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Once More, with Feeling: Design Thinking and Embodied Cognition

Abstract While leaders in business and industry maintain their interest in design thinking, academic discussions of the concept have become less common. This article examines design thinking in relation to developments in cognitive science and embodied cognition. We examine an influential theory of metaphor as central to cognition, along with theoretical nuances of the body, perception, and feeling. We argue that some material design practices may augment the creative process. We propose a broad interdisciplinary account for the role that feeling plays in design and cognition both.

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The fate of design thinking is unclear, and its present status uncertain. Some advocates for design thinking have distanced themselves from the concept.[1] Others continue to celebrate its achievements and possibilities. In a 2015 cover feature article for the *Harvard Business Review*, Jon Kolko maintains that design thinking has "come of age."[2] In that issue, Tim Brown, Roger Martin, and Kolko – all well-known proponents of design thinking – trace the expansion of the concept from the realm of product design to broader spheres and more complex problems.[3] By contrast, there are fewer academic discussions of design thinking. Some researchers argue against the notion of design thinking as a "panacea for the economy"[4] and some discussions of innovation now avoid the term. Moreover, certain methods of design thinking used in business and management – engaging with users and iterative prototyping, for example – appear to support incremental innovation rather than radical product innovation.[5]

Many argue that the concept of design thinking is "not well understood, either by the public or those who claim to practice it"[6] and it lacks "sustained development"[7] in the academic literature. These authors describe differences between academic definitions and those used in industry. They schematize these differences, suggesting ways to better develop the concept.

Some definitions of design thinking in academia and industry are related. Johansson and Woodilla find a substantial parallel increase in academic and industry publications during the first decade of the twenty-first century. Both peak in 2009.[8] Nonetheless, work on design thinking in industry pays little attention to the academic history of design thinking. Its development began during the Conference on Design Methods in 1962, and it includes an extensive trajectory of research since the still-current Design Thinking Research Symposium began in 1991.[9]

However, academic work with the concept is not unified. Ulla Johansson-Sköldberg, Jill Woodilla, and Mehyes Çetinkaya identify five sub-discourses, each with "clear roots and a substantial academic following"[10] within academic discourse. They use the umbrella term *designerly thinking* for these. They reserve the term *design thinking* for the three identifiable management discourses. Lucy Kimbell, who maintains that "design remains a fragmented discipline,"[11] schematizes three ways of describing design thinking: as a cognitive style, as a general theory of design, and as an organizational resource. Business and managerial discourse includes the last of these. According to all these authors, the notions of design thinking prevalent in business and management are based on anecdotal evidence rather than on robust theory.

Despite the convoluted design thinking discourse, these authors suggest further research into the concept of design thinking, along with a search for clarity. Kimbell recommends a shift in focus toward "situated, embodied material practices"[12] within a broader interdisciplinary context. She acknowledges the cultural and social position of designers – and recognizes their limits. As one of three suggestions for future research, Johansson-Sköldberg, Woodilla, and Çetinkaya propose linking popular design thinking discourses from the innovation domain with the designerly view of meaning creation. They warn that "the design thinking discourse will most probably die if it does not acquire a scholarly base that relates more to designerly thinking."[13]

This article is a contribution to the "critical rethinking"[14] of design thinking. While we do not pursue the research directions that these authors propose, our direction aligns with their approach. We explore how material design practices may contribute to the innovation process by relating these competencies to a theory of meaning making that we adapt from cognitive science. We attempt to link design practices from the popular design thinking discourse – sketching and prototyping, for example – with a theory that explains how understanding emerges and relates

1 Bruce Nussbaum, "Design Thinking Is a Failed Experiment. So What's Next?" *Fast Company*, May 4, 2011, https://www.fastcodesign.com/1663558/design-thinking-is-a-failed-experiment-so-whats-next.

2 Jon Kolko, "Design Thinking Comes of Age," *Harvard Business Review* 93, no. 9 (2015): 66.

3 Tim Brown and Roger Martin, "Design for Action," *Harvard Business Review* 93, no. 9 (2015): 57–64.

4 Ulla Johansson-Sköldberg, Jill Woodilla, and Mehves Çetinkaya, "Design Thinking: Past, Present and Possible Futures," *Creativity and Innovation Management* 22, no. 2 (2013): 121–46, DOI: https://doi.org/10.1111/caim.12023.

5 Donald A. Norman and Roberto Verganti, "Incremental and Radical Innovation: Design Research vs. Technology and Meaning Change," *Design Issues* 30, no. 1 (2014): 78–96, DOI: https://doi.org/10.1162/DESI_a_00250.

6 Lucy Kimbell, "Rethinking Design Thinking: Part I," *Design and Culture* 3, no. 3 (2011): 288, DOI: https://doi.org/10.2752/175470811X13071166525216.

7 Johansson-Sköldberg, Woodilla, and Çetinkaya, "Design Thinking," 121.

8 Ulla Johansson and Jill Woodilla, "How to Avoid Throwing the Baby Out with the Bath Water: An Ironic Perspective on Design Thinking," paper presented at the European Group for Organization Studies Colloquium, Lisbon, June 30–July 3, 2010.

9 Kimbell, "Rethinking Design Thinking: Part I," 285–306.

10 Johansson-Sköldberg, Woodilla, and Çetinkaya, "Design Thinking," 124.

11 Kimbell, "Rethinking Design Thinking: Part I," 290.

12 Ibid., 300.

13 Johansson-Sköldberg, Woodilla, and Çetinkaya, "Design Thinking," 131.

14 Kimbell, "Rethinking Design Thinking: Part I," 301.

to experience. The concepts in this article fit broadly within the discourse of design thinking as a *cognitive style*. In relation to the academic discourses identified by Johansson-Sköldberg, Woodilla, and Çetinkaya, this article offers a perspective on cognition that may help to develop the discourse of "design and designerly thinking as a *reflexive practice*"[15] developed from the work of Donald A. Schön.[16]

While this article explores perspectives on individual cognition, it does not assert that designers have special cognitive capabilities. Rather, it is an attempt to shed light on how the designer's ability to capture whole concepts or perspectives in the form of prototypes and sketches supports the creative thinking of the people who engage with them – whether or not they are designers. In this way, we explain designers' contribution to the collaborative innovation process. This article is an attempt to outline developments in cognitive science that may interest designers and design theorists as they consider design thinking. Interdisciplinary in its approach, this article is suggestive rather than definitive, offering a perspective that may lead to future theoretical and empirical exploration.

A Theory of Metaphor

In this article, we draw on the stream of cognitive science grounded in a theory of metaphor. We outline this theory, along with the changes it has undergone, in a way that will help to make sense of design thinking in the broader history of design. The changes center on the roles of the body and feeling in cognition and understanding.

Cognitive science began with theoretical models of cognitivism established in the 1950s and developed over the following decades. These theoretical models primarily described cognition as the manipulation of abstract, amodal symbols in the brain, symbols that exist separately from sense perception. This theory relied heavily on the metaphor of computation, an extension of the confidence in the ability of analytic logic and mathematics to represent and solve problems.[17] Herbert Simon's *Science of Design* is one of the earliest key works in the history of design thinking. It epitomizes this approach to problem-solving, relying on a metaphor of the mind as a "disembodied information processor."[18]

George Lakoff and Mark Johnson's *Metaphors We Live By*, published in 1980, brought metaphor into the field of cognitive science. Their theory unsettled the notion that abstract concepts exist separately in the mind. Instead, they argued that metaphors structure our experience and our understanding. Essentially, we use certain aspects of our experience to organize our understanding of phenomena that are less clear to us. In so doing, we organize our actual experience of those phenomena. Metaphors serve to *highlight* or *conceal* aspects of phenomena in ways that make both our understanding and our experience deeply interpretive. This approach emerged in discussions of linguistic evidence.[19] More recently, it has drawn upon neuroscience and psychological studies of consciousness.[20]

We understand and experience some things in terms of other phenomena that we understand more naturally or directly. This leads us to ask how that more clear or basic understanding develops, which leads directly to the concept of embodiment. Johnson addressed this with the concept of "image schemata"[21] – gestalt and analogue modes of understanding that we develop through physical interaction with the world. For instance, our understanding of various types of physical force develops through interactions with objects. We then use this understanding to form abstract concepts by projecting our understanding to other domains. For example, reaching and grasping are basic physical movements and abilities that we develop very early on in our lives. Our experiences seeking and holding physical objects provide us with basic, gestalt modes – holistic patterns – of

15 Johansson-Sköldberg, Woodilla, and Çetinkaya, "Design Thinking," 124.

16 Donald A. Schön, *The Reflective Practitioner: How Professionals Think in Action* (New York: Basic Books, 1983).

17 George Lakoff and Mark Johnson, *Philosophy in the Flesh: The Embodied Mind and Its Challenge to Western Thought* (New York: Basic Books, 1999).

18 DJ Huppatz, "Revisiting Herbert Simon's 'Science of Design,'" *Design Issues* 31, no. 2 (2015): 37, DOI: https://doi.org/10.1162/DESI_a_00320.

19 George Lakoff and Mark Johnson, *Metaphors We Live By* (Chicago: The University of Chicago Press, 1980).

20 George Lakoff, "The Neural Theory of Metaphor" in *The Cambridge Handbook of Metaphor and Thought*, ed. Raymond W. Gibbs Jr. (Cambridge: Cambridge University Press, 2008), 17–38; Mark Johnson, *The Meaning of the Body: Aesthetics of Human Understanding* (Chicago: University of Chicago Press, 2008).

21 Mark Johnson, *The Body in the Mind: The Bodily Basis of Meaning, Imagination, and Reason* (Chicago: The University of Chicago Press, 1987), 25.

understanding. These patterns are then metaphorically projected onto phenomena other than physical objects, such as ideas. Projection enables us to understand them and speak about them. Thus, we *grasp* a concept, we *get it*, but we might *hold on* too tightly to it, or even *drop* a line of argument. Our physical experiences with real objects in everyday life form some of our basic cognitive concepts. We then use these concepts metaphorically to understand and communicate with others about experiences that are more diffuse.

Embodied Cognition

Engagement with the notion of embodiment characterizes a broader movement in cognitive science beyond the stream that explicitly theorizes metaphor. It is helpful to contextualize the discussion so far in relation to this field, particularly with regard to theories of perception and feeling. This emerging field has been variously termed "post-cognitivism,"[22] "second-generation cognitive science,"[23] and "embodied cognition."[24] While it is by no means a cohesive field, it may be described as generally concerned with "a view of cognition as interactive, embodied, and embedded."[25] Given that cognitive science is an interdisciplinary field, embodied cognition involves researchers from psychology, neuroscience, philosophy, linguistics, and Artificial Intelligence. Although the focus can vary markedly amongst different researchers, a general concern is to understand how processes of brain and mind, which were previously considered abstract and separate from bodily processes of feeling, movement and perception, actually rely upon and develop from those very processes. In this view, human meaning and understanding depend on bodily experience, and they depend on evolutionary and developmental processes.

Many developments in embodied cognition theory focus on how processes that we usually consider to be basic level perceptions generate abstract concepts. One area that has received sustained attention is the role that sensory and motor areas of the brain play in cognition, which is investigated using neuroimaging while people perform various cognitive tasks. Mahon and Caramazza summarize the general findings:

> "The empirical evidence is not in dispute. We assume three empirical generalizations to be true: the motor system is automatically activated when participants (a) observe manipulable objects; (b) process linguistic stimuli (e.g., action verbs) the meanings of which imply bodily action; and (c) observe the actions of another individual."[26]

Put simply, understanding words or objects associated with activity employs areas of the brain that direct bodily movement in that individual. This activates brain areas that govern physical activity in situations in which a person is not moving or preparing for movement. One possible explanation is that this process contributes to understanding. Different theories in embodied cognitive science extrapolate differently from this evidence, often relying on a notion of simulation. They propose that the observation of an object or the understanding and use of language involves – or indeed *is* – the unconscious simulation of interactions or activity. Some theories see this process as confined to the brain, as a mental simulation.[27] However, views are converging increasingly on the notion that actual simulation in the body occurs, such as the muscles being poised for activity,[28] and there is some evidence for this claim.

Some researchers suggest a distinction between "shallow" and "deep" processing.[29] They suggest that the level of simulation may relate to degrees of ambiguity or uncertainty in a situation. This suggests that when some thing or

22 Toni Gomila and Paco Calvo, "Directions for an Embodied Cognitive Science: Toward an Integrated Approach," in *Handbook of Cognitive Science: An Embodied Approach*, ed. Paco Calvo and Toni Gomila (San Diego: Elsevier, 2008), 1–25.

23 Lakoff and Johnson, *Philosophy in the Flesh*.

24 Lawrence Shapiro, *Embodied Cognition* (New York: Routledge, 2010).

25 Gomila and Paco, "Directions for an Embodied Cognitive Science," 3.

26 Bradford Z. Mahon and Alfonso Caramazza, "A Critical Look at the Embodied Cognition Hypothesis and a New Proposal for Grounding Conceptual Content," *Journal of Physiology-Paris* 102, no. 1–3 (2008): 60, DOI: https://doi.org/10.1016/j.jphysparis.2008.03.004.

27 Lawrence W. Barsalou, "Perceptions of Perceptual Symbols," response to commentaries on "Perceptual Symbol System," *Behavioral and Brain Sciences* 22, no. 04 (1999): 637–60, DOI: https://doi.org/10.1017/S0140525X99532147.

28 Paula M. Niedenthal et al., "Embodiment in Attitudes, Social Perception, and Emotion," *Personality and Social Psychology Review* 9, no. 3 (2005): 184–211, DOI: https://doi.org/10.1207/s15327957pspr0903_1.

29 Ibid.

phenomenon is more difficult to understand, simulation is more likely to involve the body.

Despite areas of overlap, a basic distinction seems to remain between theories that see sensory and motor perception as discrete forms of information that are brought together and projected in the formation of concepts, and those that see sensory and motor perception as initially gestalt. The latter refers to evidence that some neurons in the brain do not – at a basic level – distinguish between different forms of sensory information about an object or a situation, such as the way an object looks, the way it feels in your hand, and the motor movements associated with engaging with the object.[30] That some neurons function in this way implies that our most basic and general perceptions emerge from interactions, and all of this information is brought to bear even when simply looking at an object. This relates to the notion of *affordances*, often mentioned in the field of design.[31] Johnson describes visual perception as follows

> "When you see a cup sitting on the table in front of you, you are not just having a *visual* experience. In addition to the activation of neuronal clusters in parts of your visual cortices, you are experiencing that cup as something that you could reach for, grasp, pick up, and raise to your lips to quench your thirst. The cup affords not just a visual form; it also affords pick-up-ability."[32]

Visual Thinking

In his work on visual thinking, art historian Rudolf Arnheim prefigured the view that perception and cognition are similar processes. He states that perception is "not a mechanical recording but the active grasping of structural features."[33] For Arnheim, visual perception inherently involves categorization. In some uncertain situations, it may involve a metaphorical projection of categories. Arnheim argues that we perceive gestalts and then discriminate further. He states that all levels of cognition involve abstraction – in the sense of perceiving generalities – and he sees visual perception as a mental operation, and therefore a cognitive process.

> "High generality is a quality of perception from the very start. It is a generality brought about by primary abstraction, in the sense that the differences which it hides are well above the threshold of the sense of sight. Details accessible to the eyes are not yet differentiated by the mind."[34]

Arnheim gives vision priority as a medium for thinking because of its high level of detail and variety – "it offers structural equivalents to all characteristics of objects, events, relations."[35] Learning to see and understand, then, comes from attending to particulars, and making increasingly fine perceptual distinctions. Even the highest level of theorizing relies on engaging with the world, rather than on progressively withdrawing from the world as traditional notions of abstract thinking suggest. In this way, Arnheim sees similarities between the practice of art and the practice of science.

Arnheim's work on visual thinking is a precursor in the design field to later developments in embodied cognition. For instance, one can describe the development of image schemata through physical interaction in an environment[36] as the development of visual-spatial understanding. However, even when we conceptualize gestalt modes of understanding as developing through interactive, physical processes, rather than perception alone, the role of qualitative experience – feeling – remains unaccounted for.

Johnson explores this problem in recent work,[37] and it is a burgeoning theme across the field of embodied cognition.

30 Lakoff, "The Neural Theory of Metaphor," 17–38.

31 Stella Boess and Heimrich Kanis, "Meaning in Product Use: A Design Perspective," in *Product Experience*, ed. Hendrik N. J. Schifferstein and Paul Hekkert (Amsterdam: Elsevier, 2008), 305–32.

32 Johnson, *The Meaning of the Body,* 160.

33 Rudolph Arnheim, *Visual Thinking* (Berkeley: University of California Press, 1969), 97.

34 Ibid., 166.

35 Arnheim, *Visual Thinking*, 232.

36 Johnson, *The Body in the Mind*.

37 Johnson, *The Meaning of the Body*.

Feeling as a "Sense of Fit"

Some research in the field of embodied cognition studies the relationship between emotion and cognition.[38] However, much of the field focuses on processes that would normally be considered perceptual – the sensory and motor as perceptions of the body – rather than the overall feeling of bodily movement in a situation.[39] This may be a tendency within the field of cognitive science generally – the notion of cognition does not traditionally include emotion or motivation.[40] However, feeling and emotion are central to recent developments in neuroscience, which are in turn aligned with the field of embodied cognition.

Prominent neuroscientific theories of emotion offer perspectives on the relationship between emotion and so-called "reason."[41] Rather than treating emotion as separate from rational or higher order thinking, this approach identifies emotion with unconscious processes that guide complex forms of behavior. Feeling is the most basic level of conscious experience that may or may not emerge as a result, and abstract thinking relies on all of these processes. While this characterization represents a simplification of body-brain functioning, it is easiest to understand these different processes as levels in hierarchical relation. Thus, one might describe *lower level* processes[42] that precede consciousness as being the impetus to act, which we can outwardly observe – at times – as emotion. Depending on the overall situation and how it constrains an individual's current needs, feeling emerges – initially as the sense of how well an action might meet the demands presented by the situation. This is feeling a "sense of fit."[43] These lower level processes and our feeling experiences then set the tone for more differentiated perceptions, including the use of abstract concepts and logical thinking. We have already seen that abstract concepts are metaphors that rely on understanding developed over time as an individual interacts with a given environment. Thus, if we understand feeling – as the most basic level of consciousness, and thus a whole body experience – in terms of the simulations that precede perception, then it is possible that feeling emerges as the gestalt experience of simulating past relevant situations in the present. Feeling itself may be understood as metaphor, developed over a lifetime of understanding situations as similar.

Eugene Gendlin's work supports this view. He also characterizes understanding as involving the whole body, rather than as being built up from separate sense perceptions. He says that "We act from the bodily sense of each situation."[44] Gendlin describes the role of feeling in meaning making by pointing to our "felt sense"[45] of a situation. This felt sense is always present, even if we are not actively attending to it. It is the implicit, nonverbal aspect of our experience; a gestalt experience, but one that is also precise. Cognition has two sides – this felt sense, and symbols. Symbols are explicit expressions, such as language or images. Gendlin defines meaning in terms of the functional relationships between these two sides. "The felt meaning functions … to *select* the further symbols that *explicate* it."[46] This is how we have a sense of what to say next, or how to proceed in any situation. Often we only know that something is missing or not right, and as we attend *to this feeling*, we consider alternatives. Our knowing when something is not right or not finished, even if we do not know why, is one of the most tangible ways of noticing our felt sense. Then, as we think of alternative solutions or scenarios, we also know exactly when we have found the right one. Meaning making, even in the most mundane sense, always has these two sides. These two sides of a single activity depend on each other. Cognition occurs as a dialectic between feeling, which is implicit and gestalt, and symbol, which is explicit and differentiated. We switch our attention between the gestalt and the particular.

38 Gerald L. Clore and Simone Schnall, "Affective Coherence: Affect as Embodied Evidence in Attitude, Advertising, and Art," in *Embodied Grounding: Social, Cognitive, Affective, and Neuroscientific Approaches*, ed. Gün R. Semin and Eliot R. Smith (Cambridge: Cambridge University Press, 2008), 211–36; Paula M. Niedenthal, Jamin B. Halberstadt, and Åse H. Innes-Ker, "Emotional Response Categorization," *Psychological Review* 106, no. 2 (1999): 337–61, DOI: https://doi.org/10.1037/0033-295X.106.2.337.

39 Maxine Sheets-Johnstone, "Getting to the Heart of Emotions and Consciousness," in *Handbook of Cognitive Science: An Embodied Approach*, ed. Paco Calvo and Toni Gomila (San Diego: Elsevier, 2008): 453–66.

40 Joseph LeDoux, *Synaptic Self: How Our Brains Become Who We Are* (New York: Penguin, 2002).

41 Antonio Damasio, *Looking for Spinoza: Joy, Sorrow and the Feeling Brain* (Orlando: Harcourt, 2003); LeDoux, *Synaptic Self*.

42 These processes are lower level in the sense that they occur at faster rates and are evolutionarily older.

43 Karin Lindgaard, "Nature, Consciousness and Feeling: The Therapeutic Potential of Process Philosophy" (PhD dissertation, Swinburne University of Technology, 2009).

44 Eugene Gendlin, "The Primacy of the Body, Not the Primacy of Perception," *Man and World* 25, no. 3 (1992): 345.

45 Eugene Gendlin, *Experiencing and the Creation of Meaning: A Philosophical and Psychological Approach to the Subjective* (Toronto: Collier-Macmillan, 1962), 14.

46 Ibid., 107.

Cognition and Design Activity

One can apply this understanding of cognition to the internal process of a single designer or the collective process of a collaborative group. The cyclical, iterative process of designing is one of attending between the gestalt and the particular, always guided by a feeling for a goal. As with any human activity, the design process is constantly evaluative. A designer's felt sense of a solution and exploration of the details of that solution may be a process of having a structural pattern in mind – a metaphor – and then attempting its application. The overall fit of the metaphor unfolds. Kees Dorst's concept of frame creation resonates with this description of the design process.

> "New approaches to the problem situation can then be created through a subtle process of inference: once commonalities in themes have been identified, comparisons can be drawn, often through metaphor, to situations outside of the problem domain in which these themes are realized."[47]

Some studies of design activity also point to such processes. Gabriela Goldschmidt, who also draws on Arnheim's work, describes the role of sketching in an iterative process of discovery and reflection. She terms this the "dialectics of sketching."[48] Goldschmidt defines the dialectic as a movement between "seeing as" and "seeing that."[49] "Seeing as" describes a gestalt perception through metaphor and "seeing that" describes the exploration of a particular implication of the metaphor to the task at hand. It is important to note that Goldschmidt does not see the process of creative thinking as specific to design, or specific to the arts.

> "The use of physical metaphors in all disciplines entails 'seeing as' and in design, in science, and in art there are many examples of metaphors which led to new developments and important innovations, discoveries, and inventions."[50]

Goldschmidt proposes that sketching supports the organization of visual thinking into the dialectical pattern. This may be because sketches offer specific details. Externalizations are far more distinct than mental images. Ilse Verstijnen and her colleagues also claim that "the crucial aspect of sketching conditions … appears to be the possibility to perceive new structure in externalizations of mental images."[51] However, we have questioned the separateness of visual information. We propose that externalization supports the deeper forms of simulation we use to test the aptness of metaphors in novel situations. Externalizations such as sketches and prototypes support the *conscious comparison and projection* of structural relationships. But they also support the *unconscious, embodied simulation* of structural relations. This simulation emerges in consciousness as the feeling we get for the appropriateness of any solution to any problem – the gestalt sense of fit that we rely upon, sometimes even with explicit awareness. We suggest that sketches and prototypes assist the dialectical process of creative discovery in collaborative situations because they are analogue representations of gestalt concepts. They contain the implicit in their precise, yet unfinished, nature. A designer's ability to capture the implicit in an analogue representation relies on the skills gained in practice-based design training.

Our interpretation of design practice does not diminish the importance of design research for embodied cognition. An understanding of design processes can contribute to conceptions of human cognition. For example, Goldschmidt's dialogic process of "seeing as" and "seeing that," emerging from protocol studies, is one way of describing generative cognition that supports and extends theories of metaphor and embodiment. Studies of the use of analogy[52] and reinterpretation[53] in design present similar themes, including further work by Goldschmidt.[54] There is debate amongst theorists of metaphor and analogy over the kind of cognitive process that

47 Kees Dorst, "Frame Creation and Design in the Expanded Field," *She Ji: The Journal of Design, Economics, and Innovation* 1, no. 1 (2015): 27, DOI: https://doi.org/10.1016/j.sheji.2015.07.003.

48 Gabriela Goldschmidt, "The Dialectics of Sketching," *Creativity Research Journal* 4, no. 2 (1991): 123–43, DOI: https://doi.org/10.1080/10400419109534381.

49 Ibid., 138–40.

50 Ibid., 140.

51 Ilse M. Verstijnen et al., "Creative Discovery in Imagery and Perception: Combining Is Relatively Easy, Restructuring Takes a Sketch," *Acta Psychologica* 99, no. 2 (1998): 179, DOI: https://doi.org/10.1016/S0001-6918(98)00010-9.

52 Linden J. Ball and Bo T. Christensen, "Analogical Reasoning and Mental Simulation in Design: Two Strategies Linked to Uncertainty Resolution," *Design Studies* 30, no. 2 (2009): 169–86, DOI: https://doi.org/10.1016/j.destud.2008.12.005; Bo T. Christensen and Christian D. Schunn, "'Putting Blinkers on a Blind Man': Providing Cognitive Support for Creative Processes with Environmental Cues," in *Tools for Innovation: The Science Behind the Practical Methods That Drive New Ideas*, ed. Arthur B. Markman and Kristin L. Wood (Oxford: Oxford University Press, 2009): 48–74.

53 Catherine Stones and Tom Cassidy, "Seeing and Discovering: How Do Student Designers Reinterpret Sketches and Digital Marks During Graphic Design Ideation?" *Design Studies* 31, no. 5 (2010): 439–60, DOI: https://doi.org/10.1016/j.destud.2010.05.003.

54 Gabriela Goldschmidt, "Visual Analogy: A Strategy for Design Reasoning and Learning," in *Design Knowing and Learning: Cognition in Design Education*, ed. Charles Eastman, Mike McCracken, and Wendy Newstetter (Oxford: Elsevier, 2001): 199–220.

each describes,[55] but we argue that analogy to pertains more to conscious processes of comparison and metaphor to unconscious projection, a literal "seeing as." Thus, it makes perfect sense that forming analogies may be central to the generation of possible solutions and novel perspectives. But those that hold – that provide solutions that we sense as fitting – are used as metaphors. These metaphors entail the structure that we project from them. The details of a solution are as much discovered as created.

The Problem of Feeling for the Field of Design

It is worth clarifying the trajectory of the development of design thinking. Initially, its development was similar to that of cognitive science – both fields embraced a cognitivist approach, and then questioned that approach. In the academic field of design, a period of increased confidence in a rational and scientific basis for design was followed by an acknowledgement of the limitations of this basis. Design activity in a social or cultural context is more complex than such models explain. However, the field of design still needed to distance itself from the notion that design is intuitive or creative – and therefore unable to be theorized. Design researchers developed a view of design as a form of plan-making or problem-structuring, often through rational and deliberative processes. Thus, second-generation design methods remain focused upon reasoning,[56] and critiques of the rational problem-solving paradigm have not led to genuine alternatives.[57]

While the stream of cognitive science we describe has developed theories of embodiment and feeling, design theorists may remain uncomfortable with these developments because of the struggle for design to be recognized as an academic discipline. As Huppatz says, "For design research and education, Simon's 'science of design' – with its focus on problem solving – remains appealing as an opposing model to a 'crafts'-oriented image of the designer."[58]

Ambivalence towards the role that feeling plays in thinking may be one source of the ambiguity of design thinking. Kolko explains that design thinking transcends the historical view of designers as "artistic savants."[59] On the other hand, Brown speaks about designers as basically "feeling their way through" the process of design.[60] This, in turn, is at odds with Huppatz, who says,

> "[The] promise of greater control has proven popular in recent characterizations of design thinking closely aligned to management. The logic of optimization promises greater predictability and profit while rigorously stripping judgment, intuition, and experience from systems and service design."[61]

Even so, some industry-based versions of design thinking do place emphasis on emotion – that of users or customers. This emphasis is on *empathy*, or concern for the emotions elicited in the user or customer, and not on the emotions elicited during the process of designing. As Kimbell explains, the designer appears to be rather uncritically accepted as able to understand users and interpret their needs, in a process that "shows little of the reflexivity of the social science traditions."[62]

Some moves in design theory align with the view presented in this paper. Tonkinwise, for instance, rightly points out that managerial versions of design thinking downplay – and at times completely exclude – the role of aesthetics in design. This, he argues, fails to acknowledge the role of style. Tonkinwise defines style as "the ground of a practice, that which coordinates actions and makes them meaningfully part of a practice"[63] – including the link between innovation and stylistic discernment learned as part of a practice-based design education. The "felt sense" or "feeling for" described in this paper is central to aesthetic practice and reproduction. Indeed, more recent work by Johnson extends earlier work on

55 Dedre Gentner and Brian Bowdle, "Metaphor as Structure-Mapping," in *The Cambridge Handbook of Metaphor and Thought*, ed. Raymond W. Gibbs, Jr. (Cambridge: Cambridge University Press, 2008), 109–28; Sam Glucksberg, "How Metaphors Create Categories—Quickly," in *The Cambridge Handbook of Metaphor and Thought*, ed. Raymond W. Gibbs, Jr. (Cambridge: Cambridge University Press, 2008), 67–83.

56 Horst W.J. Rittel, "The Reasoning of Designers," Arbeitspapier zum International Congress on Planning and Design Theory in Boston, August 1987, *Schriftenreihe des Instituts für Grundlagen der Planung, Universität Stuttgart* (1988).

57 Kees Dorst, "Design Problems and Design Paradoxes," *Design Issues* 22, no. 3 (2006): 4–17, DOI: https://doi.org/10.1162/desi.2006.22.3.4.

58 Huppatz, "Revisiting Herbert Simon's 'Science of Design,'" 35.

59 Kolko, "Design Thinking Comes of Age," 67.

60 Kimbell, "Rethinking Design Thinking: Part I," 285–306.

61 Huppatz, "Revisiting Herbert Simon's 'Science of Design,'" 38.

62 Kimbell, "Rethinking Design Thinking: Part I," 295.

63 Cameron Tonkinwise, "A Taste for Practices: Unrepressing Style in Design Thinking," *Design Studies* 32, no. 6 (2011): 538, DOI: https://doi.org/10.1016/j.destud.2011.07.001.

metaphor and image schemata, exploring meaning, feeling, and their relationship to art and aesthetics.[64] More broadly, the philosophy of aesthetics and the body has become a major theme, generating an interdisciplinary field termed *somaesthetics*, which "redirects aesthetics back to the core issues of perception, consciousness and feeling" and provides "an exploratory orientation for new research in philosophy of mind"[65] through aesthetic inquiry.

Concluding Remarks

This article has explained some key developments in cognitive science towards embodied cognition. We considered the contribution of material design practices to creative thinking and innovation in the context of these developments. The stream of cognitive science we discussed is heavily influenced by theories of the role of metaphor in the generation of experience and understanding. Some cognitive scientists have developed these theories in relation to empirical and theoretical research on the body, perception, and feeling. We made attempts to link existing design concepts – such as affordances and visual thinking – to this broader narrative. We also showed how specific studies in design align with the notion that applying and exploring metaphors occurs as a dialectical style of thinking between the gestalt and the particular. Explicit moves always occur in relation to an implicit "sense of fit" or "feeling for" a solution. Material design practices such as sketching and prototyping may assist this "feeling for," particularly in collaborative situations. Thus, we have situated one aspect of design thinking within broader theories so as to clarify some potential contributions of design to both theory and practice.

We offered theoretical perspectives in the context of a trajectory of development. We aimed to demonstrate how the trajectory of design thinking differed from that of cognitive science. Our purpose was to highlight the ambivalence that design theorists may have towards the role of feeling in design and cognition. Ironically, paying more attention to the role of feeling in cognition counters the notion of designers as "artistic savants," although in a different manner than that of industry advocates for design thinking. Our perspective does not privilege the creativity of the designer, but not because we change the definition of design activity. Rather, we situate design in a theory base that acknowledges the profound creativity of the processes underlying *ordinary* human cognition. These processes may be augmented by specific practices, including design practices.

We provided an account of one stream of embodied cognition that may be of interest to a broad audience that already has some interest in design thinking. However, our description of the differing theoretical trajectories is in some respects a simplified account. Although much research on embodiment exists in the field of Human Computer Interaction (HCI), it would require a lengthy review in light of the ideas presented in this article. We chose to foreground the area of design theory from which academic concepts of design thinking emerged. This field has developed largely in design departments with a tradition of practice-based training.

Developments towards embodiment within HCI have taken a different trajectory, more inspired by the philosophical tradition of phenomenology. Many authors cite Paul Dourish's 2001 work *Where the Action Is* as a classic that solidified embodied interaction as a key theme in HCI.[66] Some researchers propose embodiment as a "third paradigm" successor to other approaches in HCI.[67] Yet embodiment remains a plural concept in HCI, characterized by a variety of terms and definitions.[68]

Some recent work in HCI does align with some of the concepts presented in this article. In particular, Dag Svanæs offers the concept of the *feel dimension* of *interaction gestalts* to describe user experience, inspired by philosopher Maurice

64 Johnson, *The Meaning of the Body*.

65 Richard Shusterman, *Thinking Through the Body: Essays in Somaesthetics* (Cambridge: Cambridge University Press, 2012), 3.

66 Paul Marshall, Alissa Antle, Elise Van Den Hoven, and Yvonne Rogers, "Introduction to the Special Issue on the Theory and Practice of Embodied Interaction in HCI and Interaction Design," *ACM Transactions on Computer-Human Interaction (TOCHI)* 20, no. 1 (2013): 1, DOI: https://doi.org/10.1145/2442106.2442107.

67 Steve Harrison, Phoebe Sengers, and Deborah Tatar, "Making Epistemological Trouble: Third-paradigm HCI as successor science," *Interacting with Computers* 23, no. 5 (2011): 390, DOI: https://doi.org/10.1016/j.intcom.2011.03.005.

68 Marshall et al., "Introduction to the Special Issue on the Theory and Practice of Embodied Interaction in HCI and Interaction Design."

Merleau-Ponty's view of perception as an interactive, whole body experience. Svanæs also discusses the importance of movement and the *kinaesthetic sense* for creativity in the design process.[69] In the context of performing arts, David Kirsh studied the way expert dancers learn new dance phrases. He found that the imperfect simulation of new phrases – a process called marking – is a better method of practicing than performing complete phrases.[70] He likens this to the creation of a model or sketch. The notion that incomplete, analogue and gestalt representations are better for learning complex dance phrases resonates with our understanding of sketches and prototypes as representations of the implicit dimension of experience. At the same time, Kirsh draws some of his views on perception from a different stream of embodied cognition than the one we have discussed. The finer points of this are beyond the scope of this article but would be worth exploring in future research. Some connections have also been made between the burgeoning interdisciplinary field of somaesthetics and HCI.[71] These interdisciplinary connections are fascinating and full of potential for further exploration, theoretically and empirically.

More broadly, a move beyond dualisms of objective and subjective, which necessitates dialectical thinking, is underway in many disciplines. This context is a theoretical movement, which philosopher Arran Gare terms "speculative naturalism."[72] Design thinking benefits from being situated in existing, well-developed theories, as already suggested by some.[73] Today's complex problems demand an understanding of human creativity that does not privilege any one discipline but explores the potential contribution of specific skills and paradigms. The fact that design thinking de-politicizes design for management[74] is a problem. Humanity is currently facing genuinely complex problems. To even begin to solve these, we need to stop the jostling for position in pre-set economic agendas and seek possibilities for change inherent in our common humanity.

69 Dag Svanæs, "Interaction Design for and with *the Lived Body*: Some Implications of Merleau-Ponty's Phenomenology," *ACM Transactions on Computer-Human Interaction (TOCHI)* 20, no. 1 (2013): 8, DOI: https://doi.org/10.1145/2442106.2442114.

70 David Kirsh, "Embodied Cognition and the Magical Future of Interaction Design," *ACM Transactions on Computer-Human Interaction (TOCHI)* 20, no. 1 (2013): 3, DOI: https://doi.org/10.1145/2442106.2442109.

71 Shusterman, *Thinking Through the Body.*

72 Arran Gare, *Philosophical Foundations of Ecological Civilization: A Manifesto for the Future* (London: Routledge, 2016).

73 Peter Dalsgaard, "Pragmatism and Design Thinking," *International Journal of Design* 8, no. 1 (2014): 143–55.

74 Kimbell, "Rethinking Design Thinking: Part I," 285–306.

Commentary

Making Sense of Design Thinking

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It is no accident that the word "sense" appears in the expression "making sense." We traditionally interpret making sense as an activity that largely occurs in the mind. This is because the phrase is a metaphor, and like most metaphors, we instantly and uncritically associate it with a meaning. Upon careful inspection, the phrase betrays the bodily origins of thinking and reasoning which are – in embodied accounts of cognition – grounded in the senses. While embodied cognition is a relatively recent addition to academic dialogue,[1] the language we use to describe cognition suggests that we have always known that the senses are involved in thinking and reasoning about the world.

The stated goal of Karin Lindgaard and Heico Wesselius's article[2] is to make sense of design thinking by bringing the senses back into the understanding of how designers think and reason during design activity.

To achieve this, the authors begin by introducing several key ideas from an embodied account of cognition. They introduce sense making processes including metaphor theory, visual gestalts, and felt experience, and suggest that these processes may be foundational in designers' material practices. They situate their work as fitting into the academic discourse about design thinking as a cognitive style, as articulated by Lucy Kimbell, and take a stance on design activity as reflective practice as articulated by Donald Schön. The authors state that their contribution is "suggestive