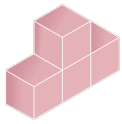
NORDES 2021



DISTRIBUTED THINKING THROUGH MAKING: TOWARDS A RELATIONAL ONTOLOGY IN PRACTICE-LED DESIGN RESEARCH

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ABSTRACT

Practice-led design research is a celebrated but debated field of inquiry. Although it offers appropriate tools to advance design knowledge through and within making, its scope remains limited to the scale of individual practice. Such a limitation hinders the possibility to account for particular design instances in relation to more general contexts. To address this issue, the paper at hand presents an exploratory literature review discussing why practice-led design research may benefit from adopting a relational ontology—i.e., a stance wherein to be is to relate. The review identifies two streams of relational thinking that exhibit potential overlaps with practice-led design research: sociomateriality and distributed cognition theory. In revealing these overlaps, I introduce the term "distributed thinking through making" to formulate a novel framework from which to reconsider the ontological dimension of practice in practice-led design research. The term illuminates a research gap that appears especially relevant to empirical studies in which making constitutes both the platform and the focus of inquiry.

INTRODUCTION

With the increasing involvement of professional designers in academia, the last three decades have witnessed an explosion of research approaches in design. The need to advance knowledge from within practice has propelled the emergence of a research stream wherein design is no longer an object of study but has become a platform of inquiry. The origins of this stream can be traced back to the 1970s (Chow, 2010, p. 145), yet the idea of designing to produce knowledge did not gain momentum until twenty years later, when the notion of *research through design* was first sketched in an academic publication (see Frayling, 1993). Since then, this notion has been iterated by different people in different contexts (see e.g., Archer, 1995; Gaver, 2012; Koskinen et al., 2011; Stappers & Giaccardi, 2017), accommodating divergent approaches that share a common orientation towards the use of design practice as a vehicle of research. Without entering into detailed discussion, this paper elaborates further on one of these approaches, namely *practice-led design research*.

In particular, practice-led design research highlights the instrumentality of making in the generation of knowledge. Making, in this sense, is understood as a competence-based creative activity that fundamentally partakes in the thought processes of designers. Because designers are professionally trained to think generatively, they possess the ability to accomplish tasks by simultaneously ideating the ways of accomplishing them (cf. Gherardi & Perrotta, 2013). This means that designers are capable of producing not only creative outcomes but also knowledge about their creative processes. Typically referred to as *thinking through making* (see e.g., Carter, 2005; Mäkelä, 2007; Nimkulrat, 2012; Olsen & Heaton, 2010; Pasman &

Boess, 2010; Rajmakers & Arets, 2015), this feature of design activity constitutes the operational principle of practice-led design research: it offers designers a mode of inquiry that is familiar to them, thus asserting the epistemic role of making in the context of design practice.

Although this mode of inquiry has proven efficient in advancing design knowledge, it remains considerably limited to particular design instances. Because practice-led design research allows for the use of one's own acts of making as a platform of investigation, knowledge production in this field exhibits a tendency to be overly self-referential. Against this backdrop, the paper at hand asks: *how can practice-led design research account for the epistemic role of making beyond the scale of individual practice?* To answer this question, I review relevant literature across different domains by conducting an exploratory study (see Arksey & O'Malley, 2005). The review discusses various approaches to practice grounded in relational perspectives. This means that all approaches discussed herein contend that the relationships established between the actors of a given practice are more significant than the actors themselves. Based on a detailed analysis of these approaches, I propose the term *distributed thinking through making* to mobilize practice-led design research beyond the boundaries of the first-person singular.

To contextualize, the term distributed thinking through making accounts for a synergistic process of knowledge creation in which *thinking* exhibits two main characteristics: (a) it is socially and materially constituted, and (b) it is operationalized by bringing things forth into being. The former is met when thought processes extend beyond a single individual to include other individuals, artifacts, and the environment. The latter is met when these thought processes occur via open-ended, inventive, and affective tasks. Typical examples of thought processes with both characteristics can be found in activities such as collective art making, co-designing, group cooking, community gardening, writing music for an ensemble, or choreographing a dance. Central to these activities are the conditions of non-linearity and collectivity: none of these activities follow a fully articulate logic, yet all of them rely on the intersubjective articulation of knowledge.

One of the main endeavors of practice-led design research consists in articulating the type of ineffable knowledge that unfolds during design practice. It has been well documented that since designing is a largely tacit activity, utilizing it as a mode of inquiry situates the research endeavor within an ambiguous epistemological space (Gaver, 2014, p. 153). Assuming the double role of designer and researcher comes with the challenge of assessing how the tacit nature of design practice can contribute to the articulation of explicit knowledge (Koskinen & Krogh, 2015, p. 124; Mäkelä & Nimkulrat, 2018, p. 1; Pedgley, 2007, p. 463). Although this issue has sparked a vivid debate in design research at large, the use of design practice as a mode of inquiry has been celebrated in studies that necessitate the living knowledge of practicing designers. This living knowledge becomes an invaluable asset in a field like practice-led design research (see e.g., Evans, 2010; Groth et al., 2015), especially because it offers the kind of insider's perspective that other research approaches are far from reaching.

Following these lines of thought, the term distributed thinking through making reconsiders practice-led design research not epistemologically but ontologically. Put simply, it *maintains* the locus of knowledge production within design practice but *expands* the nature of such practice beyond individual modes of practicing. In reviewing the literature to lay out the foundations of this ontological shift, I reveal a research gap that appears especially relevant to empirical studies in which making constitutes both the platform and the focus of inquiry. The next section describes the methods employed in the review and outlines the overarching structure of the analysis.

MATERIALS AND METHODS

Relevant literature was selected based on a three-step procedure. The first step consisted of selecting a starting set of publications from the main sources used in practice-led design research. These sources were identified between 2019 and 2020 via access to research seminars, reading circles, and leading journals in the field. The selection was limited to publications that offered theoretical or empirical insights about the role of making in the production of knowledge. The second step consisted of expanding the scope of the review by including relational perspectives from other fields. To that end, a list of keywords was extracted from the starting set of publications and supplemented with terms expressing aspects of relationality. All keywords and variations thereof were combined with boolean operators (e.g., "making" or "materiality" and "network") and searched for in scholarly databases such as ScienceDirect, Scopus, and Google Scholar. The resulting publications were included for review insofar as they examined acts of making or offered approaches to practice that were compatible with practice-led design research. Lastly, the third step consisted of performing backward snowballing (Levy & Ellis, 2006; Webster & Watson, 2002) to identify relevant citations in the selected literature. This step yielded new publications and showed a few connections among the previously included ones.

The method described above allowed for the collection of a total of 61 research publications found in scientific journals, conference proceedings, books, book chapters,

and doctoral dissertations. Relational approaches compatible with practice-led design research were found in areas of cognitive anthropology, science and technology studies (STS), social theories of practice, material culture, and ecological psychology. Combined with the exploratory nature of the research question, the breadth of the selected literature did not allow for a systematic review but rather lent itself to a scoping study (see Arksey & O'Malley, 2005, p. 21). This strategy permitted me to identify the extent of available knowledge related to the research question regardless of disciplinary allegiances. To ensure depth in the analysis, nonetheless, I focused on five aspects of practice-led design research that emerged among all areas of the selected literature: (a) the epistemic dimension of practice, (b) the importance of materiality, (c) the limits of individuality, (d) the non-linearity of thought processes, and (e) the double role of the practitioner-researcher. The analysis was conducted at the intersection of these five aspects, revealing two streams of relational thinking that exhibited potential overlaps with practice-led design research: sociomateriality and distributed cognition theory.

To further articulate such overlaps, the review is organized into three sections. Section 1, *Practice beyond the individual*, draws on an area of the literature that conceives of practices as unitary systems of activity wherein people and things are inextricably bound. In this section, I employ sociomateriality as a theoretical lens to address matters of scale, relationality, and the inclusion of social and material actors in practice-led design research, thus anchoring the act of making not only in human-material interaction but also in social practice. Section 2, *Literacies of Making*, encloses the review of various publications coming from, and referred to in, practice-led design research. In this section, I discuss how practitioners and scholars champion the idea that making is not only a way of knowing but also a means to produce knowledge. Section 3, *Distributed thinking and reflective practice*, focuses on how design practitioners utilize multiple cognitive resources that are spread across space and accumulated over time. In this section, I review the theory of distributed cognition and lay out a way of triangulating it with practice-led design research. The remainder of this paper comprises an additional section where I summarize the findings and discuss their appropriateness in filling the research gap.

PRACTICE BEYOND THE INDIVIDUAL

This section concentrates on the idea of treating practices as relations. The review takes as its point of departure the work of cognitive anthropologist Edwin Hutchins (1995), which offers a revolutionary view of the mind by examining cognitive activity not at the level of individuals but at the level of practices. Upon acknowledging that a more nuanced comprehension of human accomplishment lies in the study of phenomena beyond the individual, I review how various theories of practice place emphasis not only on the social but also on the material. This idea sets the stage to review sociomaterial approaches grounded in relational perspectives to epistemology and ontology, which I discuss in relation to practice-led design research. Before closing this section, I underline one key aspect that has been ignored in this area of the literature, which, in contrast, has been the focus of attention in practice-led design research. This aspect concerns the idea of employing the act of making as a means of knowledge production.

In his influential book *Cognition in the Wild*, Hutchins (1995) proposes a framework for the study of mind that cuts across anthropology and cognitive science. Based on the observation of a group of navigation practitioners operating aboard a naval ship, he examines cognitive activity in a real-life setting instead of limiting its study to laboratory conditions. Informed by social anthropologist Jean Lave's work on knowing-in-practice (1988), STS scholar Lucy Suchman's work on situated action (1987), and psychologist Lev Vygotsky's work on activity theory (1978), Hutchins's studies constitute one of the cornerstones of a growing research approach called *situated cognition*. This approach has been acclaimed in a wide variety of fields because it puts human thinking back in context. Further, it is considered pioneering because it *situates* thought processes in social and material interaction rather than confining them to the individual's head. In what follows, I discuss two implications of adopting this approach in practice-led design research. First, I focus on the social aspect of practice; then, I concentrate on its material dimension.

The first implication of adopting a situated cognition approach in practice-led design research lies in the need to reaffirm the locus of the individual within a larger system of activity. Hutchins (1995, xiv) does so by expanding the unit of analysis from individuals to practices. This procedure allows him to examine the coordinated operations of the entire navigation team. With examples describing how the team manages to keep the ship under control and bring it safely into port, he empirically demonstrates that human accomplishment does not depend on the skills of individuals but on the often-implicit structures that enable the exercise of such skills in the first place. This means that even when carried out at the individual level, cognitive activity is driven by tacit understandings of practice that are socially and culturally situated (Lave, 1998, p. 171; Schatzki, 2001, p. 16). In this context, Hutchins (1995, pp. 27, 176) maintains that it is "shipboard navigation culture" that prescribes the navigators' way of thinking and thus the cognitive properties of the entire navigation team.

Acknowledging the relation between practice and culture places this idea of *situatedness* in high resonance with practice-led design research. In the quest of employing their practice as a platform of inquiry, designer-researchers who ascribe to this field need to situate their knowledge within the disciplinary culture in which this knowledge operates (Evans, 2010; Groth, 2017). In this sense, Hutchins's work resonates well with practice-led design research because it exhibits a process of in-depth data collection facilitated by the adoption of an insider's perspective. His extensive experience as both a cognitive anthropologist and an open sea sailor enables him to describe, with the utmost precision, the peculiarities of shipboard navigation culture and the social conventions, behaviors, and attitudes performed therein. This ability to understand such aspects from an insider's perspective is crucial in explicating the practice in question and its implicit structure. Moreover, it typifies the double role that practitioner-researchers have to adopt, as researchers and informants (Mäkelä & Nimkulrat, 2018; Pedgley, 2007), when they confront the task of articulating how their tacit understandings and situated experiences play a formative role in the generation of knowledge.

The second implication of adopting a situated cognition approach in practice-led design research is concerned with matters of scale, relationality, and the inclusion of material objects, flows, and forces as active participants in the shaping of practices. Whereas matters of scale and relationality are largely overlooked in practice-led design research, issues about the inclusion of material and environmental actors play a central role in this field (see e.g., Aktaş, 2020; Latva-Somppi & Mäkelä, 2020; Nimkulrat, 2009; Scott, 2010). Nevertheless, this latter aspect needs to be considered from a broader analytical perspective and not only from a practitioner-centered one. An insightful take on this issue can be found in the research stream of *sociomateriality* (see e.g., Carlile et al., 2013; Hultin, 2019; Orlikowski, 2007), which holds that the social and the material are equally malleable and actively shape each other. Sociomateriality is grounded in a relational ontology that assumes no a priori division between people and things (Jones, 2013, p. 221; Orlikowski, 2007, p. 1437), thus accounting for the primacy of relationships over entities in the study of practices. Below, I draw on this ontology to discuss how adopting a sociomaterial lens could be beneficial for practice-led design research. In doing so, I reassert the reasons why the idea of expanding the unit of analysis may assist this field in overcoming matters of scale and relationality.

As mentioned above, practice-led design research engages in knowledge production by highlighting the subjective input of the designer from a singular, first-person stance. Addressing research problems at the scale of disciplinary practices, however, demands the use of analytical tools that cannot be deployed by individual metrics alone. Therefore, matters of scale need urgent attention in a field like this. Practitioner-researchers Maarit Mäkelä and Nithikul Nimkulrat (2018, p. 1) remind us that "practice-led [design] research has been under debate for three decades". One of the most salient aspects of this debate concerns the question of whether analyzing one's own design activity constitutes a proper means to yield unbiased and generalizable knowledge claims (Pedgley, 2007). This question embodies what design philosopher Johan Redström (2017, p. 7) identifies as "the tension between the universal and the particular". In a similar way to what the situated cognition approach proposes, the literature on sociomateriality suggests that this tension can be softened by shifting the unit of analysis from individuals to practices. Such a shift is of great relevance to practice-led design research because it posits knowledge as a relational process rather than a localized property. Changing the scale from individuals to practices thereby allows practitioner-researchers to tackle issues of relationality. In other words, this change of scale assists in "clarifying the relationship between the practitioners as individual sources of knowledge and the practice itself as the unit of knowing" (Vega et al., 2021, p. 11).

Treating practices as a unit of analysis is a common procedure used in theoretical studies seeking to address research problems at the scale of social structures. Commonly referred to as *practice theory* (see e.g., Reckwitz, 2002; Schatzki, 2001; Shove, 2003), this approach offers yet another way to investigate human activity in context (Gherardi, 2017). Although rarely made explicit, practice theory and situated cognition are closely related. Both approaches are grounded in a relational epistemology that rejects the dualistic separation of knowing and doing. In the same vein, sociomateriality draws on practice theory but takes it even further by assuming this relational perspective not at the epistemological but at the ontological level (see e.g., Carlile et al., 2013). In line with shifting the unit of analysis from individuals to practices, sociomateriality shifts the status of materiality from passive to active by granting equal ontological treatment to the social and the material. In this view, practices are not constituted by social structures acting upon inert material worlds. Instead, as STS scholar Wanda Orlikowski (2007, p. 1437) pronounces, practices are "entanglements" of social and material structures that actively co-constitute the world.

Comparably, practice-led design research tends to emphasize the active role of materiality in the generation of knowledge. It is also common to observe that designer-researchers reject dualistic assumptions in the same way as sociomateriality scholars do. In this regard, practice-led design research and sociomateriality operate under similar tenets. They, however, differ in two fundamental aspects. The first aspect is

epistemological, thus concerning the locus of knowing within the practice under scrutiny. The second aspect is ontological, thus concerning the question of what constitutes a practice in the first place.

Epistemologically, practice-led design research differs from sociomateriality because its locus of knowledge production lies in the individual instead of the social. This aspect could be tackled by anchoring the epistemic dimension of the practice in question in a system of activity that is larger than the practitioner—for example, by *creating* knowledge with other actors rather than *sourcing* knowledge from them. It is worth noting that this strategy does not conflict with the intention of highlighting the subjective input of the practitioner-researcher. In fact, a strategy like this could enhance such subjective input because it would inherently afford an intersubjective means of knowledge validation. Ontologically, the gap between both fields is much larger. Because practice-led design research has not yet anchored its epistemological stance in the social, it cannot yet afford the ontological shift that sociomateriality proposes, which is the entanglement of the social and the material. However, since both fields "share a concern for the material and insist that the material cannot be understood outside of the social practices in which [it] become[s] enacted" (Østerlund et al., 2015, p. 127), their ontological dissimilarities seem reconcilable.

All in all, the idea of examining practice beyond the individual poses an important challenge for practice-led design research. At the heart of this challenge lies the question of how the act of making can be employed as a relational research practice. Although some studies have started to touch upon this question (see e.g., Nimkulrat et al., 2020; Shercliff & Twigger Holroyd, 2016; Vega et al., 2021), the epistemic role of more-than-individual acts of making remains largely unarticulated in practice-led design research. Conversely, some studies in the field of sociomateriality have inquired *into* more-than-individual acts of making from a relational perspective (see e.g., Durrani, 2018; Endrissat & Noppeney; 2013; Gherardi & Perrotta, 2013), but no studies in this field have yet engaged in knowledge production *through* such acts. To maintain the locus of knowledge production within the act of making and simultaneously expand it beyond the individual, the very act of making must remain known from the inside rather than observed from the outside. For this reason, the insider's knowledge of the practitioner continues to be much needed. In the next section, I review some of the literature that explicates how scholars and practitioners in the field of making articulate these ways of knowing from the inside.

LITERACIES OF MAKING

This section elaborates on the premise that making, in addition to being a knowledge competence, is a knowledge-producing practice in its own right. The review builds upon three main approaches to the act of bringing things forth into being: a material culture approach proposed by social anthropologist Tim Ingold (2013), a design theory approach proposed by design philosopher Johan Redström (2017), and a practice-led design research approach proposed by ceramicist and designer Camilla Groth (2017). All three approaches hold that making is a way of knowing from the inside. In focus is how this way of knowing does not exist in isolation but rather emerges in relationships.

In *Making*, Ingold (2013) argues that material culture studies ought not to be only preoccupied with understanding how the world is made. Drawing on the work of philosophers Gilles Deleuze and Félix Guattari (2004), he states that these types of studies should be as well preoccupied with participating in the making of the world. With this statement, Ingold reminds us that the essence of making lies in a process of correspondence between the maker and the world rather than in an imposition of the maker upon the world. On par with Orlikowski's (2007) sociomaterial conception of practice, Ingold's work posits that the act of making entails the entanglement of beings and things that co-participate in the world's *becoming* (see Deleuze & Guattari, 2004). In explicating the notion of becoming, he expresses his discomfort with Aristotle's *hylomorphic* account of making, which is the view that making implies the imposition of form upon matter based on a preconceived idea that exists in the mind of the maker (Ingold, 2013, p. 21). Ingold's rejection of Aristotelian hylomorphism promotes the adoption of a *morphogenic* approach, which, as he notes, stresses that "form is ever emergent rather than given in advance" (ibid., p. 25). In this view, makers do not impose form upon matter but rather couple with material objects, flows, and forces in a relational act of knowing.

Adopting a morphogenic approach allows for the formulation of three points from which to interrogate the role of making in design practice. The first point is that morphogenic thinking dismantles the role of the designer as the absolute agent in the process of giving form to things. In other words, it contends that it is the *relationship* between the designer and those things that renders designing possible in the first place (cf. Hutchins, 1995; Orlikowski, 2007). The second point is that it evidences how problematic it is to think of this relationship as a condition that is subordinated to either designers or things. Although practice-led design research is well attuned to morphogenic points of view, it continues to ontologically prioritize entities over relationships. By doing the opposite, practice-led design research would be fully equipped to employ design practice, in the strictest

sociomaterial sense of the word, as a means of inquiry that can transcend the designer's first-person stance. Finally, the third point concerns the very conception of design as a form-giving activity, especially because the question of what form means has become an increasingly contested territory in design research at large.

In *Making Design Theory*, Redström (2017) tackles this question and takes the morphogenic approach even further. He begins by mapping the meaning of form in the Scandinavian tradition of design research, which conceives of designing as an act of "form giving" (ibid., p. 25). He argues, however, that contemporary design research has erred by perpetuating the idea that form is a static and discrete feature that designers assign to the things they make. Although Redström does not refer to Ingold, he criticizes, as Ingold does, the Aristotelian view that form is "the way matter builds things" (ibid., p. 70). He explains that form does not reside in the expressive structures that matter can shape but in the relations between these expressive structures and the acts associated to their perception. In other words, he advocates a relational rather than an entity-based definition of form (ibid., p. 68):

> If I talk about a "circular form," I am talking not only about circles per se but also about a certain act of perceiving, of seeing, circles. So because of the typical acts involved in watching a movie, if I say that the form of this movie is based on a circle, then you would probably think of a temporally circular or repetitive structure with no obvious beginning and end, rather than something literally showing a circle all the time.

The idea cited above bears two important implications. The first one is that Redström's definition of form sits across a spectrum that ranges from what *a thing* is to what *making a thing* is (cf. Deleuze & Guattari, 2004; Ingold, 2013). To put it in another way, form cannot be defined by stable and static criteria because that would not support the development of design as an ever-evolving discipline. As he notes in his example, design practice has evolved to a point where designers not only transform matter into circular shapes but also configure circular processes, systems, and frameworks that only become circular in the making. Consequently, the second implication is that such a definition of form can only be brought about through acts of making. Beyond coupling with material flows to bring new things forth into being (see Ingold, 2013), designers, according to Redström, are capable of coupling with other kinds of flows by perceiving where these flows are coming from and where they are going (Spuybroek, 2011). In line with Ingold's morphogenic approach, this definition of form is also emergent rather than given in advance. In such a way, definitions also fall into the category of things that can be designed or, rather, *made*. By scaling up this idea from single definitions to entire theoretical framings, Redström envisions a theory of design that is in itself a *thing* (cf. Ingold, 2013) in the making.

The ideas proposed by Ingold and Resdtröm may seem hard to grasp because they describe acts of making that are based on fluid concepts rather than stable criteria. What is more, making entails the deployment of non-linear, inventive, and affective modes of working, which, unless experienced first-hand, are unlikely to be fully understood. This kind of first-hand experience is precisely what practice-led design research has championed as an asset, in fact calling it *experiential knowledge* (see e.g., Aktaş & Mäkelä, 2019; Groth, 2017; Nimkulrat et al., 2015). The notion of experiential knowledge typifies what Ingold refers to as *knowing from the inside*, which in turn echoes what polymath Michael Polanyi (1958) termed *personal knowledge*. Because making is imbued with a series of tacit understandings embodied by the maker (cf. Lave, 1998, p. 171), the personal and experiential knowledge involved in acts of making is known to be very difficult to articulate (Polanyi, 1966, p. 4). However, this way of knowing from the inside affords an appropriate tool to explore the kinds of empirical phenomena that typically fall into the scope of practice-led design research.

In *Making Sense through Hands*, Groth (2017) deals with the challenge of rendering her experiential knowledge as a maker "researchable and explicable in an academic context" (ibid., p. 7). Through a series of case studies aimed at answering the question of how designers think with their hands, she investigates the role of the body in design practice and notes that making allows designers to think in a variety of modalities. One of her cases shows how she managed to establish "tactile communication" (ibid., p. 52) with a deafblind maker by means of throwing clay together with him. This case highlights one of the key features of making, which is the production of meaning in non-representational form. Because throwing clay occurs in a material modality, representational means such as language are not sufficient to communicate its experiential aspects. Another of her cases illustrates the same idea, this time referring not to the limits of language but to the limits of drawing. As she (ibid., p. 60) expresses it, "[d]rawing is fundamentally different from the information to be had through real-life material manipulation. The more experienced designer has the benefit of owning a larger asset of embodied knowledge of materials and may thus create more realistic mental images of intended designs". Both cases demonstrate that experiential knowledge emerges in action (cf. Hutchins, 1995; Orlikowski, 2007) and cannot be articulated by representational means alone.

In a similar way to Redström, Groth describes acts of making based on a spectrum of concepts rather than stable criteria. In this case, the discrete definitions located at the opposite poles of this spectrum are the *representational* and the *performative* (cf. Groth, 2017, p. 63). Because making entails the ability to move back and forth between these two modes of working, Groth

claims that thought processes about making can only be fully deployed through acts of making (cf. Redström, 2017, p. 6). Her approach bears strong ties to that of Ingold and Redström in that it explicates the concept of knowing from the inside at different levels. On a conceptual level, she turns to the theory of embodied cognition to explicate how the experiential knowledge of a designer is always situated and implicit. On a methodological level, she sharply asserts that "[a] methodology that grows out of [a given] practice may reflect that practice more accurately" (Groth, 2017, p. 81; cf. Redström, 2017). Finally, on an epistemological level, she legitimizes the act of making as a way of knowing by placing the locus of knowledge production in her hands.

As seen above, Ingold, Redström, and Groth boldly recognize the act of making as an epistemic practice. Their work may differ in scope, conceptual depth, and degree of theoretical or empirical evidence. However, all three authors share the ability to articulate their insider's knowledge through the handling of materials, whether these be clay or theory. They all delineate a way of *thinking through making* that allows them to position themselves in correspondence with the world. While this way of thinking is comprehensibly relational, it comes with the downside of being largely tacit: makers know how they relate to their materials, but this relationship often remains invisible. The point of adopting a relational ontology in practice-led design research is to render relationships like this visible and thereby researchable. In line with the idea of examining practice beyond the individual presented in the previous section, the next section explains how to expand the notion of thinking through making beyond the maker.

DISTRIBUTED THINKING AND REFLECTIVE PRACTICE

This section revisits Hutchins's (1995) ideas and incorporates philosopher Donald Schön's (1993) work. Here, I review how cognition extends beyond the individual and how this process is normally accounted for in practice-led design research. In focus are two constitutive aspects of practice: materiality and time. First, I introduce Hutchins's theory of *distributed cognition* and a few similar approaches that emphasize the importance of materiality in the formation of thought processes. Then, I discuss the theory of distributed cognition in the light of Schön's notion of *reflective practice*, concentrating on how practitioners develop reflective tools to accumulate cognitive resources over time. The reason for including Schön's work in this part of the review is twofold: it is influential in practice-led design research, and it bears important similarities to Hutchins's theory.

In addition to contributing empirical evidence to the situated approach initiated by Suchman (1987) and Lave (1988), Hutchins's work paved the way to the development of *distributed cognition theory* (Rogers & Ellis, 1994). His extensive research on team performance allowed him to demonstrate that cognition is not only a situated activity but also a distributed process (Hutchins, 1995, p. 203). Essentially, distributed cognition theory accounts for the coordination of individuals, artifacts, and the environment in the accomplishment of tasks. Psychologists Yvonne Rogers and Judi Ellis (1994, pp. 121–2) note that it offers a suitable framework for studying how cognition is both socially transmitted and materially mediated.

Distributed cognition theory has strong ties with a developing research program called *4E cognition*. The program is an interdisciplinary effort to provide alternative approaches to classical cognitivism, which holds that thought processes occur exclusively inside the head. In arguing that thought processes are dynamically entangled with a multitude of external factors, the 4E research program offers (1) embedded, (2) embodied, (3) enactive, and (4) extended approaches to cognition (Rowlands, 2010), hence the "4E". Although these four approaches are different and strive to demarcate themselves from one another, all of them purport to explain that cognition occurs in practice and unfolds at the interface of mind, body, and world.

The first approach, *embedded cognition*, contends that thought processes are always context dependent. In line with the idea of situatedness explained earlier in this review, this approach recognizes that the mind is ontologically inseparable from its surrounding environment. The second approach, *embodied cognition*, states that thinking can only be the outcome of having a physical body experiencing a physical world. This approach draws on philosopher Maurice Merleau-Ponty's *Phenomenology of Perception* (1962/1945), wherein the notion of *embodied knowledge* was introduced to contest the cartesian problem of separating the mind from the body. As discussed in the previous section, Groth's (2017) research adopts this epistemological stance by placing the locus of knowledge production not inside her head but in her knowing hands. The third approach, *enactive cognition*, insists that thinking emerges in action, thus being always relational, dynamic, and performative. This approach is credited to philosopher Francisco Varela and colleagues (1992), who assert that "cognition is not the *representation* of a pre-given world by a pre-given mind but is rather the enactment of a world and a mind on the basis of [the] actions that a being in the world *performs*" (ibid., p. 9, emphasis added). This idea bears a direct link to the notion of performativity highlighted in the previous section, and it is specifically related to what Groth (2017, p. 63) describes as the "non-representational" dimension of making. The performative character of enactive

cognition also echoes Ingold's (2013) morphogenic stance, in which form is emergent, or *enacted*, rather than given in advance. Further, it resonates with Orlikowski's (2007) sociomaterial account of practice, in which the social and the material are not pre-formed entities but performed relationships (ibid., p. 1438). Lastly, the *extended cognition* approach posits that the cognitive capacity of individuals is constantly augmented by the use of artifacts, tools, and instruments. This approach is largely based on the studies of philosopher Andy Clark and cognitive scientist David Chalmers (1998), who took Hutchins's ideas to develop a model of the extended mind by stating that material objects, flows, and forces operate as cognitive resources that enhance the mental and bodily abilities of individuals.

While all four approaches are compatible with distributed cognition theory, the last two (i.e., the *enactive* and the *extended*) have a much stronger connection to it. They both hold that thought processes extend beyond the physical boundaries of the individual to include material interactions with the environment (Clark & Chalmers, 1998, p. 10; Hutchins, 2010, p. 706). Worth reminding, distributed cognition theory states that cognition is not only socially transmitted but also materially mediated. An example of the latter aspect would be any process that implies offloading one's thoughts onto a material artifact—for instance, when taking notes. Whether for personal use or to share with others, note-taking entails the use of analog or digital tools that populate a larger network of social and material resources. Taking cues from the work of anthropologist Gregory Bateson (1972) and psychologist James Gibson (1986), Hutchins (2010, p. 706) refers to this network as a *cognitive ecosystem*. Distributed cognition theory is thus concerned with material artifacts to the same extent as it is concerned with social dynamics. Further, it contends that materiality is inextricable from the cognitive ecosystems in which social practices occur.

Although the importance of material artifacts is well documented in studies of distributed cognition, little attention has been paid to studying the act of making artifacts as a distributed cognitive process. Some researchers have begun to address this topic. However, they treat artifacts as *external representations*, the only role of which is to mediate cognitive tasks or facilitate communication between individuals (see, however, Mehto et al., 2020). Because this treatment of artifacts is grounded in a representational perspective, further work is needed to comprehend their role in distributed cognition from a performative research stance. The notion of thinking through making is ideally suited to meet this need, but little is known about the inclusion of practice-led design research approaches in studies of distributed cognition. In short, while there is ample evidence of the role of material artifacts in studies of *distributed thinking*, there is no evidence of their role in studies of *distributed thinking* conducted *through making*. For this reason, the notion of *distributed thinking through making* constitutes in itself a research area that has remained unexplored.

The gap between practice-led design research and distributed cognition theory may seem wide, but Schön's (1983) notion of *reflective practice* reveals a potential intersection between both fields. Here, I further illuminate this intersection by discussing the temporal dimension of practice. In *Cognition in the Wild*, Hutchins (1995) stresses that thought processes are distributed not only among practitioners and artifacts but also across time. He notes that practitioners undertake long-term tasks by attaining partial achievements and simultaneously acquiring the competencies needed to attain subsequent achievements (ibid., 1995, pp. 165–9). This observation shows that the accomplishment of tasks entails the diachronic accumulation of cognitive resources. Further, it indicates that beyond acquiring technical skills, practitioners develop reflective tools to improve their performance. Schön's notion of reflective practice sheds light on the temporal scope of such tools, specifying that reflection can occur concurrently (reflection-in-action) or retrospectively (reflection-on-action).

Reflection is paramount in practice-led design research. Not only does it allow practitioner-researchers to accumulate experiential knowledge (see Nimkulrat et al., 2015, pp. 5–8), but it also helps them investigate their own design practice (see Scrivener, 2002, p. 25). In this context, Mäkelä and Nimkulrat (2018) draw on Schön to propose a reflective tool termed *documentation*. As they note, documentation assists in capturing and recording the experiential aspects of design practice, rendering them accessible and explicable at later stages of the research process (ibid., p. 14). Typical forms of documentation in practice-led design research include notes, studio diaries, photographs, sketches, and prototypes. Similar to what Hutchins (1995) and Clark and Chalmers (1998) explain in their models of distributed and extended cognition, documentation is the means by which practitioner-researchers offload their thoughts onto material artifacts. It is through this means that they "reflect on [their ongoing] experiences during the process (*reflection-in-action*) and on [their] documented experiences after the entire process (*reflection-on-action*)" (Mäkelä & Nimkulrat, 2018, p. 14, emphasis in the original). In addition to illustrating the potential of material artifacts as recording devices in practice-led design research, documentation constitutes a way of *performing* design practice. Further, it is an appropriate method to reveal how the cognitive repertoire of practitioner-researchers distributes across time and gives form to itself (cf. Ingold, 2013; Redström, 2017) through the accumulation of experiential knowledge.

To sum up, distributed cognition theory and practice-led design research are not as far apart as they may seem. In this section, I have laid out a possible intersection between both fields by focusing on their shared concerns with materiality and time. First, I have compared the role that materiality plays as a representational medium in studies of distributed cognition with the role that it plays as a documentation tool in practice-led design research. Then, I have articulated the relationship between reflective practice and distributed thinking by revealing how practitioners rely on materiality to extend their cognitive repertoires and accumulate experiential knowledge over time. I have, however, remarked that the treatment of materiality in studies of distributed cognition remains limited to representational modes of inquiry. Further research is needed to comprehend the significance of handling materials in distributed cognition from the performative perspective of making.

DISCUSSION

The paper at hand set out to elucidate how practice-led design research can account for the epistemic role of making beyond the scale of individual practice. A scoping study was conducted to comprehensively review the extent of available knowledge related to this question, concentrating on relational perspectives to epistemology and ontology across various fields. By discussing these perspectives in relation to the most salient issues of practice-led design research, I identified two fields of inquiry offering important contributions to the research question. These fields were sociomateriality and distributed cognition theory.

With a focus on the notion of practice, the study identified potential overlaps between practice-led design research, sociomateriality, and distributed cognition theory. Throughout this paper, I highlighted the similarities and differences between these fields and proposed a framework to integrate them. First, I argued for the study of *practice beyond the individual*, turning to sociomateriality to reconsider the ontological dimension of practice in practice-led design research. Second, I explained how the literature used in, and coming from, practice-led design research comprises a body of *literacies of making* that reassert the locus of knowledge production in the act of making. Finally, I reviewed the theory of distributed cognition to lay out a connection between the notions of *distributed thinking* and *reflective practice*.

The differences and similarities between practice-led design research, distributed cognition theory, and sociomateriality are synthesized in Table 1. To sum up, practice-led design research has thoroughly investigated the relationship between individuals and materials by focusing on acts of making. This focus on individual-material interactions, nevertheless, has come with a tendency to downplay the importance of the social as a site of knowledge production. Distributed cognition theory and sociomateriality, in contrast, have accounted for the relationship between the social and the material, but they have not yet placed the locus of knowledge production in acts of making. Because making entails the enactment of experiential knowledge, the study thereof necessitates more than representational means of scrutiny. Therefore, the insider's perspective of the maker is crucial in studying acts of making from a performative research stance.

Overall, the study strengthens the idea that adopting a relational ontology can benefit practice-led design research. This finding is discussed throughout the paper in the light of a change of scale, specifically in the unit of analysis. By taking the notion of *thinking through making* to account for the epistemic role of design practice in practice-led design research, I have introduced the term *distributed thinking through making*

Table 1. Review synthesis

Research field / stream	**Locus of knowledge production**	**Relational perspective**	**Epistemic dimension of practice**
Practice-led design research	The individual: Knowledge emerges from the practitioner in action	Epistemological: Accounts for the interaction between the individual and the material	Thinking through making: The practitioner moves between *representational* and *performative* modalities
Distributed cognition theory	The social: Knowledge emerges from the relationship between practitioners in action	Epistemological: Accounts for the interaction between the social and the material	Distributed thinking: Thought processes between practitioners are mediated by external *representations*
Sociomateriality	The sociomaterial: Knowledge emerges from the enactment of a practice	Ontological: Accounts for the constitutive entanglement of the social and the material	Distributed making: The social and the material *perform* the practice relationally

to emphasize this change of scale. The term simultaneously articulates an unexplored research area and a framework to explore a variety of research topics related to that area. Although the present review is limited to the application of the term in practice-led design research, it signals the need to reconsider the ontological dimension of practice in other fields of inquiry dealing with the study of practices from an insider's perspective. In any case, the benefit of adopting a relational ontology in practice-led design research is that it illuminates the primacy of relationships over entities in the study of design practice. In addition to offering a means to articulate the relationship between representational and performative modes of investigation, a relational ontology in practice-led design research can reassert the locus of knowledge production in acts of making that emerge from the entanglement of the social and the material.

ACKNOWLEDGEMENTS

The research presented in this paper was supported by the Academy of Finland (Project Nº 331778).

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