Abductive Thinking and Sensemaking: The Drivers of Design Synthesis

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Overview: Making Sense of Chaos

Designers, as well as those who research and describe the process of design, continually describe design as a way of organizing complexity or finding clarity in chaos. Jeff Veen, founder of Adaptive Path, has noted that "Good designers can create normalcy out of chaos."[1] Jim Wicks, Vice President and Director of Motorola's Consumer Experience Design group explains that "design is always about synthesis—synthesis of market needs, technology trends, and business needs."[2] During synthesis, designers attempt "to organize, manipulate, prune, and filter gathered data into a cohesive structure for information building."[3] Synthesis reveals a cohesion and sense of continuity; synthesis indicates a push towards organization, reduction, and clarity.

Yet despite the acknowledged importance of this phase of the design process, there continues to appear something magical about synthesis when encountered in professional practice: because synthesis is frequently performed privately ("in the head" or "on scratch paper"), the outcome is all that is observed, and this only after the designer has explicitly begun the form-making portion of the design process. While other aspects of the design process are visible to non-designers (such as drawing, which can be observed and generally grasped even by a naïve and detached audience), synthesis is often a more insular activity, one that is less obviously understood, or even completely hidden from view. Designers may follow a user-centered discovery process to immerse themselves in a particular subject or discipline, and then go "incubate" that material. After a period of reflection, they will produce a tangible artifact as a visual representation of the reflection. When synthesis is conducted as a private exercise, there is no visible connection between the input and the output; often, even the designers themselves are unable to articulate exactly why their design insights are valuable. Clients are left to trust the designer, and more often than not, the clients simply reject the insight as being "blue sky" or simply too risky.

For example, a designer developing a new digital device might study the use of digital devices used in the workplace. Typically, a designer will observe four or five users as those individuals conduct their work. The designer will ask questions of

1 Jeff Veen, *The Art and Science of Web Design* (Indianapolis: New Riders Press, 2000).

2 Jim Wicks, "Weaving Design into Motorola's Fabric," *Institute of Design: Strategy Conference*. 2006. <http://trex.id.iit.edu/events/strategyconference/2006/perspectives_wicks.php> (accessed November 3, 2008).

3 Jon Kolko, "Information Architecture and Design Strategy: The Importance of Synthesis during the Process of Design," *IDSA 2007 Educational Conference Proceedings* (San Francisco: IDSA), 2007.

each user about their jobs and record details of their responses. The designer might also take screen shots or photographs of the tools being used, and probe for details about each item. The designer will then return to the design studio. In the privacy of his or her natural work place, the designer will attempt to make sense of what he or she has learned. The goal is to find relationships or themes in the research data, and to uncover hidden meaning in the behavior that is observed and that is applicable to the design task at hand.

The user research sessions will produce pages of verbal transcript, hundreds of pictures, and dozens of artifact examples. Because of the complexity of comprehending so much data at once, the designer will frequently turn to a large sheet of paper and a blank wall in order to "map it all out." Several hours later, the sheet of paper will be covered with what to a newcomer appears to be a mess—yet the designer has made substantial progress, and the mess actually represents the deep and meaningful sensemaking that drives innovation. The designer will have identified themes, and will better understand the problem he or she is trying to solve; the designer will have discovered "the whole," as described by Daniel Fallman: "Fieldwork, theory, and evaluation data provide systematic input to this process, but do not by themselves provide the necessary whole. For the latter, there is only design."[4]

A Lack of Formality

To an observer (commonly a client), the physical output, themes, and design ideas produced seem arbitrary, or *magically derived*. The artifacts developed by the designer are messy, usually drawn in the midst of deep and reflective thinking; they are sketches drawn in Sharpie, incomplete sentences, and crude diagrams lacking adequate captions or descriptions. If the beginning state (the research data) is compared to the end state (the design idea), it is not immediately clear how one derived the latter from the former. It can be argued that *the more innovative the output*, the more difficult it is to identify how the idea was developed at all. Yet the incubation period described above can be well structured, and things that occur during that period are both repeatable and comprehendible. It is only the lack of understandable documentation, or the decision to not share that documentation, that creates the sense of *magic*.

And the *magic* may well be desirable by some clients, as it hints that their money has been well spent. (After all, they feel that they've hired magicians!) But the notion that design synthesis is magical and difficult to formalize has led to a number of very large problems that plague the industries of designed artifacts:

Clients don't see the relationship between design research and design ideas, and therefore discount the value of design research and design synthesis entirely. Because synthesis is frequently relegated to an informal step in the overall process, it is practiced implicitly; a single designer forges connections in the privacy of her own thoughts,

4 Daniel Fallman, "Design-oriented Human-Computer Interaction." *Human Factors in Computing Systems, the Proceedings of CHI* (Association for Computing Machinery, 2003), 225–32.

and performs only rudimentary sensemaking. The design output and solutions can be unique, novel, and even exciting, but because there is no artifact-based procedural trail, the client isn't aware of the various internal deliberations that have occurred. After encountering several design projects that include implicit design synthesis, a client may proclaim that they don't see the value in a discovery phase for future design activities. They are, of course, right: they didn't *see* anything of value, and so they assumed the phase to be a waste of resources.

Design consultancies don't plan for, assign resources to, or appropriately bill for synthesis activities, and so design synthesis happens casually or not at all. If there is no formal period of time allotted for design synthesis methods, and no formal deliverables associated with these methods, a strong message is sent to the designer: synthesize on your own time, or not at all.

Reflective and messy synthesis processes are considered a "waste of time," as they aren't positioned as actionable or immediately predictive. The output of design synthesis is frequently incomplete or intangible—the value of the output is not immediately evident, as the results are "half baked." Synthesis often results in a number of high level themes and paradigms that help shape future design activities, but these high level and conceptual elements may be seen as too abstract to justify the time and resources spent.

These problems are roadblocks to innovation, and illustrate a deep disconnect between the core process of insight development and the billed process of product development. Yet synthesis methods have been continually referenced as critical in sensemaking, organization, and in drawing the important connections between apparently unrelated elements. These are the keys for relating research to design—synthesis methods are the ways in which ethnographic insights lead to new, innovative, appropriate, or compelling ideas.

These principles and methods are teachable, repeatable, and understandable. They are creative activities that actively generate intellectual value, and they are unique to the discipline of design. Most importantly, when applied and formalized, these activities are billable and immensely useful in the development of novel, useful, and appropriate designs.

I. Theoretical: Grounding Philosophies of Synthesis

Synthesis is an abductive sensemaking process. Through efforts of data manipulation, organization, pruning, and filtering, designers produce information and knowledge. The methods and principles described later (in Section II) share a common grounding philosophy that is tied to both cognitive psychology and mathematics. This philosophy helps to explain why synthesis methods are effective, and better describes the long history of research done in this domain of complex problem solving.

Sensemaking

Klein, Moon, and Hoffman define sensemaking as "a motivated, continuous effort to understand connections (which can be among people, places, and events) in order to anticipate their trajectories and act effectively."[5] This definition builds on Brenda Dervin's much more abstract description. Dervin explains that "Sense-Making reconceptualizes factizing (the making of facts which tap the assumed-to-be-real) as one of the useful verbings humans use to make sense of their worlds."[6] In plain language, both definitions position sensemaking as an action oriented process that people automatically go through in order to integrate experiences into their understanding of the world around them.

Common to all methods of synthesis is a "sense of getting it out" in order to identify and forge connections. This is an attempt to make obvious the sensemaking conditions described above; emphasis is placed on finding relationships and patterns between elements, and forcing an external view of things. In all of the methods, it is less important to be "accurate" and more important to give some abstract and tangible form to the ideas, thoughts and reflections. Once externalized, the ideas become "real"—they become something that can be discussed, defined, embraced, or rejected by any number of people, and the ideas become part of a larger process of synthesis. Essentially, sensemaking is an internal, personal process, while synthesis can be a collaborative, external process.

The data that has been gathered from contextual research will often take many forms; designers gather and create photographs, video clips, transcripts, magazine clippings, and other artifacts related to the problem or opportunity context. In an effort to maintain some sense of coherence, designers frequently attempt to horde the content in their laptop—the digital format allows for ease of organization in the form of files, folders, and databases. This digital structure is, however, arbitrarily imposed by the constraints of the popular software tools and operating systems. The physical limitation of the laptop (the size), combined with the digital limitations of the software (the organizational schema), dramatically limits the designers' ability to see the forest for the trees: they lose the ability to understand the research in totality and are limited in their ability to freely manipulate and associate individual pieces of data.

Synthesis requires a designer to forge connections between seemingly unrelated issues through a process of selective pruning and visual organization. Because of the vastness of data gathered in even a simple design problem, the quantity of data that must be analyzed is often too large to hold in attentive memory at one time, and so a designer will externalize the data through a process of spatialization. The tools that allow for this are presently quite limited—a big wall, a marker, and lots of sticky notes are some of the most common tools used by designers for this process. These tools help the designer gain a strong mental model of the design space; the

5 Gary Klein, Brian Moon, and Robert Hoffman, "Making Sense of Sensemaking 1: Alternative Perspectives." *Intelligent Systems* (IEEE) 21:4 (July/August 2006), 71.

6 Brenda Dervin, "Sense-Making's Journey from Metatheory to Methodology to Methods: An Example Using Information Seeking and Use as Research Focus," in *Sense-Making Methodology Reader* (Cresskill, NJ: Hampton Press, 2003), 141–46.

externalization of the research data allows for a progressive escape from the mess of content that has been gathered.

Once the data has been externalized and the literal mess begins to be reduced, the designer begins the more intellectual task of identifying explicit and implicit relationships, physically drawing out these content-affinities through the process of organization. The designer begins to move content around, physically, placing items that are related next to each other. As described above, this process is less about finding "right" relationships and more about finding "good" relationships. All of the content is related in some way, but the important connections are frequently those that are multi-faceted, complex, and rooted in culture. Thus, it may be necessary to duplicate content (to allow it to connect to multiple groups), or to abandon or rearrange already established groupings several times during this process.

Once the groupings begin to emerge through the process of organization, the groupings can be made explicit by labeling them. The grouping label captures both the literal and the implied contents of the group—it makes obvious the meaning that has been created through the process of organization.

Frequently, designers will spend a great deal of time creating a war-room style wall of data, organizing and pinning the material up in the manner described above—and then ignore this content for the remainder of the project. The designer needs the organization in order to gain a complete picture of the design space; they then draw conclusions, and as they progress through the phase of creative ideation, the synthesis wall becomes unnecessary. It has served its purpose in delineating the design space, has allowed for a collaborative process of sensemaking, and has provided a spatial understanding of structure.

Thus, one of the most basic principles of making meaning out of data is to externalize the entire meaning-creation process. By taking the data out of the cognitive realm (the head), removing it from the digital realm (the computer), and making it tangible in the physical realm in one cohesive visual structure (the wall), the designer is freed of the natural memory limitations of the brain and the artificial organizational limitations of technology. Content can now be freely moved and manipulated, and the entire set of data can be seen at one time. Implicit and hidden meanings are uncovered by relating otherwise discrete chunks of data to one another, and positioning these chunks in the context of human behavior.

Abduction

Synthesis is an abductive sensemaking process. Abduction can be thought of as the "step of adopting a hypothesis as being suggested by the facts . . . a form of inference."[7] To better understand abduction, it's necessary to understand the duality of the forms of logic that have been more traditionally embraced by western society in argument: deduction and induction.

A valid deductive argument is one that logically guarantees the truth of its conclusion, if the premises that are presented are true. This is the form of logic that is traditionally taught in mathematics courses and manifested in logic proofs:

A is B.
All Bs are Cs.
A is, deductively, C.

This form of logic is one that is self contained, and any argument that uses deduction is one that cannot offer any *new findings* in the conclusions—the findings are presented in the premises that hold the argument to begin with. That is, A, B, and C all exist in the premises that were presented.

An inductive argument is one that offers sound evidence that something might be true, based on structured experience. This is the form of logic traditionally associated with scientific inquiry:

Each time I do A under the same conditions, B occurs.
Inductively, the next time I do A under these conditions,
B will occur.

Subsequent experiences may prove this wrong, and thus an inductive argument is one where the premises do not guarantee the truth of their conclusions. Like deduction, induction cannot offer any "new findings" contained within the logic of the argument.

Abduction has been described by Roger Martin (Dean of the Rotman School of Management) as the "logic of what might be," and while this certainly serves to embody this logic in the context of design, it isn't entirely accurate. Instead, abduction can be thought of as the *argument to the best explanation*. It is the hypothesis that makes the most sense given observed phenomenon or data and based on prior experience. Abduction is a logical way of considering inference or "best guess" leaps. Consider the example *When I do A, B occurs:*

I've done something like A before, but the circumstances weren't exactly the same.
I've seen something like B before, but the circumstances weren't exactly the same.
I'm able to abduct that C is the reason B is occurring.

Unlike deduction or induction, abductive logic allows for the creation of new knowledge and insight—C is introduced as a best guess for why B is occurring, yet C is not part of the original set of premises. And unlike deduction, but similarly true to induction, *the conclusions from an abductive argument might turn out to be false, even if the premises are true.*

Design synthesis is fundamentally a way to apply abductive logic within the confines of a design problem.[8] The various constraints of the problem begin to act as logical premises, and the

7 Charles S. Peirce, "On the Logic of Drawing History from Ancient Documents," in *The Essential Peirce: Selected Philosophical Writings, 1893–1913*, by Charles S. Peirce, edited by Peirce Edition Project (Bloomington: Indiana University Press, 1998), 95.

designer's work and life experiences—and their ease and flexibility with logical leaps based on inconclusive or incomplete data—begin to shape the abduction. Abduction acts as inference or intuition, and is directly aided and assisted by personal experience. Yet the personal experience need not be with the specific subject matter of the design problem. The abduction itself can be driven by any design or cultural patterns that act as an argument from best explanation. As described by Peirce, "The abductive suggestion comes to us like a flash. It is an act of *insight*, although extremely fallible insight. It is true that the different elements of the hypothesis were in our minds before; but it is the idea of putting together what we had never before dreamed of putting together which flashes the new suggestion before our contemplation."[9]

Johnson-Laird has argued contradictorily that, in the context of generative and creative problem solving, the insight is developed not in a "flash" at all. Instead, a four step process leads to an insight, which only *seems* to appear instantly:

The current problem solving strategy fails to yield a solution, given the existing constraints.

There is a tacit consideration of the new constraints in the strategy.

The constraints are relaxed (or changed) in a new way, thus broadening the problem space and allowing for further consideration.

Many changes in constraints lead nowhere, but, with perseverance, a change may be made that leads at once to a solution of the problem.[10]

Both Peirce and Johnson-Laird agree that abductive reasoning is related to insight and creative problem solving, and it is this creative problem solving that is at the heart of the design synthesis methods that follow.

II. Applied: Methods of Synthesis

A Synthesis Framework

The logical and cognitive background described above points to an action-framework of synthesis: there are specific types of actions taken by the designer during synthesis that yield a positive result in terms of both abduction and sensemaking. These are the acts of prioritizing, judging, and forging connections.

Prioritizing. A large quantity of data is gathered while approaching a given design problem. Stakeholder interviews, user interviews, market research, cultural trends, and forecasting all produce quantities of data. During the process of synthesis, the designer must decide that one piece of data is more important than another. This is accomplished by using an often implicit scale of importance, or a set of guidelines upon which to compare the data.

8 R. Coyne, *Logic Models of Design* (London: Pitman, 1988).

9 Charles S. Peirce, "Pragmatism as the Logic of Abduction," in *The Essential Peirce: Selected Philosophical Writings, 1893–1913*, by Charles S. Peirce, edited by Peirce Edition Project (Bloomington: Indiana University Press, 1988), 227.

10 Philip Johnson-Laird, "The Shape of Problems." in *The Shape of Reason: Essays in Honour of Paolo Legrenzi*, by V Girotto, edited by V Girotto, 3–26. (Psychology Press, 2005).

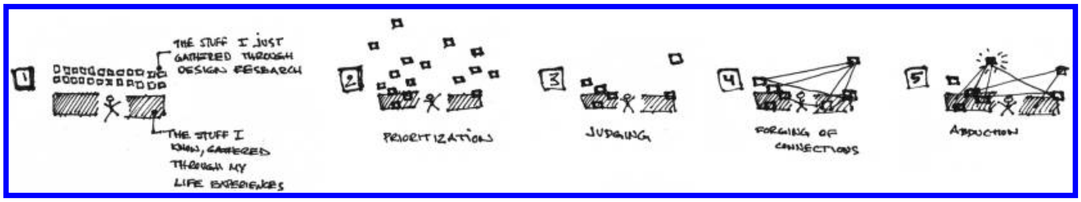


Figure 1
Synthesis process, visualized. The illustration oversimplifies this process for clarity; the actual process is not linear, nor is it as "clean" as shown.

The scale of importance is subjectively derived (but identified in a "reasonable" manner—not arbitrarily), but the use of this scale is then generally objective. (Within the system each element is compared on a consistent basis.) Data prioritization will eventually identify multiple elements that can be seen as complementary, and thus a hierarchical data structure is created.

Judging. Not all of the data identified in a discovery process is relevant. The process of synthesis forces the definition of relevance, as the designer will pass the gathered data "through a large sieve" in order to determine what is most significant in the current problem solving context. Synthesis methods, then, require a constant reassessment of the current state as compared to the unknown end state.

Forging of connections. During synthesis, it is not the discrete elements of data that are interesting so much as the relationship *between* these elements. Identifying a relationship forces the introduction of a credible (although rarely validated) story of why the elements are related. This is an abductively logical story, positing a hypothesis based on inference. The activity of defining and forging connections actively produces knowledge, in that new elements (gleaned from prior experiences in life) are combined with existing elements.

Three methods of synthesis are introduced below; each of the methods emphasizes *prioritization*, *judging*, and the *forging of connections*. These methods illustrate pragmatic approaches to design synthesis that can be applied in design problems of any discipline or subject matter.

Method: Reframing

Designers approach creative problem solving in the conceptual context of a "frame." Schön says that a creative design "hypothesis depends on a normative framing of the situation, a setting of some problems to be solved."[11] This normative framing is a perspective that highlights "a few salient features and relations from what would otherwise be an overwhelmingly complex reality."[12] The frame is usually selected without introspection, based on experience, research, and assumptions. Frames become the technique used to "organize the large-scale structure of inference making."[13]

Consider, for example, a product designer tasked with creating an innovative new toothbrush. This designer will have likely selected a frame similar to this:

11 Donald Schön, "Problems, Frames and Perspectives on Designing," *Design Studies* 5:3 (1984), 132–36.

12 Hideaki Takeda, Akira Tsumaya, and Tetsuo Tomiyama, "Synthesis Thought Processes in Design." Edited by H. Kals and F. van Houten. *Integration of Process Knowledge into Design Support Systems* (Kluwer Academic Publishers, 1999), 249–58.

13 Gary Klein, Brian Moon, and Robert Hoffman, "Making Sense of Sensemaking 2: A Macrocognitive Model," *Intelligent Systems* (IEEE) 21:5 (September/October 2006), 91.

An average person, in their bathroom, using a physical item with small bristles on the end to apply paste to their teeth; that individual will likely then produce friction with the physical item, the paste, and the teeth in order to eliminate food.

Note that this frame describes a person, a setting, and an action-based goal. It describes a very culturally-specific and archetypical example of teeth brushing.

The design method of *reframing* attempts to recast the above frame in a new perspective. Consider reframing the above example from the perspective of a different individual, rather than the non-descript "average person." The designer can purposefully view the problem from the perspective of a dentist, or a toothpaste manufacturer, or a child; the designer can shift cultural perspectives to think of an "average Indian" or "someone from Thailand"; the designer can reframe from the point of view of a person with no working limbs, or a group of people. The implications for designed artifacts are dramatically shifted each time the problem is reframed.

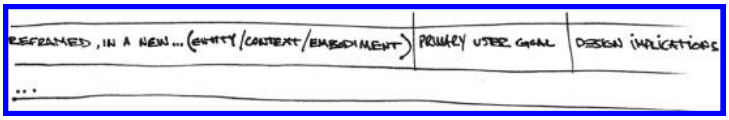
Thus, *reframing is a method of shifting semantic perspective in order to see things in a new way*. The new frame "re-embeds" a product, system, or service in a new (and not necessarily logical) context, allowing the designer to explore associations and hidden links to and from the center of focus.

From a methodical point of view, reframing can be achieved by following these steps:

Identify the initial frame. The toothbrush example provided above is purposefully over-simplified and overly analytical; a more realistic example might be in the design context of a complicated piece of enterprise software, intended to allow for pricing and configuration of parts. In this larger context, simply understanding and articulating an initial frame is difficult. For the purposes of this method, a design-specific frame can be described as: *An entity, in a context, using or considering a particular design embodiment*.

Again, the levels of specificity of the entity, context, and embodiment are dependent on the design problem being considered. It may be easy to very specifically define the frame of a "contained" design problem, while more complicated systems or services problems may require a more robust framing description.

Create blank reframing indices. Three charts will be used to structure the reframing exercises. The design opportunity will be reframed from the point of view of new entities, new contexts, and new embodiments (or new manifestations of the core artifact). Each chart will look like the example on the following page:



Reframe. The designer will begin to develop (through structured or casual brainstorming) new items for the left column of each chart. Depending on the desired level of innovation for the particular design problem, it is often desirable to include "provocations"—as deBono describes, these are ideas that may ultimately prove infeasible, but allow for "movement" across patterns.[14]

Extrapolate likely user goals. As the charts begin to become populated with new frames, the designer will begin to fill in the Primary User Goal for all items in all charts. They will paint a picture of a credible story, judging responses and adding criticism as appropriate.

Extrapolate design implications. The reframed design context will have produced new constraints or implications, or will have highlighted existing constraints and implications that may have been otherwise hidden or overlooked.

During synthesis, a designer can utilize the reframing method as described above to explicitly and fundamentally shift frames, changing the selected features and relationships and actively producing new design implications and constraints.

Method: Concept Mapping

A concept map is a graphical tool for organizing and representing knowledge. It "serves as a kind of template or scaffold to help to organize knowledge and to structure it, even though the structure must be built up piece by piece with small units of interacting concept and propositional frameworks."[15] Essentially, the map can be thought of as a picture of understanding.[16] A concept map is a formal representation of a mental model; a mental model "represents a possibility, or, to be precise, the structure and content of the model capture what is common to the different ways in which the possibilities could occur . . . when you are forced to try to hold in mind several models of possibilities, the task is difficult."[17] The concept map itself represents the creators' mental model of a concept, but it also informs and shapes that mental model during creation, as it allows designers to see both the holistic scale of the concept and also critical details within the concept. As it affords action-based understanding at both a gross and fine level, both its creation and its usage become tools for sensemaking.

Generally, a concept map links elements to one another. *Specifically*, a concept map will form connections between entities

14 Edward De Bono, "Serious Creativity," *The Journal for Quality and Participation* 18:5 (1995), 12.

15 JD Novak and AJ Cañas, "The Theory Underlying Concept Maps and How to Construct Them," *Technical Report IHMC CmapTools* (Florida Institute for Human and Machine Cognition, 2006).

16 Jon Kolko, "Information Architecture: Synthesis Techniques for the Muddy Middle of the Design Process." *23rd International Conference on the Beginning Design Student Proceedings* (Savannah, 2007).

17 Philip Johnson-Laird, "Mental Models, Sentential Reasoning, and Illusory Inferences." *Mental Models and the Mind,* 138 Part 1 (Amsterdam: Elsiver, 2006), edited by Carsten Held, Gottfried Vosgerau, and Markus Knauff.

(nouns) by describing relationships (verbs). The map provides a visual way to understand relationships through literal connections as well as through proximity, size, shape, and scale. As an artifact, the map is intended to illustrate relationships. As a methodology, the act of creation is generative and critical. The designer must make subjective value judgments in both selecting the items to include on the map and in indicating the relative strength of the relationships between items.

A concept map can be produced through the following steps:

Identification of core taxonomy. Both the noun and verb elements that describe the design problem or opportunity are listed on index cards. These elements include people, places, systems, artifacts, organizations, actions, processes, methods, and other entities and activities. To continue the oversimplified example of teeth brushing, a taxonomy may be identified as shown in Figure 2.

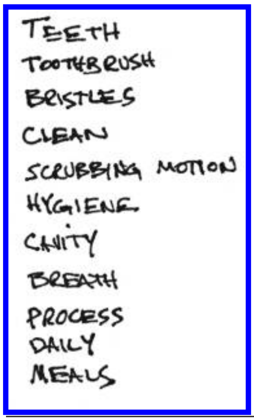


Figure 2 (above)
Raw taxonomy

Prioritization of unique taxonomy elements. The index cards are rearranged in a way to indicate the hierarchy implicit in the taxonomy. Elements are deemed to be more or less important than one another, and are physically moved to illustrate this importance. Elements can be identified as being a subset (child) of a larger (parent) element, and are then physically indented to illustrate this relationship. New elements are added at this stage as appropriate.

Again, this prioritization is a subjective exercise that forces the designer to make value judgments about each item based on his or her understanding of the problem space, arguing for or against a particular placement. The taxonomy shown in Figure 2 may be prioritized as shown in Figure 3.

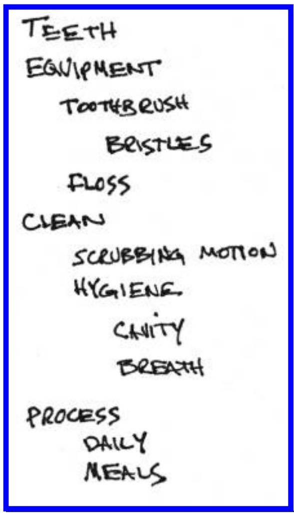


Figure 3 (above)
Prioritized taxonomy

Creation of semantic connections between elements. The index cards now serve as the rough structure for the concept map. On a large sheet of paper, the designer begins to draw circles to illustrate the entities, and lines connecting the circles to one another in order to illustrate relationships between elements.

The map begins to create small sentence fragments of meaning, such as "teeth can become clean by using a scrubbing motion." This

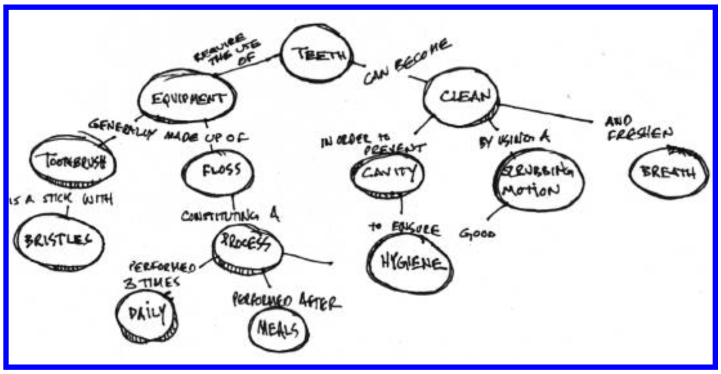


Figure 4 (right)
Concept Map

illustrates the generative and subtly abductive nature of the map, as the designer may have no deductive or inductive way of knowing that teeth can become clean by using a scrubbing motion.

During synthesis, a designer can utilize the Concept Mapping method (Figure 4, described on previous page) to organize and understand a topic, and to produce a model of that understanding.

Method: Insight Combination

Design patterns are "structural and behavioral features that improve the "habitability" of something."[18] Insight Combination is a method of building on these established design patterns in order to create initial design ideas. Through multiple steps, this method first demands the articulation of individual design insights, and then forces a structured and formal pairing of insights with existing patterns. This pairing creates a new design idea that has a strong connection to both established best practices and to problem-specific research data.

A design insight can be thought of as the additive of problem-specific observation ("I saw this") and personal and professional experience ("I know this"). This grounds an insight in both the subjective and general knowledge of the specific practitioner and in the objective data of the design problem itself. From a sensemaking perspective, this embraces the episodic and experiential uniqueness of the designer's memories, and pairs it with generally accepted ways of doing things.

By combining an insight with a design pattern, the designer is forced to examine and consider each unique insight. Methodically, the designer must think about each facet of the design problem that has been deemed useful or important. The method is then divergent, as it actively produces new ideas. Ideas are "moved forward" in a nonlinear fashion, jumping over the expected in order to arrive at the unexpected.

The method of Insight Combination can be conducted as follows:

Identify insights in the gathered data. The designer will begin to identify insights in the data that has been gathered by combining an observation (I saw this) with knowledge (I know this). They can then write the insights on yellow note cards. As an example, perhaps the designer observed someone brushing their teeth and noticed that the individual avoided using the mouthwash that was sitting next to the sink. The designer might recall his own last visit to the dentist. An insight could then be developed—that mouthwash has an implicit connection of taste and smell with going to the dentist, which taints the product in a negative light. Of course, this insight could be completely wrong, and that's perfectly acceptable.

Identify design patterns relevant to the core domain. The designer

18 Jennifer Tidwell, *Designing Interfaces: Patterns for Effective Interaction Design* (Sebastopol, CA: O'Reilly Media, Inc, 2005).

will now recall design patterns that are relevant to the discipline being studied. The patterns can be written on blue note cards. Some designers keep pattern libraries, noting trends and repeated design elements that appear in produced artifacts. Others prefer to search for patterns in the context of the problem. An example pattern that is loosely related to the toothbrush example might be the trend in consumer goods (kitchen soap, gum, etc.) to introduce new artificial flavors and smells like amaretto and butterscotch.

Perform an insight combination by pairing a design pattern with an insight and looking for affinities. Now, the designer begins to combine insights and design patterns to create design ideas by mingling the blue and yellow notes, moving them around physically and actively reflecting on potential combinations. When a combination makes sense and generates a design idea, the idea is written on a green note. Combining the insight (mouthwash has an implicit connection of taste and smell with going to the dentist, which taints the product in a negative light) and the pattern (the trend in consumer goods—kitchen soap, gum—to introduce new artificial flavors and smells like amaretto and butterscotch) yields a new design idea: produce a mouthwash that has a new flavor, one that doesn't have properties normally associated with the dentist's office.

During Synthesis, a designer can utilize the Insight Combination method as described above to directly apply personal experience in a manner that is tempered by design tendencies, and to actively produce new design implications and constraints.

Conclusion

This paper has defined design synthesis as an abductive sensemaking process of manipulating, organizing, pruning, and filtering data in the context of a design problem, in an effort to produce information and knowledge, and has introduced three methods of formalizing the synthesis process in practice. Each of the methods—reframing, concept mapping, and insight combination—emphasizes prioritizing, judging, and forging connections. These qualities are derived directly from the logical processes of abduction and the cognitive psychology theory of sensemaking.

When synthesis is "given its due," the results appear to be magical. By applying these methods in practice, by commonly and continually describing the role of synthesis, and by considering synthesis in Design Research, both practitioners and researchers can better realize how life experience drives design decisions, and how inferential leaps can systematically drive innovation.

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