Design Science and Aesthetics

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Abstract: Design science advocates focus on two possible roles for aesthetics: in evaluation of design products, or in normative claims as inform and direct the design process and choices designers make. On a general model of design success criteria, aesthetics may be one among several factors for success, others typically including cost, utility, and ease of use. This view is typical to industry and overall design practice. But such engagement with the aesthetic may be purely stipulative and frequently dispensed with, particularly when cost considerations drive out 'inessential' expenses. I propose that aesthetic values inevitably characterize design norms, as well as our success criteria of designed objects. Choosing to ignore such values does not lead to design that successfully avoids or eliminates aesthetic features. Indeed, the technical norms of design science indicate at least 'minimal' aesthetic values, which are smuggled in even on a most utilitarian construal of design science.

Keywords: Design science, aesthetic value, values conflict, design norms, design success criteria

Introduction and problem statement

Since the 1950s, proponents of a "science of design" have identified a range of formal or systematic methods they take to be common among—and even definitive of—design disciplines, which methods may resemble those of the empirical sciences but at all events engage principled, analytic, computational, and other aspects of formal sciences.[1] However, if design is a science or, more modestly, features pertinent qualities of a scientific pursuit, where would we locate aesthetics? Traditions of design science advocacy focus on two possible roles for aesthetics: (a) in the evaluation of design products, or (b) in normative claims as inform and direct the design process and choices designers make. On a general model of design success criteria—offered, for example, by Ilkka Niiniluoto (1997, 2014)—aesthetics may be one among several factors for success, others typically including cost, utility, and ease of use. Indeed, this view is typical to industry and overall design practice. But such engagement with the aesthetic may be purely stipulative and frequently dispensed with, particularly when cost considerations drive out 'inessential' expenses.

The question remains as to whether and how we may justify appealing to aesthetic criteria in more than *pro tanto* fashion. I propose that aesthetic values inevitably characterize design norms, as well as our success criteria of designed objects. My proposal rests on the notion that failure to consider aesthetic values in design pursuits itself reflects aesthetic values. Choosing to ignore such values, in short, does not lead to design that successfully avoids or eliminates aesthetic features. Accordingly, there are no technical norms of design science that don't indicate at least 'minimal' aesthetic values, on the order of "such-and-so aesthetic outcomes (from not minding the appropriate values) will suffice". In this manner, aesthetic values are smuggled into design science even on its most utilitarian construal.

To motivate and frame this "smuggling" account, I start with a brief overview of the science(s) of design, and introduce the picture of design science as a normative domain of inquiry (Niiniluoto).

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Next, I present the challenge of negotiating values in design science, and review possible solutions to design *value conflict* (van de Poel, 2015; Kozlovski, 2022). Those solutions, however, do not point to the inevitability of aesthetic values as *prima facie* central considerations in design science; to that end, I offer my smuggling account. Wherever designers are solving problems for functionality and utility, we will find, first and indispensably, aesthetic sensibility *is* a consideration in at least some attenuated form.

What a science of design is, and why we need it

The notion of a science of design, or design science, is somewhat controversial and, across the diverse design literatures, a bit inchoate—ranging over such (sometimes) occult domains as 'design thinking'. Nevertheless, we can broadly characterize a science of design as comprising modes of design research modeled on scientific methodologies—including though not limited to those of the formal sciences—as lend systematicity and rationality to such research. This is not to say that design science consists in the sciences upon which it relies: design draws on engineering as well as basic natural and formal sciences, including physics, chemistry, and computer science. These are none of them design pursuits, nor is design science an amalgam of parts of their theories, models, explanatory frameworks, etc. Rather, there are at least these three possible modalities to a science of design:

1. A formal science of design objects, their components, and interactions. In part, we can think of this as an applied mereo-topology, an exploration of the possible shapes, spaces, and parts of design rudiments and their combinations. Other formal scientific aspects of design—advanced by developments in digital technologies—include *data and representational design*, encompassing problems of storing, relating, mining, and displaying design information; and *optimization studies*, that is, modeling design objects in virtual space and assessing their systemic and interactive features.[2]

2. A social and behavioral science of design, as concerns creation and experience or use of design objects. Such studies range over questions concerning the perceptions, affects, behaviors, and preferences of individuals; group norms, processes, and dynamics; and cultural values and expectations.[3]

3. A cognitive science of design, including studies focused on *reception*, especially special perception studies, such as of space or form; and *creation*, especially design cognition.[4]

On a broader view still, we can extend the list to include *social* sciences of design and environmental science as focused on the designed environment: environmental psychology; energy consumption; light, sound, and airflow studies; acoustics; and so forth. The objects and methods of scientific design research are as diverse as the attendant research domains and their objects, as may include designed artifacts, their parts and features; their materials and environmental forces or conditions; designers, producers, and users of designed artifacts; systems, processes, behaviors; and social and economic dynamics. The methods, correspondingly, range over such classic features of scientific method as observation and experiment; statistical analysis; random assignment to treatment and control groups; case studies; field- and laboratory work; a full complement of abductive, deductive, and inductive reasoning; hypothesis formation, prediction, and confirmation; reproducibility and testability of results; and simulation and modelling.

Indeed, long-standing pursuit of model building and simulation lab testing as methods-for-design closely track the scientific method. It may even be thought that what lends a fundamental design core to design science—beyond a collection of scientific facts, theories, or elements of a research program that happen to be about design—is the autonomous, self-standing design model. The idea is that the kinds of models by which we understand the nature, behavior, and consequences of specific design objects are not accounted for in their entirety by any other, more general (e.g., broadly physical or mechanical) models.[5] Design models in their classic forms are material, pared-down, and often miniature prototypes of all manner of artifacts, from contraptions to clothing; the modern design model is a *virtual* realization of the artifact. Graphic representation may be optional, depending on

the artifactual kind. What joins the classic and modern forms is, at a minimum, the concept of models as a means of developing synthetic accounts of diverse phenomena and behaviors associated with design objects. On this picture, models allow designers to capture the normative, make predictions, generate explanations, and articulate the range of potential states and transformations of the objects and their structures.[6] All this, in line with the received philosophy of science picture of scientific models and their use; note that such use is commonplace in contemporary design.[7]

As it turns out, though, the history of design science concepts predates the passion for modeling in philosophy of science and starts, instead, with Herb Simon's account (1969) of *problem-solving* as representing a significant parallel between the domains and goals of design and the sciences. Simon accordingly promotes formalization, empirical research, and analytic decomposition as tools and means of an optimizing, value-neutral design science.[8] This parallel is not without its critics. For example, we might protest that while design aims at *creation*, science aims at *discovery*—or that the former draws on a historical catalogue in ways irrelevant to the latter. Yet such complaints cannot be registered consistently: For one, the natural sciences are vigorous in pursuit of creation (molecules, particles, elements, etc.), whereas designers, at least for the Platonists among them, may be said to discover new forms. Similarly, the sciences comprise historical enterprises, and design may be conceived of ahistorically (again, as suits the Platonist). And even accepting that design studies may be fruitfully formalized, the dedicated critic may worry how a value-neutral design science will capture aesthetic *qualities* as manifest in design; or how aesthetic *value* may be characteristic of, or judged in, designed artifacts. I return to this set of worries below.

Normative claims in design science: Niiniluoto's proposal

First, however, note that something like the creation/discovery distinction is embraced by Simon, who proposes that the core claims of design science are causal claims about producing sought-after ends through suitable means. In short, they are about creation (rather than discovery). Niiniluoto (1997, 2014) follows Simon in this vein, and points out that, for centering on causal claims that aim at solutions to practical challenges, design science is a *normative* science. And, following von Wright (1963), Niiniluoto characterizes such means-end analyses as taking the form of what he calls 'technical norms' or 'conditional recommendations'. Consider, for example, the needs to serve and to carry hot coffee, and the situation that we may be moving from place to place as we serve or carry the coffee. Here the normative design solution is to create the disposable coffee cup. Such norms are roughly of the form:

> TN1 Wants/needs x + situation $y \rightarrow$ should z
>
> which we may render in natural language as
>
> TN1a Given a particular set of wants or needs x and situation y, the (rational) design solution will be to do or create z.

The difference here with core claims of the so-called standard sciences, as Niiniluoto would have it, is that the standard sciences are descriptive or predictive, and explicitly, at least, non-normative. Even someone who is a materials engineer by day and sociologist of food by night will not tell us that we *should* devise the disposable coffee cup, or what designs for such *should* be executed. That is fair ground for the designer, by contrast.

As Niiniluoto sees it, the challenge of the normative science of design is to wrestle with the value-ladenness of technical norms. He is a little vague about where exactly the values seep into the norms. I suggest they are everywhere. Thus, when we state our want or needs, those often reflect our values.[9] This seems to be Niiniluoto's clearest concern—as he puts it, "any social value could take the place of the value [x] of a technical norm" (14). To revisit the disposable coffee cup example, our needs to serve and to carry hot coffee[10] are deeply infused with all manner of social values concerning coffee

consumption (and many *other* values, as well, including aesthetic values relative to taste). The consolation Niiniluoto offers is to suggest that the values so embedded in the first clause of the antecedent don't commit us to such claims of design science—or the underlying theories or models—those values merely set up the conditional.

I'm not sure this is sufficient to grapple with the depth of value-ladenness in technical norms of design science. For his part, Niiniluoto worries that the decision to fixing (securing) the situation *y* and producing solution *z* to accommodate (rather than swap out) *y*, is an additional entry point for introducing values. So, for example, given that

> (x) we need to transport ourselves around the urban environment; and
> (y) the city (and the world) is polluted by low-capacity automotive combustion engines;
> then
> (z) our solution is to devise electrical cars.

This places a premium on the low-capacity automotive solution that is perhaps better met by mass transit to begin with. That assessment is fair enough, but the larger issue is that we may also bring our values to how the situation is described, that is, what we take to be the problem space, circumstantially, for which the design poses a solution. After all, circumstantially, that we have organized ourselves into cities with separate districts for work and life, or with non-optimized infrastructure for distribution of goods and services, may reflect our high valuation for organic urban development; or, perhaps, our low valuation for urban planning and design; or some other valuation still. And, the consequent of design-wise technical norms is *also* value-laden and not in a hidden way: *whatever* our wants, needs, or circumstances, the conditional recommendation that we *should* pursue the design solution described in *z* may require (perhaps always requires) not just establishing that *z* satisfactorily addresses (wants, needs, or circumstances) *x* and *y*, but that there is some value in so doing, be it intrinsic to solving the design issue or extrinsically driven by other values we wish to promote. Not every design problem merits addressing, in short, and each normative drive described in such conditional recommendations needs to rated, that is, *evaluated*, to see that we really should be pursuing *z*, after all.

Where to fit aesthetics? Niiniluoto again, and van de Poel's optimization problem

Taking design science as a normative science along roughly the lines that Simon and Niiniluoto propose, I have suggested that we run into value-ladenness at each turn, for any (normative) causal claims of the science. This by itself does not pose any worries; Niiniluoto is happy to suggest that we need merely decide what matters to us and then proceed with the science. And perhaps this could work out well in a world narrowly limited in value-kinds. Niiniluoto's concern focuses on ethical value and if we could gauge good, bad, and neutral, for example, this might be sufficient to the task of fully characterizing and judging the normative claims of design science. That is not the world we live in, though. In fact, a 'Value Sensitive Design' approach has emerged in the design disciplines, which approach mandates attention of designers to a wide range of political, social, and humanitarian values, as well as standard or more generic ethical values.[11] And, as is central to many, if not all, designers' concerns, we might well suppose that *aesthetic* value should feature prominently in the value-ladenness of design science's normative claims.

But *where*, and *how* do aesthetic values feature? In an earlier essay, Niiniluoto (1997) outlines design success criteria where aesthetics may be one among several factors, others typically including cost, utility, and ease of use. As go the technical norms he later outlines, these criteria seem to mark the consequent of those norms as value-laden, if not in initial statement of the causal claim, at least as subject to multi-factor evaluative criteria at the adoption stage. So here we get the suggestion, as seen across the design literature (e.g., Pye 2007, Herriott 2021) and as sounds fairly mundane, that we *can* take (it's *possible* to take) aesthetic value into consideration when judging design. This is

incontestable, I think, but it is equally insignificant. Aesthetic value doesn't *have* to be a factor in our design success criteria, by Niiniluoto's lights; we might stipulate such but we can just as easily and frequently dispense with it. And—as designed objects will *always* have costs of production, marketing, and after-market use—attending to aesthetic value, on standard manufacturer's reasoning, may be desirable but will not be sustained if the costs of doing so grow too high. On Niiniluoto's picture, costs pursuant to aesthetic value are avoidable and can be driven out as 'inessential' expenses. In this corner of design science—evaluation of the proposed solution for adoption—engagement with the aesthetic is compelling as criterial unless overridden. And yet, as we are talking about design, after all, might we hope to justify our appeal to aesthetic criteria in more than *pro tanto* fashion?

To be sure, there *is* something to Niiniluoto's laundry list approach to design success criteria, where the aesthetic is just one among several plausible but not essential measures. For one, seeking to *balance* or manage different sorts of values is a common issue in the design science literature (even as design *theory* typically and unreservedly embraces aesthetic value[12]). For another, design is sufficiently diverse an enterprise that one may well want to exhibit maximum flexibility in determining which measures and values are important relative to a given design problem. And for a third, values discussions in design science or design scholarship all told tend to focus on raising *ethical* values—perhaps assuming inclusion of aesthetic values, though perhaps not. But the central consequence of a laundry list approach here is to highlight that, in such considerations of differing sorts of values as mark design science, we will quickly need a way to adjudicate *conflicts* among values. How tractable are such conflicts, and where will aesthetic value land among conflicting values? One helpful guide to value conflict is provided by some recent work of van de Poel (2015 and, with Royakkers, 2011/2023).

To lend some precision to value conflicts, let's follow Van de Poel and colleagues' characterization of such as those situations where (a) we make a choice as guided by two or more different and relevant values, (b) the differing values differ as well in the options they guide us toward, and (c) there is no single value that defeats all others. As Van de Poel points out, this is something of a generalization on Williams' characterization (1965/1973) of moral dilemmas (as situations where our obligations are in conflict and cannot be fully resolved), albeit without the normative emphasis on actions to be undertaken given the choices toward which we are guided. The good news is that, in many design choices, our values all lean in the same direction; or, where they don't lean toward the same choice, we weight the differing values in such ways that they clearly guide us to a single design solution—or similar enough options. The beautiful or elegant design solution may be the inexpensive and ecologically-friendly solution, as with disposable clay coffee cups. In short, there are plenty of design science cases where there is no real value conflict.

The bad news, as Van de Poel has it, is that much of the time this is not the situation that designers, or design consumers (all of us) find ourselves in. Rather, value conflicts abound and, in his picture of things, following Franssen (2005) who is writing relative to *engineering*, the appropriate framework for thinking about value conflicts in design is Arrow's social choice theorem. As a reminder, Arrow's theorem offers us the grim picture of social choice that there is no generalizable procedure for arriving at collective decisions as are based on individual preference-driven decisions, where we aren't violating one of six must-keep conditions, such as no ultimate decider, monotonicity (continuity of modified preference ranking at the social level), independence of irrelevant alternatives, etc. What exactly this entails for social choice theory is subject to debate, though notably many (including Arrow) take this as not entirely promising for picking among electoral schemes. Translating into the domain of value conflict, Van de Poel points out that we can swap values in for individual choice-makers in ordering choice options and thereby model the choice phenomena as undertaken by a single designer (the simplest case). Thus, consider a bridge designer who chooses, relative to cost savings to taxpayers (less expensive materials) and lowering risk to bridge users (more expensive materials), among three scenarios: low cost/high risk, high cost/low risk, and mid-level cost/mid-level risk. Our designer triggers an Arrovian condition if, for example, the values they

attach to each scenario defeat each other in a circle (in the manner of Condorcet's voting paradox). In this fashion, the range of standard ways of choosing among values may fall prey to Arrow's theorem. But it need not, as Van de Poel points out, though for those approaches that do not—e.g., cost-benefit analysis, trade-off strategies, or maximin strategies—other problems may arise, from commensurability of value measures, to measurability of ratios needed to calculate considered choice of values.

In sum, Van de Poel proposes, different approaches to addressing value conflict bring distinctive benefits and drawbacks, and combining approaches may be a way to optimize for the challenge of which values win out. While Van de Poel's particular focus is on moral values, he takes his meta-approach to be applicable to value conflicts with non-moral values, and in this regard his conclusion merits paraphrase relative to aesthetic value: "...the designer may not always be required to do what is [aesthetically] best, as it may be good enough to choose an option that is [aesthetically] acceptable but perhaps not [aesthetically] best." (115). Broadly, then, he is pursuing a sort of satisficing strategy and, it's fair to say about actual design practice, that probably captures much of how design value conflict and tension are approached.

Still, his strategy doesn't resolve issues attendant to commensurability, measurability, or Arrow's theorem-type issues, and as the possibility of conflict remains non-zero, it's entirely conceivable for aesthetic value to be left behind or left out altogether. A more recent try at addressing such value conflict in engineering and design (Kozlovski 2022) borrows on Ruth Chang's notion (2009, 2013) that we can, by drawing on our 'normative powers', commit ourselves to new driving values that are deciders and so resolve any value conflicts. But, and while this may represent a successful *ad hoc* strategy to value conflict resolution, it still provides no guarantee of minding aesthetic value in design problem solving or whatever counts as design science method.

The problem, which manifests as "no guarantee of aesthetic values." is a failure to take aesthetic values as foundational in design science. And if the warrant for minding those values is not there *prima facie* and fixedly, then we need some way to make sure that, contrary to at least the Niiniluoto picture of things, aesthetic values are embedded and enjoy preeminent standing. We need, in short, an account to explain how aesthetic values are smuggled in with the territory of design science.

In a fashion, this is one way we might try to read a standard functionalist approach (cf. e.g., Carroll, 1999; also Koller, 2021), the notion that accomplishment-appreciation judgments count as aesthetic judgments because they are centered on elegance of design. We might think that accomplishment value smuggles aesthetic value into design science under the guise of the indispensable task of gauging utility. If a designed object is functionally valuable, it is such that users will derive accomplishment value from its use. A similar sort of 'fashioning' might also be applied to a more canonical Functional Beauty concept, per Parsons and Carlson (2008), i.e., that designers or users actually or normatively take beauty of designed objects to be gauged against function.

But in both cases, per standard criticism (cf. e.g. Davies, 2010), the aesthetic value as intended, or as perceived and appreciated, can be separated out from functional or utility intentions, realization, and reception, as each manifest among designers or users. It's not clear that falling under a given functional type (car, coffee cup, etc.) requires actual functionality, which as Houkes notes, may be elusive anyway. So, what designers and users are gauging in Functional Beauty is beauty against a design that may not be functional, which means that we can't possibly *require* functional awareness for gauging design's aesthetic value. In short, design-for-function-in-principle is not the same as design-for-function; rather, it is design for an aesthetically rewarding object that may or may not be useful in ways we recognize. We can get, for example, a pretty good idea of a coffee cup's broad aesthetic value even if the cup is malformed or otherwise unusable. Hence the problem remains, for those taking aesthetics as foundational values of design, to assure its motivating or grounding designer's intent and problem solving in a design science.

To review, Niiniluoto's laundry list approach to values that feed into our criteria for judging design has it that *all* core values as include aesthetic values *may* factor into those criteria. By parity of reasoning, aesthetic values *may* factor into technical norms of design science. Or not. So, not only does Niiniluoto not give a weighing mechanism to adjudicate among values in tension or conflict, we see that aesthetic values are good to have but not indispensable—and, in any case, possibly overridden by other values. The literature on addressing values conflict in design and adjacent domains isn't confidence-building, given the formal challenges of Arrow's theorem and such practical difficulties as incommensurate values or escape clauses like the Chang proposal that we 'choose-our-own-commitment' to settle value conflict. In short, there are no guarantors of aesthetic value in design science from that corner, nor does it seem that we can smuggle aesthetic value into design science by hitching such value to functionality or utility in design, as such values are easily enough detached as they are hitched.

Smuggling solutions

If this seems troubling, that may be a prompt to simply build aesthetic value right into the heart of design science—we might just assume that it's been there, and will remain there, all along. Along these lines, consider:

> SMUGGLING HYPOTHESIS, GENERAL VERSION
> Design just *is* artifact-oriented problem-solving as imbued with aesthetic value—whether high or low value but nonzero value in any case.

The basic notion is to reject the view, which I have associated with Niiniluoto (and some might add Simon), that design just is artifact-oriented problem-solving, where aesthetic value is *optional*. It's not clear how it could be optional, truly, because even a decision to ignore aesthetic qualities as, for example, driven by economic cost considerations is a decision that leaves the resulting object with aesthetic qualities. They may be banal, bland, nondescript, uninspiring, prosaic, hackneyed, subtle to the point of trifling, and so on. And yet those *are* aesthetic qualities.[13] If we buy this hypothesis, I suggest we also get for free this evaluative corollary:

> SMUGGLING HYPOTHESIS, EVALUATIVE COROLLARY
> Judging design (*ineluctably*) includes gauging aesthetic value.

We get this one along with the first, on the trivial grounds that the central value(s) of design are the ones we will (that is, *should*) put at the center of our evaluative judgments. But now we can easily plug this into a version of the hypothesis that directly addresses Niiniluoto's criterial scheme:

> SMUGGLING HYPOTHESIS, CRITERIAL VERSION
> Judging design (*ineluctably*) includes gauging aesthetic value; hence judging designed objects entails judging them relative to their aesthetic qualities—and possibly other qualities (functionality, cost, etc.).

This gets us part of the way, underlining that design is always characterized by aesthetic values, such that the way we judge designed objects has to focus on their aesthetic values. Fair enough—but how do we tackle the Arrow's theorem-type challenge that van der Poel identifies? How, in a conflict among values—which we can now say will always include aesthetic values, because designed objects always have such values—(how) do we decide which values to weigh *more*, in either creating or appreciating such objects? And yet more pertinently for advocates of the Smuggling Hypothesis, how do we arrange that aesthetic values, central as they are to design as enterprise or science, are the deciding values in any such conflict or tension?

This is the easiest, if most controversial piece of all. We need merely stipulate, in the framework of an Arrow's theorem framing of the issue, that there is in fact a "dictator", that is, a universally deciding value, and it's *aesthetic* value. The theorem, or rather, van de Poel and Frassen's variation

thereupon, is satisfied, though it does require landing on one of the several Arrow theorem-wise non-desiderata. But in this sort of case, that turns out to be a *good* thing because, in the world of value conflicts, if you have a value in a domain that is *the* central, indispensable, motivating value all told for the domain, that *should be* the authoritative value.

The rest of the exercise in locating aesthetic value at the center of design science follows more or less automatically. Take the case of Niiniluoto-style technical norms, which we render accordingly as

> SMUGGLING HYPOTHESIS, TECHNICAL NORMS VERSION
> Design just is artifact-oriented problem-solving as imbued with aesthetic value, so
> where our wants/needs are x, characterized by aesthetic desiderata ad_x; and
> we have situation y characterized by aesthetic features (constraints, opportunities, etc.) as_y;
> →
> we should do or create z with fitting aesthetic values av_z.

Let's revisit the disposable coffee cup once again, as example. This particular need or desire to carry one's personal coffee around different places or with friends or colleagues, as it happens, has abundant pleasures attached to aesthetic features of (i) the substance to be contained, itself (the coffee); and (ii) the sorts of personal experiences and interactions as accompanied by coffee drinking. Here is a very rich well from which to draw on the aesthetics of the everyday. The situational context, which defines the particularity of the designer's challenge, is that we take the coffee in motion, which occasions our engagement—proprioceptively, or through internal imagery or feelings, or otherwise—with the aesthetic features of our individual walks through the world, wherever we take ourselves and have opportunity to seek pause or concentration or any other mental or social states enhanced by drinking coffee. Now, a range of aesthetically-robust or aesthetically-lean solutions (see Figure 1) will meet the antecedent to complete the conditional recommendation.

Anthora disposable coffee cup
Leslie Buck (1963)
Photo: Andy Levine (2024)

I (HEART) NY
disposable coffee cup
Milton Glaser (1975)

Unadorned disposable coffee cup

Figure 1. Aesthetically robust and lean design solutions.

Each of them, however, including the very most basic design, brings its formal properties, its suitability as affordance, and its comfort of use, as are all the source of users' aesthetic experiences of the coffee as well as of the cup. As it happens, the cup example works particularly well given the deeply aesthetically evocative character of coffee. Yet we can also point to users' aesthetic experiences of, and with, machine tools, medical equipment, electrical circuitry, and myriad other more mundane objects of design.

Finally, I mention in passing a version that will play out in model building for design, too:

SMUGGLING HYPOTHESIS, MODEL VERSION
Design just is artifact-oriented problem-solving, through model-building, as imbued with aesthetic value; so any model we craft (of, e.g., object, process, etc.) needs to capture the relevant structure and phenomena, with their projected aesthetic value fully represented.

In short, once we take aesthetic values as central to the design domain, we can tell a multifaceted story about how such values as centrally positioned shape a science of design—as primary criterion by which we gauge value of a designed artifact; as indispensable information characterizing problem solving in the domain; and as projected features of models of designed objects (or processes, etc.).

Justifying smuggling

By this point the reader may be asking what justifies *any* version of the Smuggling Hypothesis. It may seem arbitrary and perhaps counterintuitive if arriving at design science via engineering or other functionality- or cost-centered pursuits. And yet, as we have seen, the hypothesis definitively addresses worries about slippage in the ranking of aesthetic value, in criteria for gauging design overall, in problem-solving norms on the creation side, and presumptively other aspects of design science. Of course, that still leaves the question as to why we don't want to just *allow* aesthetic value to slip down, if that should look like the right design decision.

To address that question, consider the proposal that the basic proposition, or charge, of design problems is to create an artifact that addresses the problem space. The base assumption of most design theorists or philosophers of design, reasonably enough, is that this proposition can be completed as "...with whatever functional features are necessary to solving the problem", and secondarily as "by the way, make it look good, too".

But this is the wrong emphasis, because design problems just *are* aesthetic problems. So the actual way the proposition should be completed is "...with whatever aesthetic features are necessary to solving the problem", and secondarily as "and of course, make it work, if you can". Scanning across the world of design, one finds plenty of evidence for this approach, where aesthetic problem solving was clearly frontloaded in front of functional problem solving, whether or not the designed object was an aesthetic or functional success.

I cannot take this approach as definitive or even most common, though; there are *also* many designers who would finish the proposition in the first way entertained here, frontloading functional concerns and treating aesthetic values secondarily at best. So, too, are many designed objects assessed by many of their users in primarily functional terms. This does not look to be normative on any view of design science as focused on aesthetic features of our artifactual world. But lots of designers, engineers, and users, follow a non-normative path in this regard, and they have every incentive to do so if (a) no one is asking for the normative path and (b) it's cheaper, in whatever dimensions, to do so. At all events this is not problematic to explain as puzzling deviance from the norm. For one, as noted, there are cases where, under the right circumstances, it's rational hence *not* puzzling; and for another, we can simply take those designers or users who fail, non-normatively, to put a premium on aesthetic features or values of their designed objects, as placing a *low* premium on aesthetic features, with corresponding aesthetic results.

And this brings us to the reason why it's normative for design science to focus first and foremost on aesthetic value, and—though this perhaps sounds strange—to worry about non-aesthetic functionality secondarily, despite Simon and others apparently urging to the contrary. The reason is that the problems that designers solve are at root aesthetic problems, no matter what other wants or needs designers are meeting, under whichever circumstances or descriptions, with whatever functional achievements to which they or we aspire. For, on any of the going conceptions of aesthetic value—hedonic, collaborative, social, achievement-oriented, and so on—such value is built (well or poorly) into solutions to design problems. Correspondingly, the way we set up the problems (e.g., tracking

technical norms) may reflect keen attention to or outward neglect of aesthetic value but in any case, will reflect an attitude toward what is aesthetically acceptable. Attempts to cut aesthetic value out of the solution space will simply generate aesthetic value by neglect—probably a recipe for the banal, or perhaps the comically bad. Terrible aesthetic features are, after all, still aesthetic features.

By contrast, those who want solutions to functionality challenges with no aesthetic commitments, no reflection on aesthetic values, and no prospect of yielding aesthetic features in the solutions, likely need to look outside of design—in whatever realm we can produce artifacts that have no aesthetic features or values, good, bad, or otherwise. I just don't know what realm that could be.

Conclusion

I have argued that the place of aesthetic values in a science of design is at its core. This is in contrast to a traditional view that design science, as a problem-solving domain, (a) has the primary task of recommending courses of action to meet functional challenges, and so (b) should maximize utility even as doing so comes at the expense of aesthetic value. The primary questions about the corresponding place of aesthetic value in design science can thus be summed up as these: (1) if we don't think aesthetic value should possibly slip away all told here—if we don't think it's defeated by functional value or cost—how do we block that result; and (2) how, in the adjudication of conflicting values in in design science, can we assure that aesthetic value remains a motivating force in design creation and a central criterion in judging designed objects?

To address these questions, I have proposed, we need to see that the traditional view can't account for the presence of aesthetic features, however impoverished or ordinary, in all designed artifacts. The most banal elements of public infrastructure, like a highway entrance or a striped crosswalk, all have aesthetic features, though they may be less pronounced than those of other elements of the designed environment. And so, too, for yet more quotidian designed objects, including our pet example, the plainest disposable coffee cup. The designer who chooses to mute their aesthetic choices, on grounds of cost or function, has elected to foster muted aesthetic features. As such pervasive drawing on *some* form of aesthetic value plays out in the technical norms of a formalized design science, what we need—and our circumstances as give parameters for our need—are all aesthetically inflected. We don't merely need to carry coffee around in ways that are highly mobile—we could drink coffee out of a balloon if that was the most physically elegant way to do so. Rather, we are also seeking the tactile and visual pleasures that come with a cup shape and holding it. It is hardly surprising, then, that our design solutions—and the ways we judge those solutions—are also all aesthetically inflected.

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Notes

[1] Competing views of design research reject, or lower expectations from, a science of design; cf. Cross (2001). It also merits mention that approaches to a science of design are varied and evolving; cf. Baskerville et. al. (2015).

[2] Cf. e.g., Haakonsen et. al. (2023) and Papalambros and Wilde 2017).

[3] Cf. e.g., Donovan and Gunn (2012), Murphy (2016), and Lupton (2018).

[4] E.g., Goldschmidt (2014). On psychology of design more broadly, cf. Carbon (2019).

[5] If this was talk of theories rather than models, we would likely speak of being 'subsumed under'; aside from the general move towards a semantic or model based-conception of theories in philosophy of science, there are no obvious candidates for architectural theories in the manner traditionally associated with scientific theories per the classic philosophy of science discussion—whereas the same does not apply to models.

[6] Consider design phenomena **A** (which may or may not be *unique* to design) which are produced or endured by, or go into the creation of, design objects (which may or may not be *unique* to design). One way to grasp the nature of those **A**-phenomena is by crafting and exploiting a satisfactory model of the associated design objects, their behavior, relations, genesis, development, etc. The best models will have characteristically scientific features:

a. We build the model by representing in abstract form the features of the system—that is, the set comprising the design object, the processes it undergoes, and the phenomena it endures. The key feature is the *structure* of the system, the collection of patterns and relations among the system's elements;
b. We postulate how the system works based on the model, craft equations to characterize its behavior, and fashion simulations of behavior in the system;
c. If the simulations yield accurate visualizations and projections of real-world behavior of the system, then the model may be validated; models are typically judged by their conformity with the observed data, predicted outcomes, simplicity (or other aesthetic properties), and utility (explanatory or otherwise).

In short, we have a formalized model of the real-world system (the complex of design object, processes, and phenomena), where assumptions replace real-world measurements and where, as a bonus, model-wise experiments serve as proxies for controlled, real-world experiments. In design, this model-wise conception entails two related scientific projects: understanding the structure of design systems for token design objects and, more broadly, for the overall universe of possible design objects, which may entail individual type-oriented models, as well. On the token level, it happens that such features are common in computer-facilitated virtual models in design. In such contemporary design modeling, designers draw on artificial languages to express data concerning *structures* (patterns and relations among the elements), along with a rule-governed *interpretation* (semantics) of the structures' elements. Even in pre-computer modeling, designers were able to use conventional models to express a wide range of information concerning the structure and provide interpretation allowing for translation into real-world artifacts of the built environment (albeit to a lesser degree of precision and with less predictive accuracy).

[7] As made manifest by the model concept, there is no obvious 'superior' or greater-encompassing framework (a) that attaches to any other single scientific domain and (b) of which design models—either for individual, token objects or for the universe of objects—are a part. That is, design models apparently enjoy a degree of conceptual autonomy; they draw on other sciences (as well as non-scientific domains) yet 'belong to' no others—not to engineering, not to materials science, not to sociology, and so forth. This autonomy in turn suggests that, after all, there are design objects and phenomena that are uniquely so, partly on classic scientific realist grounds: an empirically-validated model entails the existence of the system whose structure it represents, and where no other model better represents that structure, the system and its elements are self-standing objects of a dedicated scientific domain.

Against this suggestion it may be argued that there are other domains, perhaps also in the arts—for example, sculpture—which by the same token could be thought to have an attendant science—however, about which we would think a dedicated science to be absurd. Indeed, we might well think the criterion for a science laid out here to be so loose as to admit a science of dust or cheese. What makes the design case count and not the sculpture case is the wealth and variety of unassailably scientific research we take to feed into the standard design model—but not any model of sculpture. What rules out the other, apparently trivial cases, is that they all represent particular elements of some other general class featuring more robust explanatory frameworks—models for the universe of possible systems—of a higher taxonomic order offering *minimally* significant explanatory power, where (by contrast) design domains are already at that minimal level of explanatory power.

[8] Simon, (1969/1981/1996); see also Huppatz (2015).
[9] Though, as a reviewer points out, our needs may also contradict our values.
[10] A reviewer notes that this peculiarly North American "need" may not be as pressing elsewhere; while that may be true relative to disposable coffee cups, the broad need to carry hot coffee orients all coffee cup design.
[11] Van den Hoven, et al. (2015) discuss such values to which design should be sensitive as comprise accountability and transparency, democracy, justice, well-being, inclusiveness, presence, privacy, regulation, responsibility, safety, sustainability, and trust.
[12] Thanks to a reviewer for this point.
[13] This perspective moves in very different direction than Hamilton's proposal (2011) as to why design always features aesthetic considerations, namely, because design just is *aesthetic* invention—as contrasts with *mere* invention such as yields aesthetically 'inert' products like the Citroën 2CV. On the Smuggling Hypothesis, design and invention (or, at least, Hamilton's *mere* invention) are collapsed and some (perhaps many or most) designs just are aesthetically quotidian or bad.

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