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# Networks of Practices: Exploring Design Opportunities for Interconnected Practices

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**Abstract.** For over a decade, researchers from the practice-centered computing community are taking social practices as a unit of design. While the first generation focused on a social practice in isolation, more recent work argues for the (inter-)connections of mutually influencing practices as the primary unit of design. We discuss these current approaches to motivate the notion of a network of practices. Utilizing the case of food practices, we construct and analyze a network populated by the answers of 60 participants. Based on this network we suggest how to identify central elements and clusters as well as points for intervention within the overall network, but also within and in-between clusters of practices. Based on this, our work critically discusses how an understanding of practices as a network could improve practice-based research and design.

# Introduction

Beginning with the turn from workplaces towards everyday life and culture (Bødker, 2006) evermore elements of social practice theory (SPT) find application within practice-centered computing research and design (Kuutti & Bannon, 2014). Starting off with studying single practices in isolation, at least since the special issue on sustainable practices, it became clear that, "it is not appropriate [for HCI scholars] to consider a practice individually, withdrawn from any other practice" (Disalvo et al., 2008). Since then, design research used multiple practice theoretical lenses to better understand the relation of different practices and their interconnection (Kuijer et al., 2013; Kuutti & Bannon, 2014) to derive design relevant knowledge (Prost et al., 2018).

To account for the complexity of interconnected practices (Schatzki et al., 2001), several frameworks (Entwistle et al., 2015; Ganglbauer et al., 2013; Ng et al., 2015; Terpstra et al., 2005) to structure practices have been proposed. However, these frameworks are rather simplistic by only focusing on specific aspects of practices, e.g. hierarchies (Ganglbauer et al., 2013), consumer lifecycles (Ng et al., 2015), or materials (Terpstra et al., 2005). This simplicity does not capture the theoretical connection of practices (Nicolini, 2009, 2012; Shove et al., 2012), as interconnected networks forming a 'rhizome' like structure. Nor do they account for the needs of designers, e.g. Kuijer et al. (2013) state that identifying overlapping elements of practices should be considered during design. Besides the point that the knowledge about central elements and the connection of practices is valuable for designers, it is also of interest for researchers, who work on a deeper understanding of how practices emerge, persist and mutually influence each other (e.g. (Gram-Hanssen, 2011; Kemmis et al., 2013; Shove et al., 2012)).

Aiming to advance models of SPT as a common resource for discussion and exchange between social scientists and engineers, Higginson et al. (2015, 2016) operationalize Shove et al.'s (2012) theoretical ideas of overlapping elements towards a notion of practices as networks. While their paper (Higginson et al., 2015) makes first steps toward a theoretically grounded visualization method, they abandon their theoretical foundation and level of detail in later work (Higginson et al., 2016) for the sake of simplification. Still, their research does not discuss networks from a practice-centered computing perspective and as a source for designers to understand practices. Nonetheless, they (Higginson et al., 2015, 2016) prove the general applicability of network theory combined with SPT.

Motivated by a further improvement of the method towards applicability in practice-centered computing research, to derive design-related knowledge from networks of practices and to construct such network, our work presents the example of a network of food practices (FP) based on 60 written-interviews, inspired by Higginson et al.'s survey (2016). The resulting network is exemplarily examined from different perspectives to demonstrate the methodological capabilities. As the focus is clearly on the method and the operationalization of practices as a network, FP are just used a case to populate the network. The

method itself is not limited to FP only, therefore we aim to discuss rather general ideas on the usage of such method, by exploring the example of FP.
We choose FP as our domain of interest for three reasons. First, it is already acknowledged by various research in practice-based computing that FP are interconnected and, although we do not fully understand the connections, relevant FP were identified (Ganglbauer et al., 2013; Ng et al., 2015; Terpstra et al., 2005). Second, there exist multiple frameworks for FP, from hierarchies (Ganglbauer et al., 2013), to lifecycles of consumers (Ng et al., 2015) to follow the food approaches (Terpstra et al., 2005), which offer material for comparison and show the relevancy of modeling this domain. And lastly, Human-Food Interaction is an emerging field in HCI (Altarriba Bertran et al., 2019, 2018), which might benefit from early involvement of a practice lens and a nuanced understanding of practice networks.
By discussing social practices as networks from a methodological perspective our work contributes to future practice-based research and design, by (1) introducing the perspective on practices as a network to the community of practice-centered computing scholars, (2) providing new means to identify central elements, their (dynamic) relationships and interconnections, that otherwise would remain unexplored, and (3) supporting the identification of opportunities for design by the means of network theory.

# Related Work

## Social Practice Theory

Attempting to "overcome existing dualisms between actor and structure, by finding ways to give voice to human agency without neglecting structural constraints"(Entwistle et al., 2015), practice theory is neither focusing alone on micro nor macro-social phenomena, like individualistic behavior or structural order, but inquire observable effects at both levels. Quite influential contributions to SPT are the ones of Schatzki (1996) and Reckwitz (2002), who understand practices as the "routinized way in which bodies are moved, objects are handled, subjects are treated, things are described and the world is understood"(Reckwitz, 2002). In Schatzki's (1996, 2002; 2001) initial work two central notions of practice are to be found, one being a linked or organized nexus of different elements ('practice-as-entity') and the other being practice-as-performances. Both are in a recursive relationship, as the performing of doing and sayings "actualizes and sustains practices in the sense of nexuses"(Schatzki, 1996). Another central distinction that Schatzki draws is between dispersed practices and integrative practices. While dispersed practices are generic, usually tacit practices that are spread across a realm of actions (e.g. explaining, following rules or imagining) and mainly need some form of understanding, integrative practices are "the more complex practices found in and constitutive of particular domains of social life"(Schatzki, 1996).

Building upon Schatzki's work Reckwitz describes practice as the emergent level of the social, "a routinized type of behavior which consists of several elements, interconnected to one another: forms of bodily activities, forms of mental activities, 'things' and their use, a background knowledge in the form of understanding, know-how, states of emotion and motivational knowledge"(Reckwitz, 2002). Practices are defined by the existence and interconnectivity of these elements and cannot be reduced to any particular one of them. According to that, Reckwitz describes practices as a "block" or "a pattern which can be filled out by a multitude of single and often unique actions"(2002).
Shove and Pantzar draw upon Schatzki's and Reckwitz' formulations to develop a framework for empirical research (2005). In current research on SPT, the composition of practices from different elements is largely adopted, even though different authors introduce different key elements (Gram-Hanssen, 2011). Shove and Pantzar "work with the notion that practices involve the active integration of materials, meanings and forms of competence" (2005), which are interdependently related and equally connected. Shove et al. investigate the connections between these key elements and how these connections allow a practice to emerge, subsist, shift and vanish. The three components are described broadly so that different key features can be subsumed. 'Materials' include "encompassing objects, infrastructures, tools, hardware and the body itself"(Shove et al., 2012). 'Meaning' has been condensed from what Reckwitz has called mental activities, emotion, and motivational knowledge. For 'competences' several forms of understanding and practical knowledgeability have been summarized. Shove et al. (2012) distinguish between *practices, proto-practices,* and *ex-practices*. *Practices* are the well-established and unconsciously performed routines. *Proto-practices* are practices that are yet not incorporated by the person because relevant elements are not yet existing or are not yet linked. In contrast, *ex-practices* are practices that have been abandoned because of the breaking of one of the linkages (Shove et al., 2012).
However, there is still an ongoing debate about which key elements constitute a practice and how a practice is related to other practices via key elements resp. how the nexus between practice-as-performance and practice-as-entity can be described (Gram-Hanssen, 2011; Hui et al., 2016b; Kemmis et al., 2013). Blue and Spurling call for a theory of social practices that includes the "relationships between connections (interconnections)"(2016). They argue that although different descriptions of multi-practice compositions (like bundles, complexes, constellations, and systems) "are useful for understanding how one practice is connected to another, they are of less value in helping us understand relationships between the connections that hold practices together."(Blue & Spurling, 2016). For Warde, it is questionable what exactly can be determined in their examination as a constitutive part and where the boundaries of an integrative practice are drawn (2015). Harvey et. al. conclude that the answer lies in the form and focus of the research question being addressed. In studies of practices-as-performances researches narrowly determine practices, while practices-as-entities are investigated within loose, expansive boundaries of a certain bundle of activities to identify common elements that link practices (Harvey et al., 2012).

## Interconnected Practices as a Unit of Design

Since Shove et al. first launched their manifest of practice-oriented design (2006), several researchers (Kuijer et al., 2013; Kuijer & De Jong, 2012; Scott et al., 2009; Wakkary et al., 2008) have used their framework as a basis for their design. In contrast to the understanding of product- or user-oriented design, Shove et al. (2007) highlight the importance of practices as the unit of analysis and the designability of the evolution of practices over space and time. Within these attempts, similar questions of central elements and (inter-)connected practices arise, not from a theoretical stance, but about the efficacy of interventions and a more integrated view on change.
Kuijer et al. (2013) suggest to deliberately introduce unfamiliar elements, e.g. 'Trigger-Products' that can cause what Reckwitz calls a "crises of routine" (2002). However, acknowledging that change in practice(s) is not a matter of technological transformation alone, they stress the connectedness of the investigated practice (Schatzki et al., 2001): *"Ideas of cleanliness or perceptions of the body for example, are not elements of bathing alone. Reconfiguration of bathing may require reconfiguration of a wide range of related practices."* (Kuijer et al., 2013). Although there is a theoretical debate about the key elements of practices and their connection, and well-known work in the practice-centered computing community, such as Shove et al. (2006) who already account for such relations of practices resp. their elements as well as the need to "identify[…] points for intervention", still there is need to work on the methodological means to identify these elements as well as their relations and interconnections. Similarly, Kuutti and Bannon (2014) call for a more holistic approach to practice(s), that does not focus on single aspects only, but rather tries to better understand the role of single elements resp. "computer artifacts in the emergence and transformation of practice"(Kuutti & Bannon, 2014, p. 8).

> *"Designing interventions requires a consideration of the complex nexus of interconnected practices (dispersed and integrated) that define food practices" (Ganglbauer et al., 2013).*

Considering the interconnectedness of practices is especially important for our example of FP, as e.g. Ganglbauer et al. (2013) suggest. To understand and structure the complex entanglements of FP, several constitutional concepts have been suggested:

### Linear & Cyclic Structure

Some authors follow a kind of follow-the-actor (Latour & LaTour, 2005) approach, where the actor is not the human consumer, but the non-human, consumed food (Ng et al., 2015; Terpstra et al., 2005). Tracing the various FP has led to linear (Terpstra et al., 2005) and cyclic (Ng et al., 2015) models resp. Terpstra et al. use a linear model that "shows […] the route followed by food after its purchase by the customer" (2005). Such an approach proves to be beneficial to identify critical moments within FP (Terpstra et al., 2005), but it excludes different perspectives on practices, by focusing solely on the handling of food.

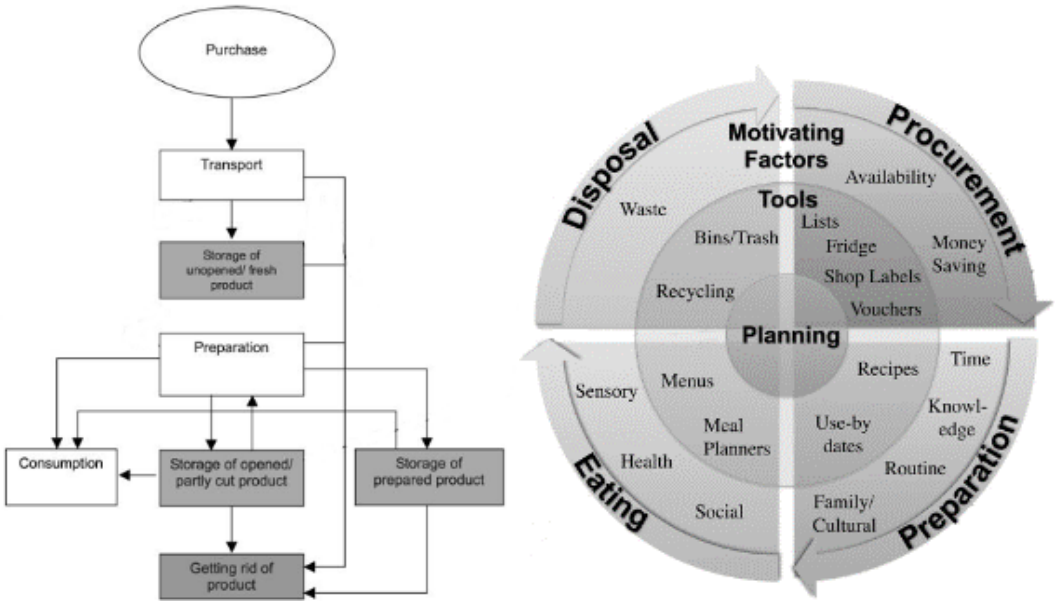


**Figure 1 a) Linear (Terpstra et al., 2005) and b) Cyclic Model (Ng et al., 2015)**

While their approach draws upon the relationship of practices as chronologically organized, they do not account for the key elements of a practice. Still using a following-the-actor approach, the food consumption lifecycle by Ng et al. (2015) already accounts for different entry points and the repetitive nature of food consumption (see Figure 1*b).* The incorporation of motivational factors in FPs, as well as the utilization of tools within different practices, are an advantage of their model. Besides, the model suggests that planning is the underlying central practice governing all FP: from procurement to disposal. This implies an individual agency making rational decisions and thereby neglects a fundamental notion of SPT, namely that an individual merely acts as the carrier of a practice (see (Reckwitz, 2003; Schatzki, 1996)). Such a view is insufficient because it considers food waste as a planned behavior, rather than an unintended result of interconnected practices (Ganglbauer et al., 2013).

Dispersed & Integrative Practices

Besides linear and cyclic approaches, Warde (2005) and Ganglbauer (2013) use the notion of dispersed and integrative practices, which suggest a hierarchical, tree-like structure of top- and sub-practices. Although they do not visualize their structure, their attempt aims to identify hidden interrelations and the inner logic of FP as a complex bundle. According to Ganglbauer et. al. integrative practices in the food domain are, e.g. “cooking practices and eating practices, where the embodied actions of the cook or the dinner are often habitual, informed by histories and cultures of performance, but also adapted to an unfolding social and environmental context” (2013). For Warde (2005) consumption cannot be considered an integrative practice but is rather a dispersed practice that is required and entailed in most integrative practices. Ganglbauer et. al. (2013) argue that food disposal, as non-consumption, is a dispersed practice as well. It is not by chance that Ganglbauer et. al. (2013) do not apply a follow-the-good-as-the-actor methodology, but use open-ended interviews to make use of people’s

competences to express relations among practices and to integrate experiences as well as to rank them into hierarchical order.

## Excursus: Network Theory

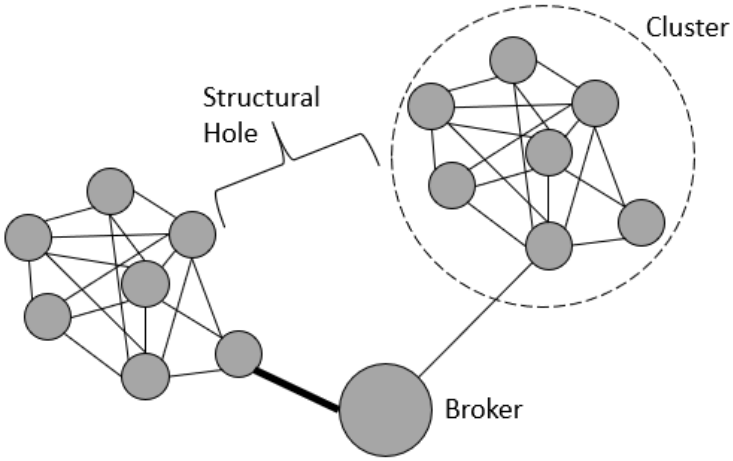


**Figure 2 Simple Example Network**

Before our work continues with an explanation of how SPT and network theory relate, we briefly want to give a short introduction on basic terms from network theory based on the work of Burt (2009) and Butts (2008). Figure 2 shows a simplification of a network. The grey circles are nodes, which represent entities in the network. Nodes are connected by edges, that have a varying thickness, which displays their degree of importance. The thicker they are, the more important and vice versa. When several nodes are closely interlinked with each other by edges they form a cluster. In our example network, the two clusters are connected by a node called broker, which creates a kind of bottleneck between both clusters. In this case, we can suggest that the broker has a high centrality, meaning a short average distance to all other nodes. Nodes have a 'degree', which describes the amount of edges connected to the node. For the limited connection between clusters, network theory refers to structural holes (Burt, 2009), where only little exchange between clusters resp. their elements exist.

## Social Practices as a Network

Addressing the downsides of current modeling approaches on SPT, researchers (Bellotti & Mora, 2014; Higginson et al., 2015, 2016; Lawo et al., 2019) suggest a new method: The conjunction of network theory and SPT. Motivated by a deeper understanding of practices as well as the creation of models to improve the communication between engineers and sociologists (Higginson et al., 2015, 2016), a further discussion and refinement of their work might contain solutions for questions arising from practice-based design.

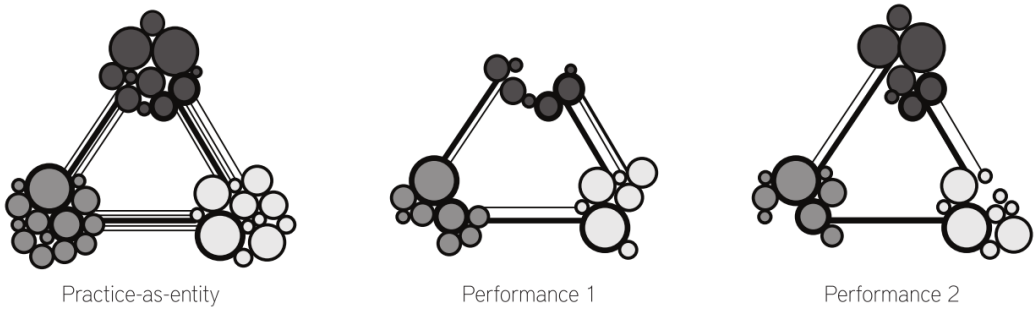


**Figure 3 Adapted Practice Model by Kuijer (2014)**

Shove et al. (2012) explore elements shared by different practices. Based on the example of driving and repairing they illustrate how masculinity is a shared element of meaning between both practices. While this perspective exemplifies the details of connections a more 'zoomed-out' perspective promises to see a network of practices forming an interconnected nexus (Shove et al., 2012). This perspective is also shared by Nicolini (Nicolini, 2009, 2012), who describes practices a forming rhizome like network structure, that is formed by connected elements, such a computer that is shared by the practice of manufacturing and using computers.

Slightly adapting the model of Shove et al. Kuijer (2014) visualizes variants of practices-as-performances, that built a partial "manifestation" of the practice-as-entity. The practice-as-performance is constituted by a sub-set of elements and therefore links connecting them. Kuijer draws upon the importance of certain links, by increasing their line strength. Strength reflects the importance of a link, whereby it is stronger when the connection is observable within more performances. Similarly, the size of the bubble represents the importance of a certain element (Kuijer, 2014).

Higginson et al. (2015) propose a different layout of the graph since the clustering of elements of the same type implies a certain proximity which does not necessarily exist. In their layout, the type of the element, either material, meaning or competence is given by color instead of position. To further increase the information gain by the means of visualization Higginson et al. suggest drawing the node size, based on its node degree (2015).

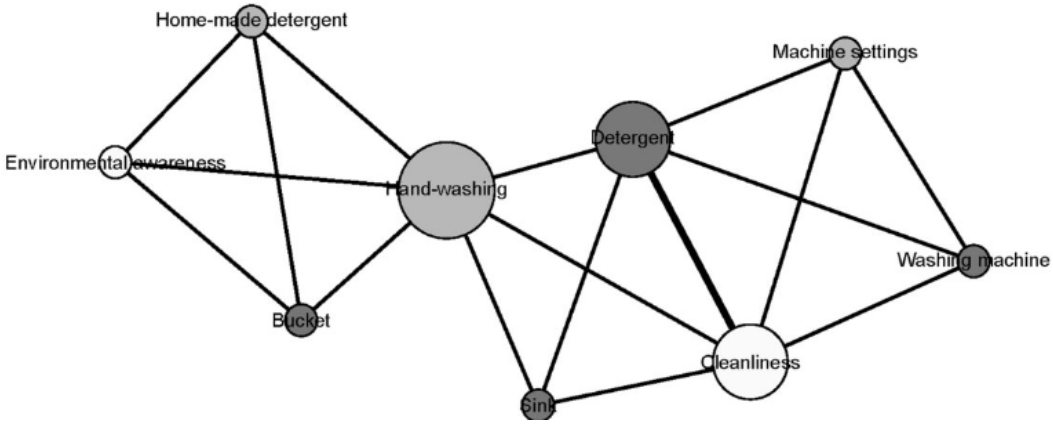


**Figure 4 Example of Laundry Practices as a Network (Higginson et al., 2015)**

In their first work Higginson et al. (2015) construct a network of a practice to identify central elements shared by the practice of doing laundry. The here investigated perspective very much refers to ‘zooming in’ as described by Nicolini (2009). Still, the comparison of different practices belongs to ‘zooming out’ for her. She ‘metaphorically’ highlights the importance of studying practices in detail, by recognizing the interaction of humans with artefacts, materials, and other humans. From this perspective, the ‘rhizomatic nature’ of practices is quite similar to Shove et al. (Shove et al., 2012). Still, shove goes a step forward in distinguishing between elements that constitute parts of the rhizome and how they have to be connected universally.
In further research on commuting as a practice, Higginson et al. (2016) take up on Shove et al.’s (2012) suggestion to ‘zoom out’, but abandon their theoretically founded ‘universal connection’ phenomenon, that implies that all elements of a practice are equally connected in constituting the nexus. Higginson et. al. (2016) move towards a follow-the-actor approach by chronologically connecting practices, that does not reveal hidden (inter-)connections of the nexus. However, despite these criticisms, their work provides the fundamental considerations to construct a network of practices. Therefore, there work more resembles the ‘zooming out by following intermediaries’ as described by Nicolini (Nicolini, 2009), that implies a stronger spatio-temporal dimension to the antecedents of practices, rather than a universal zooming out on shared elements as Shove et al. suppose (Shove et al., 2012).
In summary, we see how not different scholars attempt to operationalize the theoretical perspective on interconnected practices as network by mainly referring to Shove et al. (2012). Although there are differences in the meanings of what zooming in and out is about, we think that, in addition, to continuing to follow the path of Shove et al. (2012), the work of Nicolini (2009) is valuable to consider for a more nuanced understanding of perspectives.
Based on this inspirational corpus of ideas, our work tries to improve the method, adapt it towards applicability practice-centered computing and trigger design-related discussions.

# Constructing a Network of Food Practices

## Qualitative Online Survey

To construct a network of FP, we conducted an online-survey, similar to the survey of Higginson et al. (2016). We decided to follow the approach of Higginson et al. (2016) in conducting a survey, as this paper mainly focuses on the operationalization of practices as a network and as the method has shown to be fruitful in their research. Still, especially in the light of ethnographic research (Ganglbauer et al., 2013; Ng et al., 2015; Nicolini, 2009), we believe that it is necessary to consider other, probably more detailed methods in the future. Therefore, we discuss the choice of methods in more detail in the discussion section.

The survey of Higginson et al. (2016) was adapted to be more online and user friendly. We randomly assigned each participant to questions either about planning, procurement, storage, preparation, eating or disposal, which are most commonly used to structure FP (Altarriba Bertran et al., 2018, 2019; Ganglbauer et al., 2013; Ng et al., 2015; Terpstra et al., 2005). The questions encouraged the participants to describe the competences they use, the material context of the practice as well as the meaning of the practice. In total we asked 9 questions per practice, with 3 questions per elements category, either material, meaning or competence. For the example of cooking the questions were: "which tools / aids do you use for cooking?", "which techniques and skills do you use for cooking?" and "which (social, religious or self-defined) rules and norms influence your cooking?".
Our sample of 60 participants (10 per practice) has been recruited through an opportunistic sampling approach within the authors extended social network, to capture a variety of practices. We directly asked practitioners in our social media to participate. The resulting sample is characterized by the following socio-demographic structure:

- Age (18 – 80, Avg. 40, Std. 18.39)
- Gender (37 female and 23 male)
- Education (29 university degree, 5 trade school, 11 apprenticeship, and 15 high-school)
- Housing Situation (18 with a partner, 1 alone with children, 19 alone, 12 partner and children and 10 flat-sharing community)

The qualitative survey data were transcribed and analyzed[1] with Catma[2]. We used the practice-theoretical lens of material, competence, and meaning (Shove et al., 2012; Shove & Pantzar, 2005) to mark the elements for our later network within the given answers. After each iteration of coding, we discussed the current coding template (King et al., 2004) to ensure reliability.

## Network Construction

Analogous to the first attempt of Higginson et al. (2015) we treated the occurrence of each element within the coding of the individual survey result as equally important for the constitution of a practice. We followed this perspective as it is grounded on the perspective of Shove et al. (2012). Following the work of Kuijer (2014), we weighted the importance of connections and elements based on their number of occurrences in the complete survey. To further explain our operationalization, we imagine the following example: A single practitioner answers that s/he for cooking uses a pan (material), his/her cooking skills (competence), and follows the meaning of health.

[1] The elements identified in the interviews were translated from German to English. The coding was done by a native speaker based on the German original survey answers.

[2] https://catma.de/

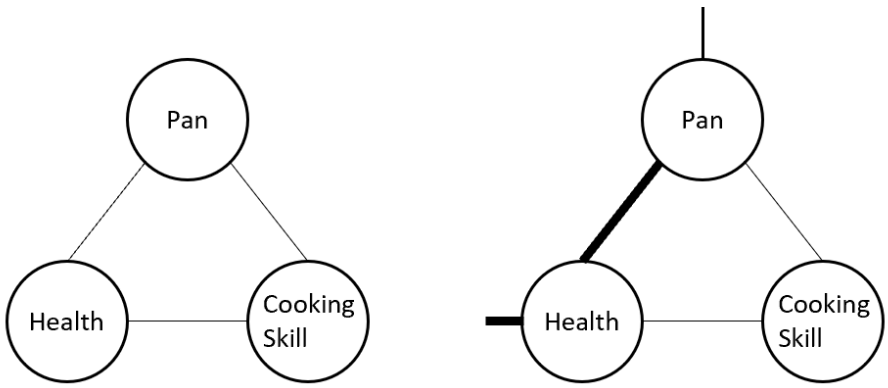


**Figure 5 (Left) Example Network for One Practitioner; (Right) Same Example Network for Multiple Practitioners**

As Figure 5 (left) shows for this single practitioner all elements are equally connected with no specific weight for the edges. If we now add answers of other practitioners, that among other elements, name the pan and health, the weight is adjusted to highlight the importance of specific connection (see Figure 5 (right)).
Analyzing our survey results, we filled out a matrix (159 elements on the x-axis and the 60 participants on the y-axis) with an one (if an element is mentioned) or a zero (if not). With the help of a Python script, we imported the results in Gephi[3], an open-source graph exploration software. This resulted in a Graph of 159 nodes (89 materials, 41 meanings, and 29 competences) with 2759 edges (weight between 22 and 1).
In line with Higginson et al. (2015) we ranked the size of each node according to its degree and then applied the force atlas 2 layout, to pull highly connected elements into the center of our network and form clusters of highly interwoven elements. However, we choose a different measure of distance, which addresses the original criticism of Higginson et. al. (2015) concerning Kuijers (2014) approach, that the three key elements of practice are resp. not necessarily strongly tied to themselves. While Higginson et. al. (2015) solve this issue by rearranging the network with the help of a force atlas algorithm, we additionally distinguish between the elements by color, according to the respective practice that has been inquired. To distinguish between the key elements, we use ‘M’ to tag meaning, ‘S’ for material and ‘C’ for competence in brackets behind the name, e.g. Food (S).

# Food Practices as a Network

Examining networks of practice with a theoretical focal point in mind and visualized by the means of network theory, we will interpret and discuss certain perspectives on the network of FP to define methodological capabilities and raise questions for further research.

[3] https://gephi.org/

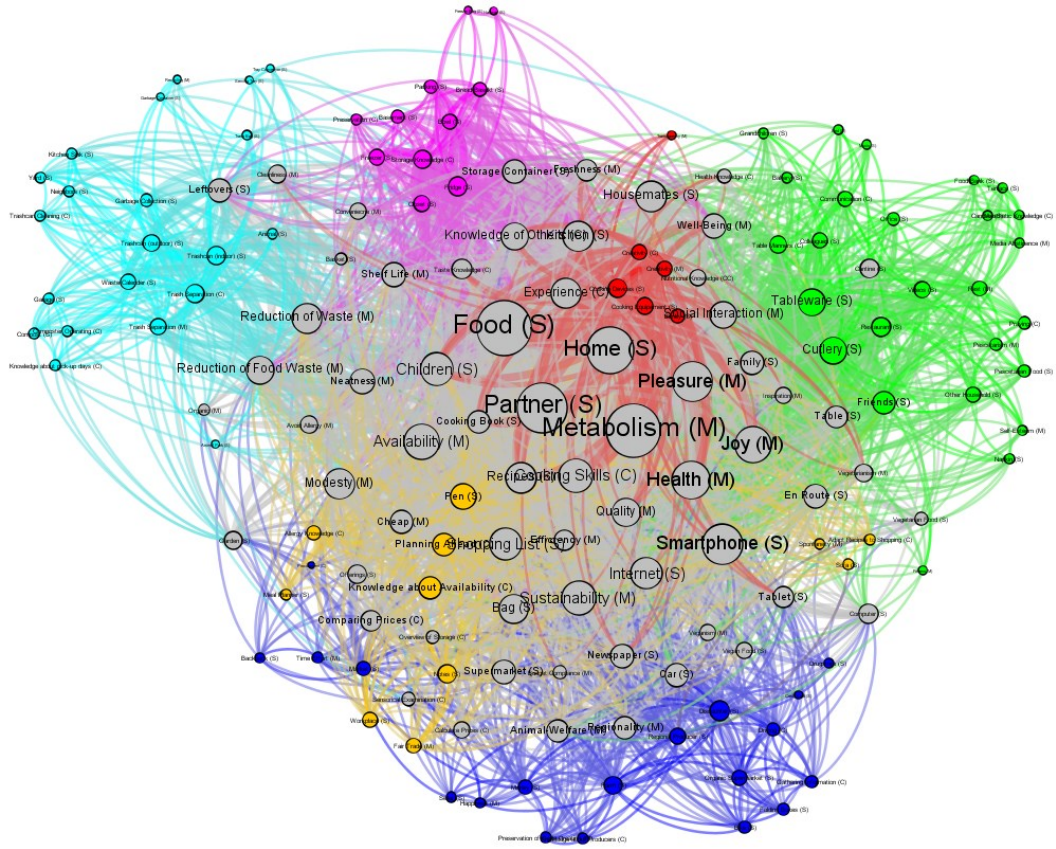


**Figure 6 Network of Food Practices (Cyan=Disposal, Purple = Storage, Yellow = Planning, Blue = Procurement, Green = Eating, Red = Cooking, Grey = Multiple Practices)**

## Zooming Out

When 'zooming out' we are able to first identify the overall arrangement of practices, by analyzing the clusters (practices) separated by their respective color and second the central elements of the overall network. While we mainly follow the perspective of Shove et al. (2012) when zooming-out as means to see the relation of practices, still, this is similar to what Nicolini describes as "Zooming out by following the relationships among practices" (Nicolini, 2009).
In Figure 6the elements are colored according to the practice, that they constitute. When an element constitutes multiple practices, we colored it grey.

### Arrangement of Clusters within the Network

When observing the network of practices from a 'zoomed out' perspective, we first see how practices, given by their clusters of elements, are separated and visualized by color as a measure of distance. The practices all include several elements that are colored by their unique given color and therefore are essential to this practice only, while other elements (grey) are constitutive for several practices. With a further look at the overall arrangement of practices within the network, we can see that practices of eating (green), procurement (blue), planning (yellow) and storage (purple) group themselves around the practice of cooking

(red). Besides the red elements of the cooking practice, a cluster of shared elements, strongly connected to cooking, as visualized by the edges, is located in the center. Those elements, such as *Food (S)*, *Partner (S)*, *Metabolism (M)* or *Home (S)* are shared by several practices. These elements are represented with the biggest nodes, based on the frequency of being mentioned. Therefore, they can be seen as central to the overall network of FP. The constitutive elements of the practice of disposal are connected to the practices of planning and storage, but in general not central within the overall network of FP.

Central Elements – Central Clusters

Besides the whole cluster of elements of disposal practice, single elements of other practices are placed in the peripheral area around their respective practice. Higginson et al. (2015) state within their reflection on core and peripheral elements, that "[c]entral elements are defined as 'core' to the practice; those which appear at least once in each variant and are shared by all variants. Marginal elements are 'peripheral'; they are herein defined as those elements which are unique to a single variant. Elements that do not fall into either the 'core' or 'peripheral' groups logically form a third group, which is referred to as 'intermediary'. These elements are shared by some, but not all, variants."(Higginson et al., 2015). At this point we want to extend the corpus of analytical lenses on the network of practice, by defining central and peripheral clusters. We define central clusters as those, being 'core' to a network of practices, resp. those contributing to the overall doing of the practices. Peripheral clusters are similarly not important for the network of observed practices, in a way that the incorporated doing of several (inter-)connected practices might be possible without this specific practice (depicted as a peripheral cluster).
After describing the overall structure of the network and how clusters are arranged, as well as defining the ideas of central and peripheral clusters resp. practices, we now want to have a further look on those central grey elements, having a high node degree. While *Food (S)* as a central element is quite an expected result, as already mentioned by follow-the-actor approaches (Ng et al., 2015; Terpstra et al., 2005), other elements such as *Metabolism (M)*, have not been mentioned in attempts to structure FP. Especially when utilizing the lens of dispersed and integrative practices (Ganglbauer et al., 2013; Warde, 2005) to interpret the importance of the cluster constituted by the central 'meaning'-elements *Metabolism (M)*, *Joy (M)*, *Health (M)* and *Pleasure (M)*, we see the notion of consumption as a dispersed practice. Thereby consumption is not constituted by any competences, at least no competences mentioned by our participants, but the food as the material to be consumed and several meanings that are attributed to the (prospectively) consumed material by the participants.

## Zooming In-Between

When zooming in but remaining on a perspective on the whole network of practices, to which we refer as 'zooming in-between', we are able to identify elements that connect practices and therefore function as intermediaries. This

zooming on intermediaries originates from Nicolini (2009) but is used in a more immediate sense rather than overtime in our work.

Elements and their Connections

From a practice-centered computing perspective, the central role of the smartphone is interesting to see (*Figure 6*). To follow the links of the *Smartphone (S)* we colored the smartphone red and its adjacent nodes pink. Other elements are dark grey. This, on the one hand, shows how many direct neighbors the smartphone has, and on the other hand how it is linked to nearly the entire network. The smartphone being centered between the practices of cooking, eating, procuring and planning, shows how digital technologies integrate whole parts of FP, by e.g. allowing to write a shopping list on the smartphone, using it whilst shopping, searching recipes on the smartphone or even using them as a starting point for planning and finally watching videos during mealtime or sharing photos of food with others.

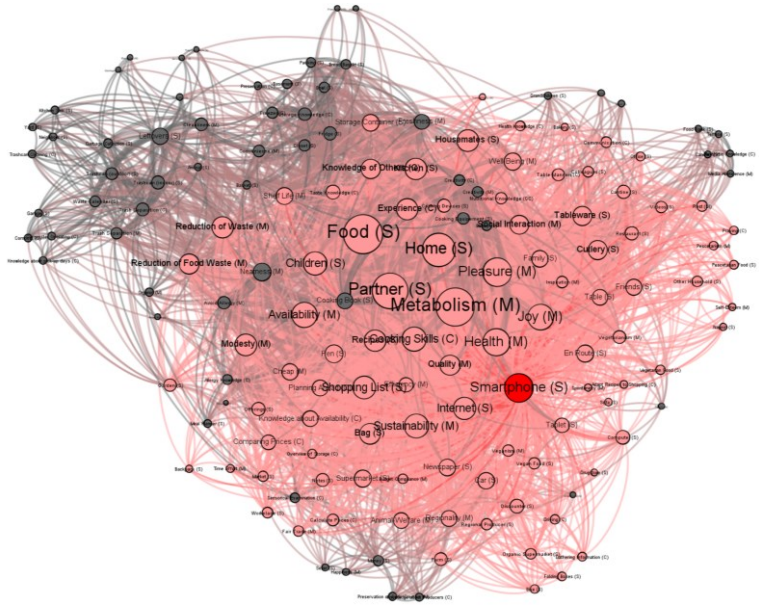


**Figure 7 Smartphone Connecting Practices**

Apart from that, we see how the smartphone is not central for practices of storage and disposal yet. These practices remain excluded from data exchange, at least from a digitally mediated data exchange, through the use of smartphones.

Practices and their Connection.

When having a look at the overall arrangement of practices, the question of *why disposal is not equally connected to the highly connected cluster of cooking resp. to the rest of the network* arises. To answer this question, we 'zoom in-between'. By doing so we are able to reveal the links between disposal and the other practices in detail. To do so, elements only belonging to disposal are colored in light blue, elements shared with another practice are colored according to the practice (purple = storage; blue = procurement; green = eating; dark grey = multiple practices).

Although disposal practice is in general only loosely connected to the main cluster, its elements are linked to some of the central elements of FP, e.g. the food itself, the kitchen and residents of the household. Those connections are quite expected, due to shared household activities and the food, being the material that is thrown away. Similar to the element *Kitchen (S)*, eating is connected to disposal due to the *Cantina (S)* as a shared location of eating and throwing away food.

Besides those obvious links, is the linkage between two thematic clusters worth having a look at. First the cluster of '(Food) Waste Reduction', constituted by elements such as *Reduction of Waste (M)*, *Reduction of Food Waste (M)*, *Sustainability (M)*, *Modesty (M)* and *Neatness (M*); and second the cluster of 'Unspecific Food Competences', constituted by elements such as *Experience (C)*, *Taste Knowledge (C)* and *Knowledge Taught By Others (C)*. Those links show how disposal is, in the mind of the participants, not meant to be a part of FP, but a practice whose performance has to be minimized. However, the competences, besides *Taste Knowledge (C)*, do not indicate a clear strategy, despite the trust in one's own experience. *Taste Knowledge (C)* as a competence describes the knowledge about one's own as well as flavor and ingredient preferences of others. This seems to be a method of ensuring the procurement and cooking of meals that are not in danger of being thrown away caused by the mismatch of preferences and characteristic flavors. Interestingly participants mentioned other skills belonging to disposal, such as the cleaning of the trash can, the knowledge about the pick-up days and the operation of a composter. While the first two and the meaning of *Cleanness (M)* indicate a strong connection between disposal and other cleanness-related practices, e.g. laundry practice identified by Higginson et al. (Higginson et al., 2015), the operation of the composter indicates a connection to gardening.

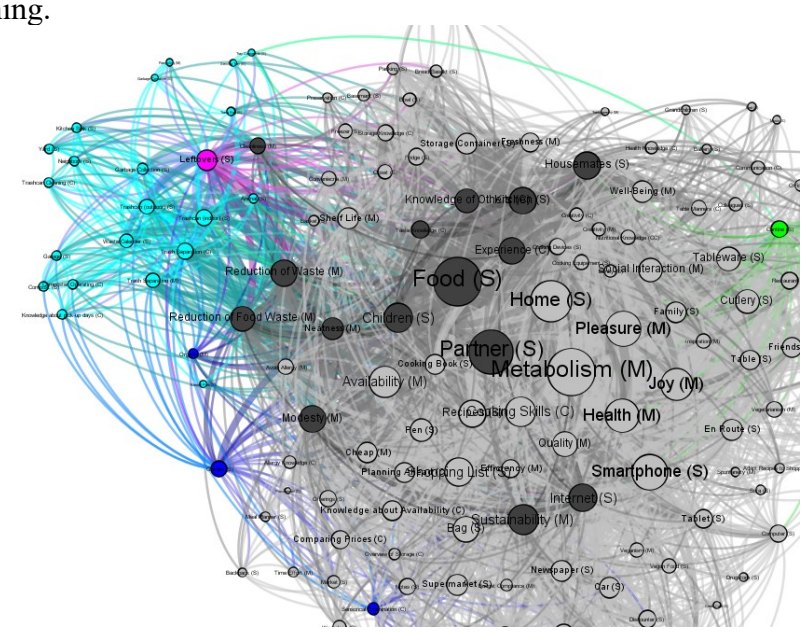


**Figure 8 Zooming In-Between Disposal**

Having a look at the links towards procurement (blue elements) the connection to gardening becomes more obvious. Especially the meaning of *Organic Food (M)*

as well as the *Garden (S)* as a place to procure food, show how disposal might be connected to the overall cluster in the sense of a lifecycle. However, gardening to grow one's own food is not a common practice (Church et al., 2015). Therefore, this connection is not strongly tying disposal to procurement. Besides *Gardening (C)*, procurement and disposal share the competence of *Sensorial Examination (C)*. Food is examined according to certain sensorial characteristics when being bought, but also when the decision of whether to keep or dispose of food or leftovers. Besides the dark grey elements, *Leftovers (S)* as an element shared with the practice of storing food, has the highest degree (node size). This element indicates the change of perception on the food, so it becomes another material: The food which was previously integer becomes a leftover because it was once prepared and meant for eating or was partly not needed during food preparation.

## Zooming In

When 'zooming out' we were able to recognize the central position of the cluster of elements of cooking practice. To further understand its centrality, we should 'zoom in' this cluster of practice itself to have a more detailed look. To observe a specific practice, we have chosen a coloring that fade out elements not belonging to the practice, as well as gradually coloring those elements constituting the practice according to their centrality for the practice itself (see Figure 9). This helps visualizing central elements of the overall network, based on the size of the nodes, as well as the centrality of the elements for the practice itself, based on the gradual coloring. While elements central to the overall cluster, such as *Food (S)*, *Home (S)*, *Metabolism (M)* or *Partner (S)*, are of minor interest here. Nodes, such as *Cooking Skills (C)*, *Recipes (S)* and *Cooking Devices (S)*, as well as *Cooking Equipment (S)* are more interesting. Based on the coloring we can see how *Cooking Skills (C), Cooking Devices (S)* and *Cooking Equipment (S)* (small Nodes above Home) are equally colored, which means, that they are equally central for the practice of cooking, but their node size is different, which means, that they are of different importance to the overall network.
Furthermore 'zooming in' shows how *Cooking Books (S)* and *Recipes (S)*, which are less central to cooking, based on our network, are central to the network of food practices. Examining their connections suggests how the knowledge about cooking, either informal or as a formalized recipe, is used during planning and procurement practices.

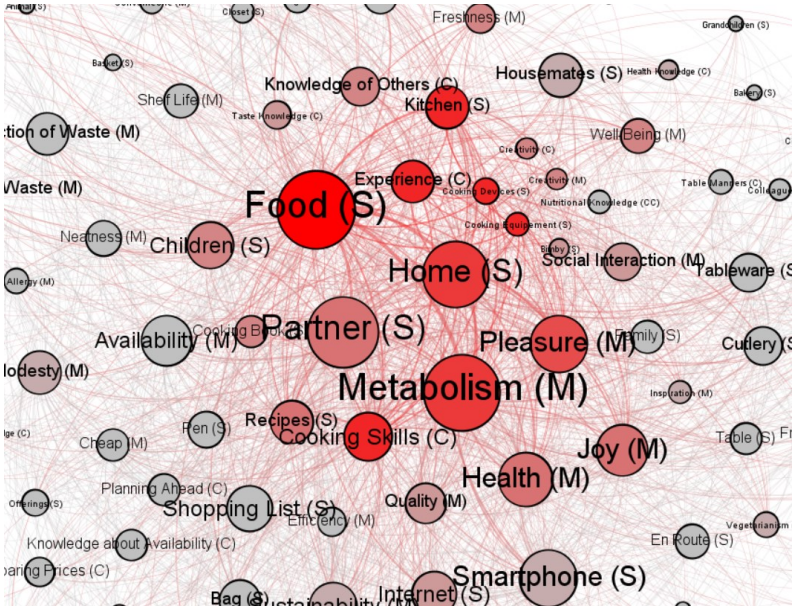


**Figure 9 Zooming In Cooking**

# Discussion & Critical Reflection

## Informing Design through Networks of Practices

Our example of FP as a network as well as Higginson et al.'s (2015, 2016) work present the analytical capabilities of the approach to visualize practices using network theory. However, still, there is a need for discussion about how the method enhances our understanding of practices and what kind of implications resp. incentives it provides for design. We argue that networks of practices provide the means to identify opportunities for intervention as well as new methods to evaluate design, both through the visualization of static and dynamic networks of practices.

### Identifying Opportunities for Intervention

Our example network indicates two different opportunities for intervention: first, the identification of, what network theory calls 'structural holes' (Burt, 2009; Butts, 2008) and second the identification of elements that are central to the overall network, meaning that they are connected to several other elements and practices.

Regarding *structural holes,* the food network reveals that there is a hole between the practice of procurement and the practice of disposal. While our network already indicates possible connections through *Gardening (C)*, the practice of growing one's own food is not widespread anymore (Church et al., 2015). The identification of such a structural hole might provide opportunities for intervention, e.g. the (re-)introduction of a practice to fill the hole and tie practices together more strongly or implementation of other mechanisms or

technologies to connect the elements of the practices through a, for the lack of a better word, broker-technology. 'Brokerage' (Butts, 2008) indicates the role of a certain node as a connector of different clusters. In our example, such broker-technology might e.g. connect a competence of the procurement practice, such as *Sensorial Examination (C)* to disposal practice, so that food is more commonly examined by the status quo of edibility and not by the narrow definitions of food regulations, e.g. the best-before date. Identifying opportunities for such brokerage might be especially valuable for technology probes (Ganglbauer et al., 2015; Hutchinson et al., 2003). They could act as a means to fill the gaps and explore opportunities for a (re-)connection. While traditionally, probes focused on reflection on and changing of practices, brokerage in this sense offers a new opportunity for restructuring and recombining whole networks of practices.

In order to facilitate digital support for practices, practice-centered computing researchers can find the means to widen the field of investigation in an network-theoretical approach to everyday (food) practices especially by investigating digital artifacts (the smartphone) with regard to connected elements (competences, meanings and other materials), the connections to different practices, its comparable importance to a particular cluster and the overall network, and the relationship of these connections (interconnections). Thereby practice-centered computing research can evaluate how a design intervention can influence other elements, practices resp. their nexuses, and in particular how storage and disposal can be included in the development of integrative systems to support FP.

Regarding *central elements and clusters,* our network shows how central and widespread certain elements are. For example, the *Smartphone (S)* is connected to several practices of the FP network, expected storage and disposal practices. Similarly, *Cooking Skills (C)* (formal or informal), as well as the cooking practice itself, are central to the network. The identification of such elements for intervention is quite alike to what Shove et al. call "points for intervention" (2006). These points might enable change within a network of practices, reaching more than one practice alone, but several connected practices. Within our example, an intervention focusing on the central role of *Cooking Skills (C)* might influence other practices next to cooking practice. Being able to cook healthier might for example lead to more healthy procurement practices. Likewise, the whole cooking practice might bring change to FP as a whole when being influenced by an intervention. However, our work provides no answer on how a change in a central practice effects the nexus of other practices.

A network of practices overcomes the focus on a particular practice (or its central element), towards "an emphasis on the interdependencies, connections and configurations that are central to the constitution, reproduction and transformation of social life"(Blue & Spurling, 2016). In this way, design interventions can be examined for their effects on other practices or their nexuses. Before interventions are initiated, they can be diagrammed in different network graphs representing the distinct nexuses of practices based on different intended interventions. Furthermore, the current stage of interventions, somewhere between proto-practice and practice can be analyzed. By these means, researchers and designers can discuss and evaluate design decisions.

Networks of practices can support practice-centered computing research in the development of design interventions and decisions by giving it access to previously unexposed information, in particular, to illustrate interconnections. We were able to show that a 'zooming in' is possible in the form of representing a practice within a nexus by visualizing both, the relevance of a central element for the practice and the nexus. In the ‘zooming in-between’ the different connections to a central element or a cluster of a practice, in our example, the smartphone or food disposal were presented. Likewise, in ‘zooming out‘ the connection between clusters of practices become investigable. In the study of these different forms of connections, the understanding of the relationship between connections (interconnections) can be extended.
As Kuijer et al.(2013) already suggest, central elements are not a ‘magic bullet’. They bear the danger of making interventions more difficult and complex due to the need for a reconfiguration of other practices as well. In line with their considerations, networks of practices help to identify the interconnectedness of these elements and therefore raises the awareness about how difficult and complex a certain change might be as well as which practices and other elements an intervention should consider, too.

### Evaluation through the Dynamics of Practice Networks

Both network theory and SPT are not only interested in static representations but challenge the understanding of dynamics. This is especially interesting to understand how complexes (of practices) change (Shove et al., 2012) and how spatio-temporal patterns arise (Nicolini, 2009). While network evolution supports the approach of Shove et al. in an analogous way, processes might be applicable for observing certain elements or clusters as they move through a network of practices. Processes are comparable to the notion of ‘threading through’ which is a term in an open discussion within the social sciences in order to find a theoretical framework for how “an object or a practice, can move or advance through the nexus of practices, thereby linking the practices through which they pass or to which they are connected”(Hui et al., 2016a). For the practice-centered computing community, these approaches promise to give valuable insights into the course of hardware, technical devices, and other artifacts through daily usage. An exploration and elaboration of such dynamic diagramming of networks of practices is open to future work.
While some short-term interventions allow measuring certain key-values, such as the amount of food discarded (Altarriba et al., 2017; Farr-Wharton et al., 2014, 2012; Ganglbauer et al., 2015) or the amount of organic food purchased (Zapico et al., 2016), sustainable, long term practice change, especially when it is still in a phase of transition, requires other means for evaluation. Networks of practices allow for such evaluation of interventions, concerning the dynamic of social practices (2012). Although our work did not capture two or more different networks of FP in terms of time, that could be compared, the example of the smartphone indicates how appropriation and access of an intervention could be analyzed. Comparing a depiction of a network of food practices, captured before the invention of the smartphone, could reveal how such a widespread technology might have influenced and changed the interconnected FP. Further research could

draw from our results by looking into the influence and change in certain clusters of practices and the rearrangement of connections between certain elements.
However, as we have seen in our example, the smartphone is central, but not reaching disposal and storage practices so far. Comparing our network with another empirically captured network after a smartphone-based intervention, that focuses on storage practice, might help to understand how the practice has changed with respect to its elements and their connections. Additionally, side-effects on other practices and the overall network, as well as barriers for appropriation, can be analyzed. Having such a measure at hand might, therefore, support more sophisticated and integrated evaluations of design.

## Gathering Data & Constructing Networks of Practices

Lastly, our work wants to critically reflect on the method of creating a network of practices from different perspectives.

### Avoiding the Trap of Oversimplification

Although our research, so far, presents the opportunities of this new approach from quite an optimistic point of view, networks of practices similar to any other modeling of social life may be too condensed. Any trivial representation of a nexus runs the risk of undermining the complexity of elements and their connections if these connections themselves are just another element. Schatzki debates practices cannot be modeled or simulated without jeopardizing the irreducible complexity and dynamism of social affairs (Schatzki, 2012). Shove et al. (2012) already considered the danger of their model falling "prey to the scientific urge to build simplifying, diagrammatic models of social life"(Schatzki, 2002, p. 12). Also, Higginson et. al. bring into the debate, if the approach of diagramming social practices into one graph can fall into the "trap of reducing the insights of SPT so significantly as to undermine their contribution"(2016, p. 16). However, the possibility of that trap should not prevent us from researching new means to make SPT more accessible for empirical research agendas and thereby scaling up its impact on design. Shove et al. (2012) argue similarly, when they state that their approach helps them to gain insights into the conceptualization of stability and change as well as into the recursive relation of practice-as-performance and practice-as-entity. While we have not evaluated our method towards its capabilities to support insights gained in a real-life design case so far, we see from a methodological point of view how a condensed network approach supports the identification of certain characteristics of connected practices.
However, these potential benefits do not liberate us from the awareness of the boundaries and downsides of social practice modeling and the task to critically scrutinizing our own method as well as to improve it in regard to accuracy and precision. Higginson et al. argue that "thinking critically about how one might model practices and experimenting with different approaches is in itself a valuable aim"(2015, p. 3). The very difference in the level of detail between Higginson et al.'s (2016) work and our approach shows how little advanced the discussion about networks of practices is and how much networks of practices

have to be created and analytically used to understand the capabilities and barriers of the method.

### Empirically Populating a Practice Network

While our work has adapted the survey of Higginson et al. (2016) such that people not familiar with SPT can answer the respective questions, we have not questioned the procedure in general. This might be less important for our example network due to the methodological contribution of this paper but is a key question for the applicability of network theory in future design-oriented work.

Considering the unequal distribution of material, competences, and meanings, that have been gathered with our survey, the question of how to gather as many nodes and their connection as possible arises. While Higginson et al. (2015, 2016) and our work uses a qualitative survey, that needs interpretation and coding of the results to identify the elements of the network, other SPT based research uses a broad variety of methods, e.g. qualitative interviews (Ganglbauer et al., 2013) or ethnography with a sense cam (Ng et al., 2015) as well as closed-questions quantitative surveys (Warde & Hetherington, 1994). In our view, the use of other empirical methods could also be applicable to networks of practices. However, our work does not provide an answer on which method to use to gather empirical data for the construction of a network of practices. Here, further research should focus on a better match between the collection of data and the visualization. Using a deeper ethnographic inquiry might allow for thicker data sets and elements that remain hidden when directly asking the participants.

However, ethnographic research is time-consuming and often relies on smaller samples, and networks of practices require some kind of quantification by definition (Dorogovtsev & Mendes, 2002), e.g. to determine the edge weights before letting the layout algorithm run. Kuijer (2014) already laid the basis for edge weights depending on the importance of a certain edge resp. the number of occurrence within the sample (Higginson et al., 2015), but we so far do not know how big our samples need to be to identify the weights of the edges. correctly. Furthermore, the occurrence of all performances and their elements as well as their connections is a matter of quantity, if researchers want to prevent ‘anomalies’. One example of such an ‘anomaly’ in our food network is the competence *Allergy Knowledge (C)* which seems to be misplaced. Although the competence could be applied in several food-related practices, such as eating, procurement, and cooking, it is, however, only present in planning practices. This ‘anomaly’ occurs due to our small sample size and the random assignment of the probably only allergy suffering participant to the survey on planning.

Without wanting to take up the old discussion of qualitative and quantitative research (Halkier, 2011; Schrøder, 2012), we still want to raise awareness about certain issues. Networks with a higher degree of detail or a more explorative character might be created by ethnographic methods, while a stronger quantification is needed for more robust networks with more causal significance. Especially when choosing smaller qualitative samples researcher should be aware of outliers and probably other yet unidentified phenomena that are not correctly visualized within such networks.

Analysis – A Matter of Distance

Methodically our approach uses, in contrast to Higginson et al.(2015, 2016) in particular their later work, color to visualize the distance of nodes instead of reducing their connectivity. While they (Higginson et al., 2016) argue that they reduced the connections, since they observed a low tendency to cluster as well as less obvious geometries, our results show that clusters and geometries of the overall network can be visualized, although nodes are highly connected. From our perspective, this difference is based first on the means of visualization and second on a distinction between practice-as-entity and practice-as-performance.

Regarding the *visualization,* our coloring approach shows how practices are forming quite homogenous clusters, although all practices resp. clusters despite disposal are closely tied together. The introduction of the additional layer of color is however not only helping us to identify overall geometries when 'zooming out' but due to the versatility of coloring, we were able to visualize and therefore provide more detailed explanations. A gradual highlighting of nodes and edges, e.g. when 'zooming in or in-between', allows to clearly trace the connections of certain elements or the importance of a particular element for a certain practice and the network of practices as a whole. Therefore, with regard to the discussion about oversimplification, we argue that networks of practices should not simplify reality, but adapt towards the complex social life and therefore provide means that might at first glance be complex as well, but upon further observation are more helpful when researchers want to apply SPT to inform design.

Regarding the *distinction between practice-as-entity and practice-as-performance,* our work indicates that practices-as-performances form clusters, that represent practices-as-entities. From our perspective, the network of Higginson et al. (2015) shows the same tendency to cluster, although they (Higginson et al., 2016) argue that there is a low tendency. Attempting to capture different variants of laundry practice, their (Higginson et al., 2015) network, visualizes different performances of doing laundry. Those performances cluster towards one entity, that then does not allow for differentiation between the different performances. Within our results, the gathered performances of one practice (e.g. cooking) form a practice-as-entity cluster as well. Within this cluster, we are not able to distinguish between the performances or 'variants' of performances as well. Here it might be interesting to see which additional measures of distance, e.g. layer of color, could visualize those categories to allow for an even more detailed 'zoom in'. Generally speaking, we disagree with Higginson et al.'s (2015, 2016) observation that practices do not cluster but argue for more adaption of the method towards a higher level of detail. This means that research on a practice-as-entity level needs distance measures that are less selective than research on a practice-as-performance level within the entity clusters.

# Conclusion

Adapting the approach of Higginson et al. (2015, 2016) our work introduces the combination of network theory and SPT to the practice-centered computing

community. Furthermore, we attempted to improve the method to address, what we have identified as downsides in current approaches. Based on the constructed network of FP we identified design opportunities and benefits of an understanding of practices as interconnected networks.
Rather than focusing on practices in isolation our work indicates the chance for interventions by a focus on structural holes and central elements through what we call 'broker-technologies'. Nonetheless, we argue that this focus is not a 'magic bullet', that changes practices towards desired outcomes. However, an understanding of how practices are interconnected might support understanding barriers of intervention as well as barriers of appropriation over time.
While our work contributes to SPT based practice-centered computing research by introducing, adapting and discussing a new research method, we are aware of the still unanswered questions. Limited by a small sample of 60 participants and no application in a real design study, many of our thoughts remain theoretically and more questions arise than have been answered. We especially want to encourage researchers to contribute to the discussion about networks of practices, research methods to empirically gather elements of practices as well as to evaluate its usage in real design studies.
With our work, we intended to create a deeper understanding of the methodological capabilities of network theory applied to SPT and an understanding of practices as a network. This paper offers the potential to inspire designers and researchers to engage and contribute to the discourse about networks of practices.

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