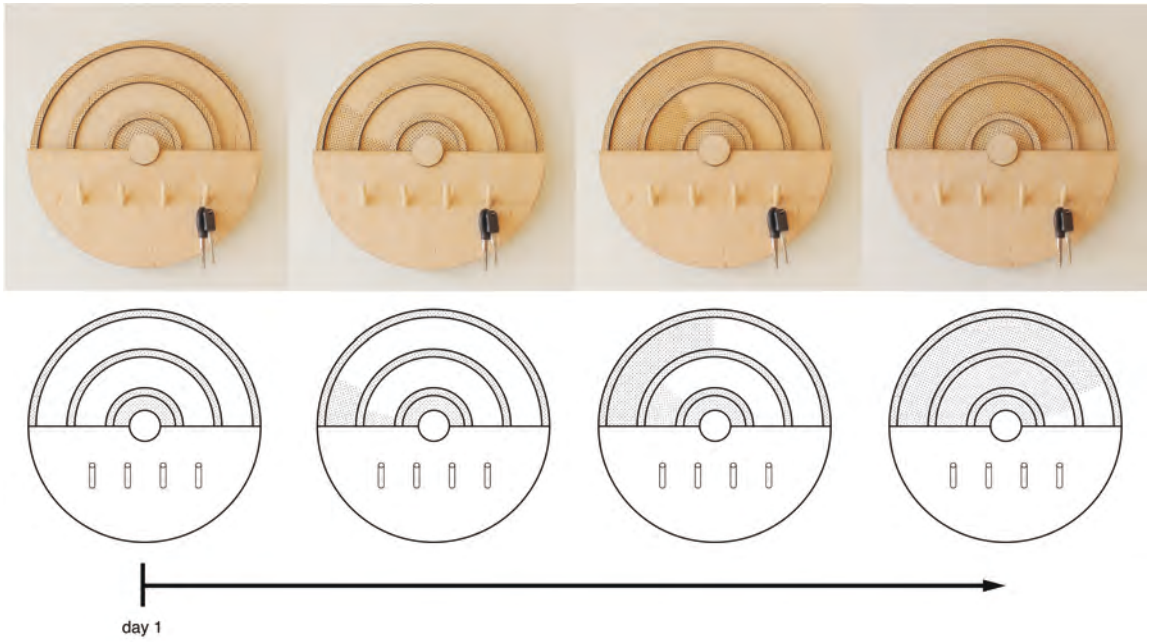

Fig. 8. Kucheh's different rotation degrees of concentric disks, from day 1 (left) throughout the month (right).

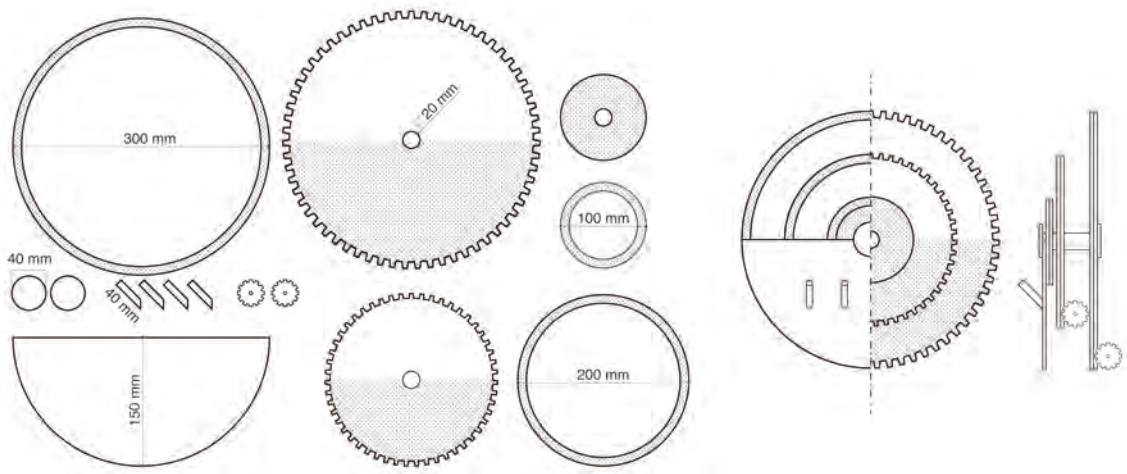

Fig. 9. Kucheh's technical drawings and components for prototyping.

5 SYNTHESIZING THE FORMS

Reflecting upon the form giving processes and final forms of two prototypes - Sóle and Kucheh - we return to the question that animated the project: how does the design act of form-giving help resolve the apparent contradiction between practical and evocative qualities? While the conceptual properties of objects for reflection served to define the design concept, that is designing a practical everyday use object for reflection, the physical shapes that through sketching and prototyping came to materialize the theories as tangible and perceptible forms. It continued to propel the design process forward, thanks to the externalized forms providing "back talk" [56] to the evolving design concept. In what follows, we describe and analyze the prototypes, in relation to the forms.

5.1 Conventional practical functionality

Both prototypes (Sóle and Kucheh) are examples of simple and useful everyday objects for home environments. Their familiar physical forms and components make them intuitive and easy to use. For instance, the basic cylindrical form of Sóle recalls familiar table lamps, while the simple and functional hooks of Kucheh intuitively recall their functionality as key hooks.

In addition, Sóle's white and neutral light makes it appropriate and useful as an everyday lamp, which can for example provide a relaxing light while dining or watching TV. The practical and functional forms were borrowed from already existing and meaningful objects within the familiar context of home environment. Further, their temporal and evocative forms do not create frictions with their basic physical forms and their basic practical functionalities. For instance, Sóle's one light bulb is always on, even if users do not achieve their sustainability goals, and do not progress in their behavior change. Therefore, Sóle is always a lamp and can be used as a useful everyday object.

The slow rotating behaviors of concentric circles in Kucheh, which interact with the users by informing them about the progress achieved regarding their goals —sustainable urban mobility behaviors change— do not hinder its main functionality as a key-hook. Similar to Sóle, even if users do not reach their goals, Kucheh still works as a key-hook, so it retains its functionality as a useful everyday object.

5.2 Evocativeness

Both Sóle or Kucheh are designed as evocative objects, too, in that they are intended to stimulate thoughts and reflections in users about their actions and behaviors. This is made possible by not only the way they interact with the users, its temporal and interactive forms, but also by their physical forms that enable such secondary forms. While physical forms are mostly concerned about their everyday use, the temporal forms and interactive behaviors in these examples call attention to themselves in ways that contribute to the evocative character of those objects [34, 52].

Such a calling attention to itself happens for instance in Sóle, when the lamp changes the position of light by accumulating or raising the level of lights. By doing so, it seeks to trigger the user to think about the meaning of the changes, even though it continues to provide useful light. Its evocativeness does not seem to be in friction with, or in any kind of opposition to, its being a useful lamp. Indeed, the lamp's utilitarian and evocative roles complement each other and are synthesized within a coherent physical structure. Likewise, Kucheh's rotating concentric circles, symbolizing the user's relationships with and inclusion within the community and natural environment, are not at odds with its functionalities as a key hook for home entrance. Sóle's arising/accumulating lights and Kucheh's rotating disks are temporal and interactive forms that are enabled by the basic physical structure, designed to trigger thoughts and reflection in the user. So, while it might be the case that many of the critical designs popularized by Dunne and Raby eschew practical use in favor of provocation, the presence of criticality in designs does not intrinsically exclude practical use. Criticality can be used as a mechanism that triggers a reflective response in objects that otherwise serve practical purposes, as both Sóle and Kucheh do. One might even argue that the impact of criticality within design can be magnified if it is synthesized within objects of otherwise practical utility.

6 DISCUSSION

Everyday use objects aim to support a specific user activity or simply be useful in addressing a specific user need. We recognize these as conventionally practical forms that fill up our lived environments – sofas, workstations, automobiles, etc. Designing conventionally practical objects with the further intention of evoking thoughts and reflection in users might seem to be a challenge, as the practical functionality that is required for everyday settings and needs might seem to be in conflict with reflection and thoughtfulness [18]. Yet any appeal to the history of design should reveal the problem with that: cantilevered chairs, Loewy's jet engine pencil sharpener, the Eames' organic designs, and so on all synthesized evocation, provocation, and everyday utility. There is plenty of antecedent in design for the idea of everyday objects serving as tools for reflection by synthesizing the practical functionality and evocative forms in one coherent form that fits within a context of use, as the "ultimate object of design" as stated by Alexander [1], or the "ultimate particular" as defined by Nelson and Stolterman [41].

The forms, as Alexander described, are created as a response to the irregularities of the world; without those irregularities, there would be no need for form. Hence the design is not only the form alone, but also the interactions between the form and its context – The concept of good fit, then "is the desired property of this ensemble which relates to some particular division of the ensemble into form and context" [1]. The coherent structure/form according to Alexander is the result of complex and step by step differentiations which are caused by transformations. These transformations are required to create a design, which is ordinary and functional, but it is extraordinarily coherent and fitted to the irregularities of the context [2]. We believe that any good fit, or design, needs to follow these subtle differentiations. Sóle and Kucheh are ordinary and functional, and through their practical and evocative forms they fit to the irregularities of the context and seek to achieve the design purpose, that of the user's reflection.

6.1 Modes of Synthesis

In this paper we identified and presented two main modalities of design forms of an everyday use object for reflection, that of evocativeness and practical functionality. We argued that the belief that practical functionality and evocativeness are inherently in opposition to each other is mistaken. The question then shifted to how they can be synthesized within the form-giving act of the designer, a question that we explored both at the levels of theory and via the concrete cases of Sóle and Kucheh. At the level of theory, we argued that forms are complex or dense, that is, that they can accommodate multiple rationalities simultaneously and unproblematically, much as a line in a poem can sustain multiple meanings. At the level of practice, we showed how Sóle and Kucheh concretely synthesized theoretical (e.g., the human relationship to nature), functional (e.g., light-giving, key-holding), social (e.g., interactions with one's community via the medium of design), as well as material (e.g., the warmth, rigidity, and affordability of wood) intentions.

As we stepped back and reflected upon the final forms of the two prototypes described in this paper, we were able analytically to identify two modes of this synthesis. By this, we do not mean to provide an exhaustive list of possible syntheses, of course, but rather to offer reflections on the activities and outcomes of this research through design project as a contribution to design knowledge. One such mode is seamless synthesis, in which practical forms and evocative forms are not distinguishable and they create one coherent functional whole. The other is complementary synthesis, where the forms are functionally independent, but they together shape the ultimate form of the object as a whole. By explicitly identifying these two modes, we hope to contribute vocabulary that supports future design work that integrates evocation and practical use.

6.1.1 Seamless synthesis. By seamless synthesis, we mean the intertwining and integration of conventional practical functionality and evocative forms. One form needs the other form to function and/or to evoke. In such synthesis, evocative forms are included within or derived from practical functional forms. Sóle, the interactive lamp, demonstrates one example of this kind of synthesis. Sóle's physical and modular structure seamlessly blends with the conventional practical forms seen in everyday lamps while adding dynamic light behaviors that contribute to its evocative purpose. That synthesis allows it to function as a lamp. Further, the light behaviours (i.e., its to accumulate and to arise modes) are seamlessly dependent on the physical modular structure of the lamp. In Sóle, the evocative features cannot work at all unless the lamp is providing light. Or, to consider the cantilevered chair, we might analogously argue that the cantilevering only achieves its evocative purpose if, in spite of apparently lacking sufficient support, the chair nonetheless does support the weight of someone sitting in it; if the chair collapsed under such weight, not only would the chair fail as a chair, but also the evocative effect of the cantilevering would likewise fail.

Earlier we observed that highly evocative designs, including critical designs, nonetheless have their own pragmatics, that is, their intended uses and how such uses shaped the design processes that led to them and also evaluations of their success. For example, if their provocativeness is meant to trigger debate, they can be evaluated for their provocativeness and whether they in fact actually triggered any debates, and if so, whether the debates contributed to knowledge and/or had other benevolent impacts. Their intended debatability, as Augur has argued [7] entails a synthesis of familiar and unfamiliar codes. To that, we would add that that synthesis must attract the sort of contemplation it is intended to support, which in turn implies numerous aesthetic decisions that would shape how it enters into human perception and sensemaking.

But most designs do not end up in art museums as objects for debate. And here we observe that "to evoke" can be used in stronger as well as weaker senses. The strong sense entails an object having a powerful psychological effect, as when Proust's madeleine cake famously evokes his childhood and becomes generative of 4,000 pages of literary

reminisces [49]. Yet "to evoke" also has a weaker usage, simply meaning "to call something to mind," or to activate a memory or a thought, as when a marketing slogan (e.g., Apple's "Think Different") evokes in our mind a brand in connection with creativity, learning, and going against the grain. One might go so far as to argue that the psychological concept of affordance [26], and later popularized in HCI [43], is akin to this more everyday sense of evoking. For example, the fit between a door handle's form and the context of our hand and its capabilities evokes in our mind (aka "affords") the action of grasping and turning.

Applied in the context of designing objects for reflection, it seems that the seamless synthesis of practical and evocative forms might bring about this weaker sense of evoking, merely calling to mind, with the effect of making evocation and affordance very similar concepts. In this sense, the seeming opposition between the pragmatic and the evocative collapses altogether. Of course, in Dunne and Raby [16] and in Forlizzi et al. [18], when they assert an opposition between the pragmatic and the evocative, they are tacitly referencing "evocation" in a stronger sense, but it seems clear that there is a spectrum from stronger to weaker degrees of evocation, and what each of them shares is signifier of how something can be done, whether it is surprising (as Mart Stam's 1926 cantilevered chair must have been), weakly evocative (as Apple's "Think Different" evokes its brand identity), or somewhere in between (as Sóle's provision of functional everyday light also interactively rewards behavior change).

6.1.2 Complementary synthesis. In contrast to seamless synthesis, where practical and evocative forms are unified in a seamless fashion, we also saw an alternate relationship, which happens when two forms are functionally independent, but they together shape the ultimate form of the object as a whole. We began to refer to this as complementary synthesis. In complementary synthesis, evocative and practical forms are both part of the object, but they are also distinct from one another visually and/or functionally. With Loewy's jet engine pencil sharpener, the jet engine shape has little to do with the practical purpose of pencil sharpening (indeed, one suspects that inside that evocative shape, the actual pencil sharpening mechanism is identical to that of any other pencil sharpener). In the context of this paper, Kucheh, the interactive key hook, features complementary synthesis. The rotating disks - the evocative forms - are not designed to improve the practical functionality of the key hook, but are part of the object as a whole and complement its final form. Kucheh's semicircles simply complement each other to create a final form of a circle.

In both cases, we note that a third meaning emerges, which is the basis of the juxtaposition of the complementary elements, without which the synthesis might seem absurd if not outright meaningless. It might seem that placing a pencil sharpener in the form of a jet engine is completely arbitrary and even absurd. Yet both share an important quality: both are metallic machines that operate via the twisting of its interior mechanisms. And operating the pencil sharpener semantically gestures toward the screaming power of the jet engine—making pencil sharpening feel cool. Likewise, with Kucheh, the spinning disks, capturing these three abstract relationships might also seem to make no sense as a keyholder. Yet the keyholder and each of the disks are all diverse signifiers of home, and to experience them together is to evoke diverse notions of home and its related concepts – belonging, responsibility, relating, safety.

Returning to the relationships between affordances and evocation introduced above, in complementary synthesis they are pushed away from one another: conventional functionality is afforded through some of the forms that compose the whole, while the evocative qualities are embodied in different forms. The effect of that – the user's grasping two different rationalities simultaneously in a single object – is part of what makes it evocative, as the user seeks to grasp their coherence. Kucheh affords hanging keys and separately evokes reflections on sustainable behaviors. The design as a whole still achieves coherence, however, as the evocative forms and practical functionality forms integrate while

yet maintaining their separate identities by participating in a unified, coherent synthesized form, as multiple distinct melodies make up the pleasing synthesis at the end of a fugue.

6.2 Forms, Knowledge, and Research through Design

The process of form giving to Sóle and Kucheh, their practical functionality and evocative forms, and their synthesis towards one coherent and particular outcome, can contribute to the ongoing discussions around design as a way to generate knowledge. On the one hand, this project pursued intellectual design knowledge. Its starting point was the apparent opposition between so-called practical and so-called critical design practices (or: affirmative vs. critical design)—and the fact that that contradiction—apparently accepted in the research literature—did not resonate with our experiences as designers and design researchers. To address that, we appealed to the notion that most human-made artifacts—be they works of art or everyday product designs—don't mean just one simple thing, but often complexly mean many things. Our accounts of Sóle and Kucheh foregrounded how each design came into being, from an initial concretization of a theoretical concept, through to the shaping of material forms, and finally into interactive objects supporting various behaviors. Throughout the process of their design, they acquired various meanings, including those reflecting the designer's intentions and more serendipitous ideas that emerged through the "back-talk" of sketching and prototyping.

On the other hand, this project also pursued knowledge embodied in designs, that is, reusable design forms that fit the contexts for which they were designed (i.e., design patterns). In this case, those contexts required simultaneously to meet everyday practical household needs and to call attention to how those needs are connected to, and situated within, a swiftly warming planet. These contexts are simultaneously diverse—one apparently local and banal (i.e., a lit living room, a place to store keys), the other more abstract and threatening (i.e., how resource extraction contributes to climate change)—and if Alexander's theory of forms is right, a designer will need to craft some highly irregular forms to fit into them. Sóle and Kucheh both introduced such forms, though in both cases they were drawn from existing design patterns. Yet it was in the study of these two products that we came to notice and subsequently theorize about seamless vs. complementary modes of formal synthesis. That is, we saw that these two specific designs, despite their uniqueness or "ultimate particularity," can nonetheless propose and embody intellectually comprehensible design patterns that are applicable to other design situations.

7 CONCLUSIONS

In this paper we presented practical functionality forms and evocative forms, as two distinct meanings, which can be synthesized in the final form of a design object. We presented and reflected upon form giving processes and synthesis of forms of interactive everyday useful objects that also evoke thoughts and reflection in users. We provided a brief background in design of computing technologies and interactions with the purpose of thinking and reflection in users in areas of education, HCI and design. We presented and discussed the characteristics, functionalities and forms of everyday use objects for reflection, through two prototypes, namely Sóle and Kucheh, a lamp and a key hook, as examples of two simple everyday use objects for the home environment. We sought to critically analyze and define what those forms are, why an everyday use object for reflection needs both of those forms, and how they can be synthesized. We positioned their two organizing principles as both conventionally functional and evocative objects. We argued that conventional functionality and evocativeness can be synthesized in different ways: seamless and complementary synthesis. Finally, we argued on how this work, the synthesis of forms as particulars can potentially generate generalizable knowledge and contribute to the design research community.

We believe those critical analysis, along with the two examples of modes of synthesis, the seamless and the complementary syntheses, can further help to define generalizable design knowledge . Specifically, we believe that this form of knowledge though produced through particular design objects [11] is universal and replicable, as it can be applied to similar projects by design researchers [19]. Further, it can also be used as generative tool for designing everyday use objects for reflection, as a categorical example provided in this paper, but also as an evaluative tool to answer the question of whether or not an object is an everyday object for reflection.

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