Embodied and Enactive Cognition in Practice:

Planning for the Direct Potable Reuse of Wastewater in Arizona

by

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ABSTRACT

How can we understand and pursue sustainability transitions that disrupt everyday practices and social norms? This dissertation finds potential answers to this fundamental sustainability governance question in Arizona utilities’ efforts to legitimate wastewater as a drinking water source. Due to widespread public concern regarding the direct potable reuse of wastewater (DPR), utilities and other stakeholders have developed innovative governance approaches. By offering tastings of DPR water (often in the form of beer), utilities create spaces for deliberation within a traditionally top-down policy planning paradigm, and furthermore, invite feelings—emotions and bodily sensations—into policymaking.

This dissertation explores and advances Arizona's emerging transition to deliberative water governance through three distinct investigations. The first of these, an institutional analysis based on interviews with 34 regional stakeholders and observations at 56 water industry meetings, identifies direct experiences with DPR (e.g., tastings) as a pivotal strategy to institutionalize new wastewater practices. The second investigation examines utility-sponsored initiatives to promote DPR and finds that, instead of assuming that consumers behave as rational choice or bounded rationality would predict, water utilities’ use of drinking water tastings reflects a new normative assumption, termed *embodied rationality.* The third investigation applies embodied rationality in action research with skeptical consumers and reuse industry stakeholders to co-design an exhibit about DPR that engaged more than 1,100 people. Drawing insights from the literatures of embodied and enacted cognition, practice theory, organizational institutionalism,

sustainability transitions management, and design research, this dissertation proposes an analytical approach, normative framework, and practical tools for collaboratively addressing real-world sustainability challenges.

DEDICATION

To Kirk and Bay. Thank you for your love and patience.

And, in memory of my parents, who would have been delighted by this career turn.

ACKNOWLEDGMENTS

I wish to thank my advisor, Dave White, who applied his knowledge and relationships to advance this dissertation in numerous ways. I am also indebted to my committee members, Christy Spackman and Hallie Eakin, who demanded both academic rigor and originality and whose advice strengthened this dissertation immeasurably.

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Many individuals contributed to the success of the co-design workshops and the resulting *Future Taste of Water* exhibit. I thank the following research collaborators: Christy Spackman, Laura Dicochea, Asha Ramaswamy, Joe Austin, Qyania Jimenez, 20 anonymous workshop participants, Shahnawaz Sinha, Claire Lauer, Zach Burnham, Matthew Thornton, Katie Thompson, Esteve Giraud, Natalia Arruda, and Ray Quay. Critical to the success of this project was the support of: Brian Biesemeyer, Valerie Schneider, and David Walby of Scottsdale Water; Masavi Perea and Blanca Abarca of Chispa Arizona; Natalie Marsh and her team at Scottsdale Arts; Bret Waters of O.H.S.O. Brewery; and, Tom DiDomizio from EPCOR.

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MAKING PERCEPTIONS ACTIONABLE IN SUSTAINABILITY GOVERNANCE

In August, 2022, the United States Bureau of Reclamation declared shortage on the Colorado River, one of the main sources of supply for the 4.6 million residents of Central Arizona (US Bureau of Reclamation, 2021). Although no surprise for Arizona water managers, this announcement was a collective, "Oh, shit!" moment for many others in the state. Water governance actors in Phoenix and Scottsdale, Arizona seized on the moment to announce their intentions to begin the direct reuse wastewater as a drinking water supply, a practice known as direct potable reuse (DPR). In DPR, municipal wastewater, including greywater and blackwater flowing from bathrooms, hospitals, roads, and factories, undergoes advanced water treatment so it meets, or in many cases exceeds, potable water quality standards. This dissertation examines the planning processes leading up to these announcements, and the special role that utility-sponsored tastings have played in building DPR's social legitimacy.

The invitation to sample DPR provokes a different kind of "Oh, shit!" response as consumers, utility employees, regulators, engineers, and politicians realize that adapting to drought may require adapting drinking water practices to accept what was once considered abhorrent. To taste, or not to taste—sustainability transitions are the accumulation of these decisive moments. Utility-sponsored tastings turn these decisions into deliberative governance in a way that builds on the sensory expertise consumers acquire during a lifetime of drinking water and brings private emotions of concern, hope, trust, disgust, and ambivalence into the public realm. Through ethnographic investigation and action research, this dissertation therefore finds that *feelings*—both sensations and emotions[1]—have shaped Central Arizona's DPR planning, and that utility experiments with tastings as a strategy to legitimate DPR also legitimate feelings in water governance.

The insights gained from this research apply to the governance of other sustainability transitions that disrupt everyday practices and social norms. Given the complexity of most sustainability dilemmas, it is rare for governance actors to have complete knowledge of the relevant policy elements or broad consensus on governance goals (Cosens et al., 2021; Folke et al., 2005; Olsson et al., 2016; Renn et al., 2011; Scoones & Stirling, 2020; Voß et al., 2009). Negotiating the trade-offs inherent to sustainability governance often provokes strong emotions and conflict among competing interests (Martiskainen & Sovacool, 2021; Nightingale et al., 2021). Rather than pursuing socio-politically fraught sustainability transitions, policymakers may delay their adoption or choose less transformative pathways. Therefore, governance strategies that increase public consensus on the legitimacy of sustainability transitions are urgently needed (Armitage et al., 2012; Bulkeley & Mol, 2003; Caniglia et al., 2021; Cosens, 2013; Pereira et al., 2018).

Adapting to everyday life under climate change will also require new modes of communication between policymakers and residents (Davies et al., 2012; Feagan et al., 2019; Pluchinotta et al., 2019). Take, for example, urban heat, where research has demonstrated that pedestrians' perceptions of temperature are substantially different than the readings of mechanical measurements (Hondula et al., 2021). Furthermore, heat

[1] This dissertation use of "feelings" refers to the somatosensory perception that is the foundation of cognition. As Antonio Damasio (2021, p. 29) writes, "Feeling provides us with the knowledge of life in the body and, without missing a beat, makes that knowledge conscious."

perception is subjective; it varies from body to body and is influenced by myriad factors, such as the aesthetic appeal of bus shelters (Dzyuban et al., 2022). Rather than dismissing such embodied perceptions as anecdotal evidence, policymakers can recognize the experiential knowledge and subtle actions of urban residents—for instance, in preferring one bus shelter over another—as skilled coping with changing conditions. However, residents' feelings are rarely invited into climate policy (N. J. Bennett, 2016; Mair et al., 2019). Emotions are frequently seen to detract from reasoning abilities, while the subjectivity of sensations poses a challenge for systematic research methods. As sustainability scholars, policymakers, and residents endeavor to proactively mitigate and adapt to climate change, the lack of practical methods and normative justification to involve feelings in governance is proving to be a significant barrier.

Public perceptions are frequently labeled a barrier to DPR adoption, a characterization that can lead reuse proponents to dismiss consumers' feelings as irrational instead of seeking to understand how they may reflect rational concerns (Meehan et al., 2013; Morgan & Grant-Smith, 2015; Ormerod & Scott, 2013; S. Russell et al., 2008; Stenekes et al., 2006). DPR proposals have met strong resistance in California, Texas, Australia, and many other locations worldwide (Hartley, 2006; Hurlimann & Dolnicar, 2016; Scruggs et al., 2020). Russell and Lux (2009) studied contentious DPR planning during Australia's Millennium Drought and concluded that, given the complex motivations for hesitancy, such situations require new participatory governance strategies:

> … [I]t is essential to provide for an iterative process in which people can discuss, question and develop their views on recycling in interaction… The aim is therefore not

> to manipulate emotions or behaviour, as implied by some notions of 'behaviour change'. Rather it is to challenge assumptions, to provoke questioning of them and reflection on them, and to encourage a reconstitution of meaning around changed conditions, technologies and use practices. (p. 31-32)

In the intervening years, water providers in Australia, North America, Asia, and Europe have sought better ways to productively engage with feelings in debates about DPR.

Foremost among these strategies are tastings and other forms of experiential engagements with DPR water and treatment technologies. This dissertation proposes that experiential engagements represent a potential innovation in participatory governance. Instead of manipulating emotions or behavior towards a desired outcome, providing direct experiences can create a two-way dialogue about the acceptability of DPR—one that is often communicated without words. DPR tastings are particularly powerful in this respect. Since, "There's no accounting for taste," tastings equivalate the experiential knowledge that consumers acquire from a lifetime of drinking with the formalized knowledge of water professionals. Furthermore, experiential engagements can make tangible the potential ramifications of a policy on day-to-day life and promote realization that routinized practices are, in fact, open to renovation in the face of changing socio-environmental conditions. Thus, the provision of material experiences has the potential to increase how feelings are involved in DPR decision-making and expand the scope and impact of policy deliberations. In this sense, utility-sponsored DPR tastings provide a real-world example of how to make practicable the emotional, embodied, relational, and practice "turns" observed in sustainability theorizing (Cooke et al., 2016; Manheim & Spackman, 2022; Martiskainen & Sovacool, 2021; Nightingale et al., 2021; T. Schatzki, 2011; Shove, 2010a; Walsh et al., 2021; S. West et al., 2020).

Tastings and other experiential engagements have been increasingly taken up by DPR policymakers in Arizona and elsewhere due to their effectiveness at increasing public acceptance of DPR. However, despite yielding valuable information that benefits planning, utilities generally conceive of experiential engagements as one-directional outreach and education within the decide-inform-defend governance paradigm. This dissertation finds potential for utilities' early success with DPR experiential engagements to introduce a broader transition towards the kinds of collaborative governance envisioned in frameworks such as Integrated Water Management and One Water (Bell, 2020; Pahl-Wostl, 2007; Paulson et al., 2017). A normative understanding of experiential engagement justifies extending the reach of this deliberative governance innovation beyond DPR policy.

During three years of field work, this dissertation sought to understand and stabilize the normativity of feelings in water governance. An ethnographic investigation of utility efforts to legitimate DPR in Central Arizona highlights how the lack of attention to feelings in governance has decreased policymakers' ability to pursue difficult sustainability transitions. Action research with drinking water consumers and producers developed and tested a process to design facilitated experiential engagements that can invite feelings and make them actionable for sustainability decision-making. The theoretical frame for this research applies embodied cognition and Enactivism to recent work at the intersection of practice theory, institutional theory, sustainability transitions, and design theory (Gayler et al., 2021; Geels, 2020, 2022; Hoolohan & Browne, 2020; Laakso et al., 2021; Lounsbury et al., 2021; Rouse, 2023; Shove, 2022; Smets et al., 2017; Wilde & Underwood, 2018). The remainder of the introduction details these theories, as well as the line of questioning that guides this dissertation and the theoretical and practical implications of the answers revealed in this study.

Dissertation Overview

Several scholars have recently noted that dominant theories and practices of sustainability rely on simplistic assumptions of human behavior (Constantino et al., 2021; Schill et al., 2019; Schlüter et al., 2017). This dissertation therefore draws from interdisciplinary scientific literature and empirical investigations into Central Arizona wastewater governance to offer alternatives assumptions to guide the descriptive, normative, and prescriptive work of sustainability governance.

The first two dissertation chapters provide the necessary foundations for the empirical and theoretical work undertaken in this dissertation. Chapter 2 reviews the relevant background information and institutional context to understand DPR and its potential role in Arizona's drinking water system. Chapter 3 asks the **descriptive question**, *what guides human action?* This theoretical inquiry begins with the early days of psychology, which sought to differentiate itself as an objective science of human experience, and traces the productive interplay between psychological theorizing about the mechanics of cognition and phenomenological philosophy's examinations of how people experience things (Käufer & Chemero, 2015; McGann et al., 2020). These lines of inquiry converge in embodied and enactive cognition (EEC), a research program that draws together findings from philosophy, psychology, human physiology, animal behavior, evolutionary theory, neuroscience, robotics, and cybernetics (Barsalou, 1999;

R. A. Brooks, 1990; A. R. Damasio, 1989, 2000; De Jaegher & Di Paolo, 2007; E. A. Di Paolo, 2005; Gallagher, 2008, 2017, 2018b; E. J. Gibson & Pick, 2003; Glenberg, 2010; Noë, 2006; D. R. Proffitt, 2006; L. Shapiro, 2019; Thompson, 2011; Varela et al., 2016). EEC theorizing seeks to explain phenomena emerging from the complex entanglement of brain-body-environment without artificially reducing the dynamical structure of these systems.

According to EEC, human perception is goal-directed and environmentally situated, meaning practical opportunities for action emerge from an organism's coupled interaction with its cultural and environmental landscape (this coupling is heretofore referred to as *humanature*). Whereas EEC provides important accounts of the biological co-evolutionary basis of environmentally situated humans, it's less interested in how and why certain cultural institutions emerge and are maintained (cf. Hutchins, 2014; Sterelny, 2010). The chapter therefore turns to practice theory to elaborate the role of culture, drawing from Joseph Rouse[2] (2023) account of humanature practices, to argue that human action is *sensemaking* involving practical, action-oriented engagement with the

[2] Note: Rouse's (2023) recent book, Social Practices as Biological Niche Construction, draws from biological niche construction to provide a "naturecultural account of practices." On page 11, Rouse writes:

> The book's naturecultural account of practices as biologically niche constructive often makes common cause with recent developments in a third research area in the cognitive sciences and philosophy of mind which emphasizes the enactive embodiment of cognition in organisms' ongoing practical perceptual interaction with their surroundings. The book relies less on detailed developments in embodied cognition than in ecological-developmental biology and niche construction or the achievements and conflicts of practice-based social theory and therefore does not review them systematically. The book's arguments nevertheless align with the overall orientation of many of these developments, particularly those situating cognition in the dynamics of bodily interaction with environmental affordances (Chemero, 2003; Gallagher, 2017, 2020; Noë, 2006).

And in a footnote on that same page, Rouse notes:

> I use "embodied cognition" as a more compact expression encompassing work on embodied, environmentally embedded, extended, and/or enactive ("4E") approaches. Those differences are less consequential for my project, which primarily intersects theirs in relations between organismic bodies and their developmental and selective environments.

socio-material environment. The dissertation applies this *embodied practice*[3] understanding of sensemaking to the subsequent empirical examinations of humanature in DPR decision-making and action research that mobilizes practice to make new meanings of wastewater.

Chapter 4 applies the embodied practice approach to an empirical inquiry into how feelings and perceptions[4] have shaped the adoption of DPR in Central Arizona. to Qualitative analysis of ethnographic data collected via interviews and observations of wastewater governance actors identifies the feelings involved in sensemaking practices about DPR. A dominant strand of institutional theory is concerned with how institutional orders are created, maintained, reproduced, and changed through the institutional work of actors (T. Lawrence et al., 2011; T. Lawrence & Suddaby, 2006). Analyzing the institutional work of reuse proponents reveals that legitimating DPR requires transforming institutionalized meanings of abject wastewater[5] and associated practices of containment, avoidance, privacy, and feelings of disgust, embarrassment, and so forth. To institutionalize alternative meanings of wastewater as a "pure" and "clean," reuse proponents have introduced practices, such as the DPR tastings and water balloon fights, that are public, celebratory and feature direct contact with DPR. As sensemaking practices, these activities activate emotions and sensations in the competent construction of new meanings of wastewater.

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[3] "Embodied practice" is a term that appears elsewhere in the literature (Tangenberg & Kemp, 2002), but its use here is unique both in its theoretical foundations in Embodied and Enactive Cognition and its application to sustainability transitions.

[4] Whereas feelings are here used to refer to the somatosensory foundation of experience, perceptions are how we make meaning of feelings.

[5] The use of the term "abject" in regards to DPR is adapted from Meehan et al. (2013).

However, existing institutional theories do not provide adequate explanation for the importance of *feelings work* in legitimating DPR. Additionally, the institutional literature struggles to theorize how institutional change can occur given that humans are *doubly-embedded* in institutions, meaning institutions shape actor agency to recognize and change institutional constraints (Hallett & Ventresca, 2006). To address these gaps, this chapter builds on one of the only explicitly EEC-informed theories in organizational institutionalism, Harquail and King's (2010) construct of *embodied cognitive capacities*, to provide an account of institutionalization as the attunement of individuals' embodied cognitive capacities to appropriately sense and respond to one's socio-material surroundings. In this view, legitimacy describes the feeling when one's embodied cognitive capacities are in alignment with one's experience of social-material reality. Applying these theoretical constructs to empirical findings reveals that reuse proponents have discovered experiential engagements to be particularly effective at attuning consumers' embodied cognitive capacities to the legitimacy of DPR as "the way we should do things." These findings offer theoretical and practical lessons for understanding processes of (de-)institutionalization in socio-technical transitions, and why certain legitimation strategies may be more effective than others.

Next, in Chapter 5, the dissertation asks the **normative question**, *given an embodied and enactive understanding of human cognition, how should we evaluate human thought and action?* This question is of pressing concern to sustainability scientists, who have observed the deficiency of prevailing models of human reasoning, such as theories of rational and boundedly rational actors, to inform policymaking (Constantino et al., 2021; Schill et al., 2019; Schlüter et al., 2017). This chapter therefore reviews data collected in ethnographic fieldwork and best practice guidance from the white and grey DPR acceptance literature to identify the various strategies reuse proponents have employed to increase public acceptance of DPR. These strategies are analyzed to identify the normative standard rationality that informs them.

This analysis finds that extant normative rationalities are insufficient for explaining the effectiveness of experiential interventions, such as DPR tastings. This chapter therefore proposes that a new normative standard rationality, *embodied rationality*, informs water utilities' use of drinking water tasting practices to promote DPR. The definition of embodied rationality is assembled from extant theorizing in embodied and enactive cognition (Gallagher, 2018b; Mastrogiorgio & Petracca, 2016; Petracca, 2021; Rolla, 2021; Spellman & Schnall, 2009). This chapter defines embodied rationality thus: to act rationally is to adapt one's embodied cognitive capacities to socio-material constraints and opportunities so as to maintain competent performance of actions. Embodied rationality's real-world utility is demonstrated by its successful application in DPR policymaking. The argument for embodied rationality as normative standard rationality is not made on objective grounds that it represents a truer version of absolute reality (although this may be the case), but because it is a better fit for the post-truth sociopolitical landscape in which contentious climate decision-making frequently takes place. Embodied rationality is therefore forwarded in response to sustainability scientists' calls for a more workable model of normative human reasoning for climate governance.

Chapter 6 turns to the **prescriptive question**, *in what ways can applying these descriptive and normative frameworks (respectively, embodied cognitive capacities and* *embodied rationality) improve sustainability governance?* This chapter describes a transitions management experiment to apply embodied rationality to governance. Material co-production is a social learning method in which a small group of policy proponents and likely opponents collaboratively design a practice-based intervention (PBI) that is then deployed among the public to promote curiosity and reflexivity about the proposal. The use of design research methods throughout the material co-production process provides a means for participants to access, translate, and disseminate their embodied cognitive capacities in policy deliberations. PBIs extend governance across time and space to better reflect participatory sensemaking. Rather than attempting to orchestrate human behavior towards a desired outcome, the application of collaborative design to produce PBIs represents a novel *governance PBI* that complements transitions management's adaptive approach to achieving societal sustainability.

Material co-production was applied in action research with five DPR advocates and fifteen tap water skeptics to co-design an exhibit about DPR, *The Future Taste of Water*, that was presented at three public festivals where it engaged more than 1,100 attendees during Fall 2023 and Winter 2024. Qualitative analysis of ethnographic data, survey responses, and material artifacts produced by participants yielded significant findings for water managers, including the surprising potential for advanced water purification of DPR to increase tap water acceptance by producing water perceived as higher quality than conventional treatment. However, the success of such informational messages depends on water utilities' ability to promote curiosity about DPR, which is best done by facilitating fun, social, PBIs that provide consumers the opportunity to directly experience DPR water or treatment demonstrations and directly interact with water utility representatives to build trust in water treatment technologies and institutions. As a PBI in governance, the expanded scope of investigation revealed the participatory sensemaking processes that attune the embodied cognitive capacities of consumers *and* policymakers to new normative universals of embodied rationality.

Chapter 7 concludes by reviewing how EEC provides the theoretical foundation, embodied cognitive capacities provides the descriptive lens, embodied rationality provides the normative justification, and material co-production provides a generalizable approach and suite of methods for collaborative governance. These contributions have potential to benefit sustainability transition processes, policies, and outcomes.

The conclusion chapter then considers how this research contributes to sustainability-theory building. First, the research finding that actors across the field of Arizona water governance share drinking water practices supports practice theorists' contention that socio-technical systems are flat, rather than the hierarchically and scalarly organized as much sustainability theorizing assumes (Reckwitz, 2002; T. Schatzki, 2016). Second, the empirical and theoretical findings reported here complement extant efforts reported in the sustainability literature to apply EEC to non-dualistically theorize socio-ecological systems and humanature relationality (Cooke et al., 2016; Hukkinen, 2012, 2014; Raymond et al., 2018). Third, a shared foundation in complex adaptive systems enables embodied cognition, via the theoretical frameworks advanced in this research, to enhance socially informed theorizing about how human culture emerges, and changes, through coupled bodily interaction with environmental affordances (Cosens et al., 2021; Preiser et al., 2018; Schill et al., 2019).

The support the embodied practice approach provides for these various efforts to advance sustainability theory does not negate the value of other humanature epistemologies. However, the combination of EEC and practice theory, with roots in Western-dominant scientific disciplines of psychology, philosophy, and sociology, is well-suited to respond to the recent call "to develop distinct normative, methodological and ontological roots for relational values" (S. West et al., 2018, p. 36). The conclusion ends by anticipating and responding to criticisms that the application of EEC is a form of "neurogovernance," "neuroliberalism," or "neurocapitalism" (Neidich, 2014; Papadopoulos, 2018; Whitehead et al., 2017). It counters that this research avoids this trap by applying EEC to governance practices rather than specific policies. The dissertation therefore concludes that embodied practice, coupled with embodied rationality, provides a foundation from which to advance transformative ontologies and practices of sustainability governance.

CHAPTER 2

BACKGROUND ON DIRECT POTABLE REUSE AND DRINKING WATER MISTRUST

This chapter provides relevant background for the empirical case explored in this dissertation, the decision-making to adopt direct potable reuse of wastewater (DPR) in Central Arizona. It is divided into three sections. The first section disambiguates between unplanned reuse and planned reuse, which includes non-potable reuse, indirect potable reuse, and direct potable reuse. The second section provides a brief historical account of wastewater reuse in Arizona. The third section reviews how mistrust of tap water leads to increased bottled water consumption, and how this is affecting utilities in the study area.

Defining Wastewater-water Integration

In most cities in the United States, greywater, such as water from laundry machines, stormwater, and blackwater from homes, hospitals, industry, and streets (heretofore both greywater and blackwater will be referred to as "influent") is collected into a single sewerage system and conveyed underground to centralized wastewater treatment plants, where it is treated (becoming "effluent") and discharged. Of this treated wastewater, most is returned to surface water bodies, such as rivers, lakes, or the ocean. Wastewater treatment plants are therefore usually located adjacent to these receiving waters. Through the US Federal Water Pollution Control Act, Pub. L. 92–500, §2, 86 Stat. 816 (1972), better known as the Clean Water Act, the Environmental Protection Agency (EPA) regulates the quality of treated wastewater discharged to waterbodies like rivers and lakes.

Drinking water standards are set by the US Safe Drinking Water Act, Pub. L. 93–523, §2(a), 88 Stat. 1660 (1974), also enforced by the EPA.[6] Drinking water treatment plants are typically centralized and located proximate to the source of supply, be it a river, a lake, an aquifer, or, with desalination technology, the ocean. Discharged wastewater might be picked up by downstream municipalities as part of their drinking water intake, an example of unplanned reuse (Tchobanoglous et al., 2015; US Environmental Protection Agency, 2019). Through unplanned reuse, treated wastewater discharged upstream can constitute 2 to 16 percent of water supplies, although in some locales during dry periods it can be as much as 100 percent of streamflow (Rice et al., 2013).

In planned reuse, influent from any source can be reclaimed by treating it according to the standards required for its intended use, a strategy known as "fit-for-purpose." Non-potable reuse strategies can be distributed or centralized. For example, greywater and rainwater captured from rooftops can be reused onsite for landscape irrigation. Alternatively, influent may convey through sewerage infrastructure to a centralized wastewater treatment plant where, with low-cost treatment, it can be reused for irrigation, industry, and other non-contact household use (e.g., toilet flushing). The treatment, service and delivery of non-potable reuse is managed by the wastewater agency. Non-potable reuses of water require separate distribution systems (referred to as

[6] Within the boundaries set by the Clean Water Act and Safe Drinking Water Act, states, territories, and Indian Reservations maintain primary regulatory authority (i.e., primacy) in allocating and developing water resources and establishing standards associated with various water uses (Sanchez-Flores et al., 2016).

“dual pipe”) to avoid intermingling with potable supplies. Non-potable wastewater reuse reduces demand on centralized water and sanitation infrastructures, as well as energy requirements of treatment (Gleick, 2002). More than half of US states have regulations or guidelines[7] permitting non-potable reuse for agriculture and landscaping (CDM Smith, 2017).

Advancements in science and technology have made it possible to treat municipal influent so it may be reincorporated, either indirectly or directly, into the potable supply. As compared to non-potable reuse, the management and physical infrastructures associated with planned potable reuse are almost always centralized to enable compliance with the stringent monitoring and reporting requirements of the SDWA. In indirect potable reuse (IPR), raw drinking water supplies are augmented with treated effluent using an environmental buffer (e.g., groundwater recharge, direct injection, soil filtration, basin spreading, blending or surface augmentation (National Research Council, 2012). IPR is an established practice associated with lower treatment costs and widespread social acceptance (CDM Smith, 2017; Fielding et al., 2019; National Research Council, 2012). In IPR, the organizational separation between wastewater and drinking water agencies persists, with the wastewater agency taking on any new management responsibilities. In Arizona, this typically includes ensuring compliance with aquifer protection regulations. Treatment facilities for reuse are often rebranded—in Arizona, they are typically referred to as “Water Reclamation Facilities” (Pitzer et al., 2007). IPR is not always an ideal solution since it requires that an environmental buffer be located proximate to a wastewater treatment plant (National Research Council, 2012). IPR also

[7] The main difference between these is that regulations are enforceable whereas guidelines are not.

increases the risk of contamination of the environmental buffer, which must be monitored and maintained, adding to operating costs (National Research Council, 2012). For IPR involving an aquifer in arid climates, evaporative losses from aquifer recharge facilities can be significant, and there are added infrastructure and energy costs associated with withdrawal (Bartos & Chester, 2014; Daigger, 2007; Middel et al., 2013).

In circumstances where IPR is inopportune, utilities may choose to pursue direct potable reuse (DPR). DPR is a newer strategy that offers a "pipe-to-pipe" solution, where advanced purification technologies (referred to heretofore as "advanced water treatment," AWT) replace the treatment provided by an environmental buffer. After effluent undergoes AWT and meets SDWA standards, DPR water can be served directly—usually in a blend with conventional water supplies—to households, schools, businesses, and industry for any use. Implementing DPR may involve upgrading a WRF so it can treat wastewater to drinking water standards, then piping the ultra-purified water to a drinking water treatment facility. In this case, wastewater operations and drinking water operations are separated, albeit with increased integration. This introduces redundancy to the system, which, though inefficient in some ways, may provide additional protections in case of error (Leigh & Lee, 2019). Alternatively, an AWT facility may combine wastewater and drinking water treatment operations and associated regulatory reporting. Integrated systems are more complex to manage, requiring operators with certifications in both drinking water and wastewater operations, as well as additional operating procedures to reduce risks of accidental contamination of water supplies (Daigger, 2011).

On the operations side, DPR poses some challenges, including high energy demands for treatment and lack of disposal options for highly concentrated waste streams. However, the primary challenges DPR projects face are regulatory uncertainty and low public acceptance (Sanchez-Flores et al., 2016). In contrast to indirect potable reuse, which is approved in 15 states throughout the US, only four have adopted regulations or guidelines allowing for direct potable reuse (US Environmental Protection Agency, n.d.). Figure 1 shows the prevalence of DPR versus IPR in the United States. The states permitting DPR, Texas, California, Colorado, and Arizona, suffer from water scarcity, as do international early-adopters Namibia, Israel, Singapore and Australia. Lack of public support has caused several IPR projects to be shelved. These include: San Diego (1993) and San Gabriel Valley, Los Angeles (2001), Dublin San Ramon District (1998), and East Valley, Los Angeles (1990s), California; Denver, Colorado (1990); Tampa, Florida (1997 and at present); Noosa (1994) and Toowoomba (2007), Queensland, Australia (Hartley, 2006; Hurlimann & Dolnicar, 2016; Marks, 2006; Morgan & Grant-Smith, 2015). Other proposed projects appear to enjoy wide support from residents (Marks, 2006; Scruggs et al., 2020). As regulations are established, the uptake of DPR is expected to accelerate in the US and elsewhere (Jiménez Cisneros & Asano, 2008). Many hope a successful track record of DPR operation will assuage public and regulator concerns about potential health risks and establish treatment system reliability to consistently meet all required drinking standards (Sanchez-Flores et al., 2016).

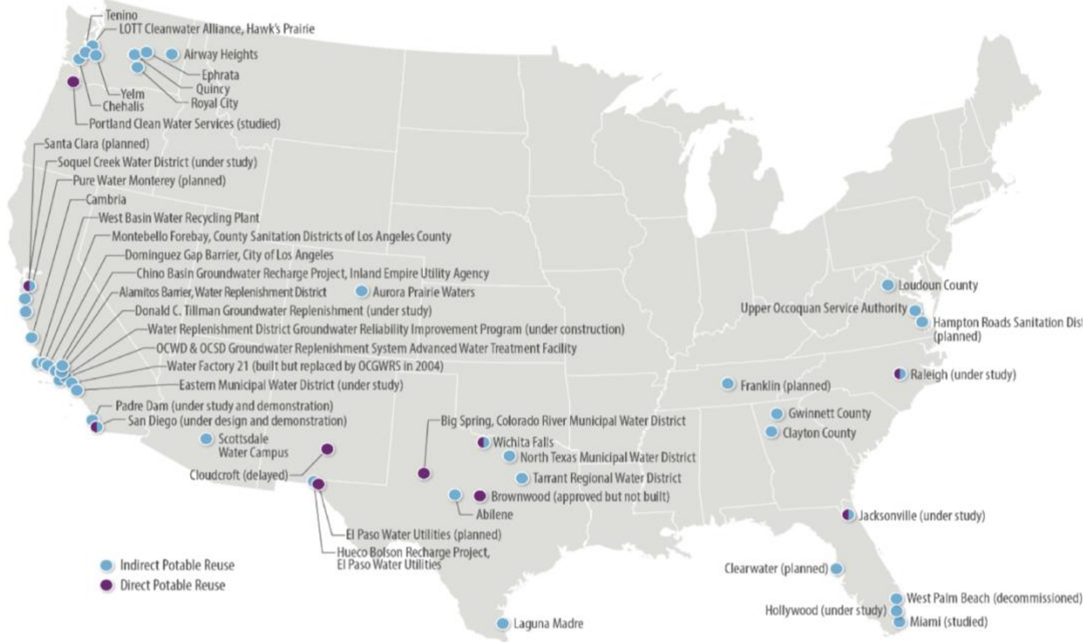

Figure 1, Planned and Constructed IPR and DPR Projects in the United States

This map shows the prevalence of IPR and DPR projects in the United States as of 2017. IPR and DPR is more common in arid locations in the Western US but can be found nationwide. (Source: EPA, 2018)

Wastewater Governance Institutions in Arizona

Arizona is located in the arid Southwestern United States. Figure 2 shows the study region in Central Arizona, which covers 5,646 square miles and comprises 24 municipalities and three Native American reservations (Arizona Department of Water Resources, 2022), including Phoenix, the nation's 5th largest and fastest growing city (US Census Bureau, 2023). This region experiences an average of seven inches of rainfall a year (Gober et al., 2016). As a result of its arid climate, Arizona has a long history of planned reuse (Gober et al., 2016; Larson et al., 2013; Middel et al., 2013). In 1926, the for-profit hotel at Grand Canyon Village installed the nation's first wastewater treatment plan to produce water for flushing toilets, power plant cooling, and railroad use (Fulton, 2014). In 1932, effluent from the Phoenix 23rd Avenue wastewater treatment plant was first used for irrigated agriculture.

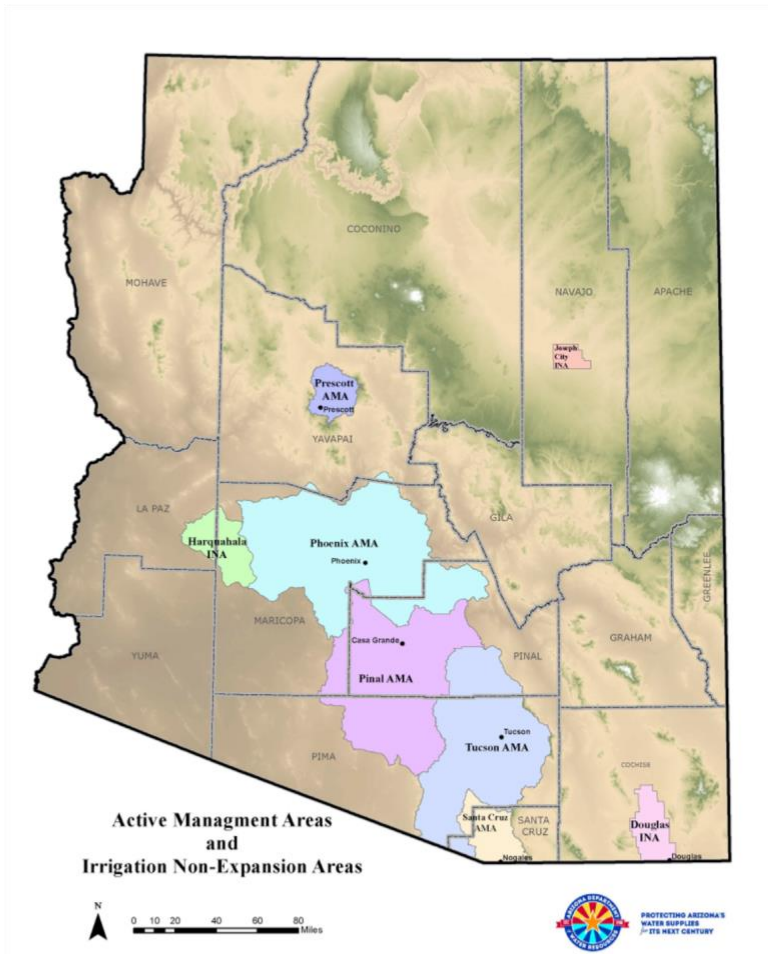

Figure 2, The Study Area

The study area is the portion of the Phoenix Active Management Area (AMA) located within Maricopa County.

Expansion of non-agricultural wastewater reuse in Arizona was slow until serious groundwater overdraft prompted the passage of the Groundwater Management Act, Ariz. Rev. Stat. § 45-562 (1980). The GMA established the Arizona Department of Water Resources (ADWR) and authorized it to manage several programs in designated Active Management Area (AMAs). For each AMA, plans were put in place to achieve a "safe yield" goal, meaning aquifer withdrawals did not exceed deposits. Due to these GMA provisions, water providers in the Phoenix AMA were required to minimize the use of "fossil groundwater" (Ferris & Porter, 2021; Hirt et al., 2008). Utilities offset groundwater cutbacks with wastewater reuse and underground storage of municipalities' portion of Arizona's Colorado River allocation. In the 1970s, Arizona began constructing a 336-mile canal, the Central Arizona Project (CAP), to transport its share of Colorado River from Lake Mead through the Phoenix AMA to the Tucson AMA. In 1985, the first CAP deliveries began in the Phoenix area.

At the time, many municipalities could not use their full CAP allocation. This was concerning because, if Arizona didn't fully utilize its allotment of Colorado River water, it risked losing its claim to neighboring states (Silber-Coats & Eden, 2017). So, in the decades following the GMA, the Arizona legislature passed a series of laws to promote widespread use of CAP water for aquifer recharge. Because groundwater in Arizona is mobile, and aquifers are open access within the guidelines of the AMA, utilities lacked a clear right to withdraw water they recharged. In response, the 1986 Underground Storage and Recovery Act, Ariz. Rev. Stat. § 45-831.01 created an accounting system administered by ADWR that provided Long Term Storage Credits (LTSCs) for future withdrawals. This had the effect of incentivizing recharge as municipalities sought to fully exploit the benefits of LTSCs by recharging as much as possible. But between 1970 and 2000, Arizona's population nearly doubled (Hirt et al., 2008). The development that accompanied this growth began using a larger share of municipalities' CAP allocations. The Underground Water Storage and Replenishment Act (UWSRA) of 1994 provided a mechanism to gain credits through indirect groundwater "recharge". In indirect recharge, or "in-lieu" groundwater, a previous groundwater use (e.g., irrigating a farm) could be replaced with a renewable supply, such as CAP water or reclaimed water.

Around this time, Scottsdale and four municipal partners, collectively known as the Sub Regional Operating Group (SROG), entered a $290 million agreement with Arizona Public Service Company (APS). The agreement was to construct a treatment plant and pipeline so that wastewater from these municipalities could be used for cooling the towers of the Palo Verde Generating Facility nuclear power plant. After the SROG-APS deal, senior water rights holders downstream from the Scottsdale municipal wastewater treatment plant sued alleging impairment caused by the lease of Scottsdale's treated effluent, which significantly decreased discharges to the stream. According to the 1919 Surface Water Code, Ariz. Rev. Stat. § 45-101, surface water is defined as "waters of all sources, flowing in streams, canyons, ravines or other natural channels, or in definite underground channels…" Consequently, once treated wastewater was discharged to a waterway, it was surface water and subject to prior appropriation. But it was unclear whether utilities had the legal right to reuse wastewater they had previously been discharging. The case made its way to the Supreme Court, which found that wastewater belongs to the entity that produces it and can be put to beneficial use or conveyed to another entity to put to beneficial use, regardless of the original source of water (APS v.

Long, 1989). In 2018, the Arizona legislature passed SB 1227, Ariz. Rev. Stat § 45-802.01, increasing the percentage that effluent earned in LTSCs as compared to surface water from 50% to 95%.

After the Arizona Supreme Court ruling established a legal rights framework for treated effluent, a similar wastewater treatment partnership formed between the cities of Mesa, Chandler, and Queen Creek in the East Valley. Wastewater exchanges have also been negotiated. The Gila River Indian Community (GRIC) exchanges Colorado River water for treated effluent with Chandler and Mesa at a ratio of 8 to 10, which the GRIC uses to irrigate farmland. Through these and other projects and partnerships, at least 82% of the effluent in the Phoenix AMA is reclaimed, with 22% reused for power generation, 22% for agriculture, 21% for aquifer recharge, and 21% for environment (Middel et al., 2013).[8]

Arizona tribes have opposed the land application of wastewater on cultural and religious grounds with consequence for how effluent is reused in the state. The use of treated wastewater on some of the GRIC farmlands opposed by some tribal members (Krebs, 2023). A plan to produce artificial snow using recycled water at the Arizona Snowbowl northwest of Flagstaff has been staunchly opposed by a coalition of tribes, including the Navajo and Hopi, environmental groups, and the general public, who have used legal and direct action tactics to halt snowmaking operations (McGivney, 2022; Middel et al., 2013; Pitzer et al., 2007). In the 1970s the Phoenix area town of Fountain Hills was forced to develop an alternative management strategy after two downstream tribes, the Fort McDowell Yavapai Nation and Salt River Pima-Maricopa Indian

[8] These percentages are based on 2010 data; however, these usage trends appear to be mostly unchanged as of 2022.

Community, would not allow discharged treated effluent to travel across their lands (Lambertson, 2019; Middel et al., 2013). Instead, in 1974, the city began disposing its reclaimed water into a 33-acre constructed reservoir that contains a fountain once ranked the highest in the world (Lambertson, 2019).

Water rights and infrastructures are unevenly distributed among municipalities, and the 4.6 million residents, in the Phoenix AMA. The Colorado River overallocation, exacerbated by climate change, makes the future of CAP deliveries increasingly uncertain (Fleck & Udall, 2021). Some areas have historical water rights to local rivers that may be less sensitive to global climate change than the Colorado River (Svoma, 2023). A third of the Phoenix AMA's annual water supply is from these rivers, whereas the Colorado River provides 20% of Phoenix's water supply (Arizona Department of Water Resources, 2020). Colorado River shortages just begun to affect Arizona's municipal supplies (BOR), but many managers are planning for a future with dramatically reduced CAP deliveries.

The state government has initiated a series of planning activities to accelerate and extend the reuse of wastewater in Arizona. The Governor's Blue-Ribbon Panel on Water Management (Mayes et al., 2010) reviewed the need, opportunity, technology, and barriers for water recycling in AZ and recommended a working group (Steering Committee on Indirect and Direct Potable Reuse) to develop guidelines for DPR. Following this, Arizona Department of Water Resources (2014) published a strategic planning document, *Arizona's Next Century*, which estimated that potable reuse could half the gap in supply and demand by 2035 and noted:

> Using reclaimed water limits use of potable water for non-potable purposes and saves

potable water for drinking water supplies. However, as demands increase and water supplies become more stretched, the need to explore and invest in direct potable reuse for drinking water supplies will become necessary. (p. 67)

One of the action items listed in this document was to change the regulatory framework to allow for DPR. The governor then convened a Water Augmentation Council in January 2016 for the express purpose of finding additional water supplies and more efficient ways to use current supplies. Parallel to this, a Blue Ribbon Panel was appointed to study unregulated contaminants and published a report (Arizona Department of Environmental Quality, 2016) summarizing how they can be managed to protect water resources and maximize reuse potential. Finally, the governor directed ADEQ to reform regulations to allow for DPR, and the agency supervised WateReuse and the Arizona Water Association, with consultant National Water Research Institute, to create a Guidance Framework for Direct Potable Reuse in Arizona (Mosher & Vartanian, 2018).

The initial outcome of the Guidance Framework was that, in 2018, the Arizona legislature repealed the statewide prohibition on the direct reuse of effluent as a drinking water supply (Ariz. Rev. Stat. § 18-9-E701). ADEQ then invited Scottsdale Water, which already had an operational AWT facility, to apply for a provisional DPR permit (personal communication with Brian Biesemeyer). Under a provisional permit, Scottsdale Water installed a small treatment system to re-mineralize the AWT-treated water[9] and began offering samples of DPR water to visitors at the end of their treatment plant tours. In 2019, Scottsdale Water hosted the first of several One Water Brewing Showcases, which has drawn media and public attention to DPR. Following this, ADEQ did not proceed as

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[9] This is necessary because AWT removes almost all minerals from water.

expected with rulemaking to formalize DPR regulations that would provide the permanent framework utilities need to permit advanced water treatment facilities. As a result, in 2022, Phoenix area utilities and real estate developers lobbied the legislature to pass a bill (HB 2129 amending Ariz. Rev. Stat. § 49-211) allocating funds to ADEQ with the requirement the agency complete DPR rulemaking by the end of 2024. As of writing, this rule-making process is underway.

Funds have been prioritized for DPR at the national and state level, making it much easier to advance DPR projects in Arizona and elsewhere. Most significantly, since 2014, federal legislation provided several financing mechanisms and grants for utilities to fund reuse projects. These include the Water Infrastructure Finance and Innovation Act, 33 U.S.C. § 3901; America's Water Infrastructure Act of 2018 (AWIA; P.L. 115-270); America's Infrastructure Act, Water Resources Development Act[10]; and, the Infrastructure Investment and Jobs Act (IIJA), WaterSMART P.L. 117-58 § 40901 (2021). The latest, the IIJA, prioritized the 17 Western states by providing $1 billion in direct appropriations to the Bureau of Reclamation, in addition to making $48 million available nationally to be administered by the EPA (Humphreys & Ramseur, 2022). Adding to this momentum, the state of Arizona allocated $1 billion in state monies to water augmentation. Although the Governor envisioned these monies funding an expensive and geopolitically complicated desalinization plant located across the US-Mexico border on the Sea of Cortez (Black & Veatch & Libra, 2020; McEvoy & Wilder, 2012), a coalition of water policy leaders successfully lobbied the state to include other augmentation possibilities, including DPR.

[10] WRDAs have been enacted as stand-alone bills (e.g., in 2000, 2007, and 2014) and as part of broader bills (e.g., in 2016, 2018, 2020 and 2022) (Humphreys, 2019).

On the regulatory side, the federal government has chosen to work indirectly. In 2020, the EPA released a co-authored National Water Reuse Action Plan that lists 46 strategic actions as a “call to action” for involvement across the water community (US Environmental Protection Agency, 2019, p. 2). National professional associations also work to coordinate and accelerate local efforts. The WateReuse Association is dedicated exclusively to reuse, while the American Water Works Association, Water Environment Federation, Association of Drinking Water Professionals, and state level utility associations have a broader mission. In addition, several water think tanks, such as Water Research Foundation and National Water Research Institute, advance frameworks and research in support of water reuse goals. At the state level, utilities and engineering firms participate in the Arizona section of WateReuse Association. Regionally, municipalities coordinate water policy through coalitions, such as Arizona Municipal Water Users Association (AMWUA) and West Valley Water Users Association.

Tap Water Distrust

Broadly speaking, drinking water utilities must provide safe, adequate water to their customers. SDWA regulations determine the statutory thresholds that define “safe” water, but within these limits, utilities have leeway to establish what constitutes “adequate” water. In making such determinations, two additional considerations come into play: consistency and affordability. Inconsistent water chemistry may cause corrosion, and also tastes and odors prompting consumer complaints (Dietrich & Burlingame, 2020). Therefore, cost-effectively achieving consistent water quality guides many of utilities’ day-to-day operational considerations. For instance, on any given day a

Phoenix Water drinking water treatment plant may be serving a mix of water sourced from the Salt River, the Verde River, the Colorado River and groundwater, each with a different water profile. Changing drinking water supplies presents considerable risks for utilities. Many in the Arizona water industry remember when, in 1992, Tucson Water sought to reduce groundwater reliance by incorporating Colorado River water into their drinking water supply without adequate preparations, leading to corroded pipes and discolored water at many customers' taps (McGuire & Pearthree, 2020). More recently, the decision to switch Flint, Michigan's water supply to the Flint River as a cost-saving measure caused a lead water crisis in 2014 that has affected thousands of residents (Pulido, 2016; Sobrino, 2023; Teodoro et al., 2022). While these dramatic incidents resulted from egregious (and in Flint's case, allegedly criminal, Fonger, 2023a, 2023b) governance failures, they highlight the difficulty of providing consistent and affordable water under changing climatic and socioeconomic conditions.

The debacles in Flint and Tucson, and the many boil water advisories before and since, erode tap water's national reputation (Rosinger et al., 2021; Teodoro et al., 2022). Trust in tap water is at an all-time low, with approximately 25 percent of consumers opting for bottled water (Junker & Carpenter, 2021). However, compared with non-Hispanic whites, African-Americans and Hispanics were half as likely to drink tap water and more than twice as likely to drink bottled water, a rate that rose significantly after the Flint water crisis (Rosinger et al., 2021; Teodoro et al., 2022). Consumers' decisions at the tap have consequences for their personal health and finances, as well as the environment. Most tap water provides fluoride that lowers the risk of dental cavities (Rosinger et al., 2021). Moreover, when individuals do not drink water, they consume more calories from sugar-sweetened beverages and have lower total water intake (water from all food and beverage sources) (C. J. Brooks et al., 2017). Tap water, on the other hand, costs far less than bottled water and sugar-sweetened alternatives. An internet search conducted September 30, 2023, found that basic residential water and sewage service in Phoenix costs less than a penny per gallon, whereas bottled water costs $1.34 a gallon at retailers like Walmart and 25-30 cents a gallon at bottling stations. On the other hand, according to one estimate, the environmental impact of one liter of packaged bottled water is 100 times that of a liter of tap water (Jungbluth, 2005). Dupont and Jahan (2012) describe discretionary expenditures on tap water substitutes as "defensive" because they are intended to provide protection to the purchaser.

Notable service failures have focused attention on failing utilities, however many residents who reside in the territories of well-functioning water utilities elect to purchase bottled water rather than drink the tap water their utilities provide (Teodoro et al., 2022). According to a 2011 survey, people who did not believe in the safety of their tap water were almost five times more likely to choose bottled water as their main drinking source (Hu et al., 2011). Teodoro, Zuhlke and Switzer (2022) investigated the relationship between tap water participation and trust in government in their book, *The Profits of Distrust.* As they write, "Drinking tap water is a sign of trust in government: The citizen who drinks from the tap implicitly entrusts her health to the agencies that provide and/or regulate her water" (p. 31). The authors argue that trust in government is shaped firstly by lived experiences with and observations of government service provision. These experiences may be direct, "e.g., I trust my tap water because it is safe, reliable, and tastes good," and indirect, "e.g., I trust my tap water because my city's libraries, police, and fire departments are good" (p. 29). Secondly, the reputations of public agencies, including and beyond the water utility, contributes to trust in government. Thirdly, a person's identity shapes government trust. Teodoro et al. explain, "People who share racial, ethnic, socioeconomic, or other elements of social identity with victims of government failure will perceive government failure elsewhere as confirmatory evidence that government itself is untrustworthy" (p. 29).

Teodoro, Zuhlke, and Switzer's research documents how, if a dissatisfied consumer expects their water utility to be responsive, they may elect to voice their dissent in the hopes that the agency will improve conditions. However, those who do not expect their utility to respond competently, or who believe their concerns will be discredited or ignored, are more likely to stop drinking tap water, for instance, by purchasing bottled water. For people marginalized by legacies of government neglect (e.g., redlining), contemporary failures—in their utility service territory and elsewhere—to consistently provide safe and adequate drinking water are more likely to prompt exit than voice.[11] Utility failures, and the supposed superiority of alternatives,[12] are amplified by bottled water marketing campaigns (Doria, 2006; Pacheco-Vega, 2019). These forces contribute to what Teodoro et al. (2022) call a "vicious cycle of distrust in tap water:" as consumers exit, there is less political participation in water governance and less resources for utility performance, which increases the likelihood of tap water failure; should this come to pass, even more consumers would likely exit, reducing participation and resources still further.

[11] It should also be noted that an estimated 1,121,120 people (±25,537 margin of error) in the United States lacked piped running water between 2013 and 2017 (Meehan et al., 2020).

[12] In fact, the bottled water industry is largely unregulated, and their quality claims are unsupported (Koran, 2019; Teodoro et al., 2022).

As noted, direct experiences with drinking water's odors and flavors inform judgements of quality and safety that, in turn, influence consumer trust (Dietrich, 2006; Grupper et al., 2021; Lahne & Spackman, 2018; Teodoro et al., 2022). In this respect, Phoenix's drinking water supplies are particularly challenged. The regional water sources are naturally high in minerals. Research elsewhere has shown that consumers find the flavors associated with these minerals distasteful (Teillet et al., 2010; Whelton et al., 2007). Furthermore, seasonal variability requires utilities to switch between water supplies, affecting the consistency of water arriving at taps. In Phoenix, Arizona, even though present-day drinking water is of consistent quality across the city, residents with high concern about drinking water quality tend to be lower-income and predominantly reside in minority neighborhoods with historic experiences of low water quality (Bolin et al., 2010; Gartin et al., 2010). Research reveals the Phoenix area aligns with national trends: higher income households tend to drink tap water (usually filtered at the tap, Brand Outlook & HMA Public Relations, 2023), while lower income households tend to consume bottled water (Gartin et al., 2010; York et al., 2011). Teodoro et al. documented the prevalence of bottled water kiosks (e.g., Water Mill Express) in the Phoenix area, and found these to be located primarily in lower income and Hispanic neighborhoods (see Fig. 3). Extant research[13] on defensive spending in the Phoenix area indicates that many

[13] As well as practical experience. As one water utility employee commented during a researcher-facilitated meeting:

> But even if you talked to people who typically buy bottled water, some bottled water tastes bad to me. It tastes funny. But yet, I think those people are not focused on the taste, they are focused on the quality, and they trust that it's cleaner because it's in a bottle. But then you have people like my husband who trusts the quality of tap water, but he just doesn't like the taste. And so it's like you're trying to educate people who have different perspectives on tap water and bottled water and DPR and it's like, how do you sway all of them to understand, because the approach has to be different for all of them.

consumers already exit the drinking water system.

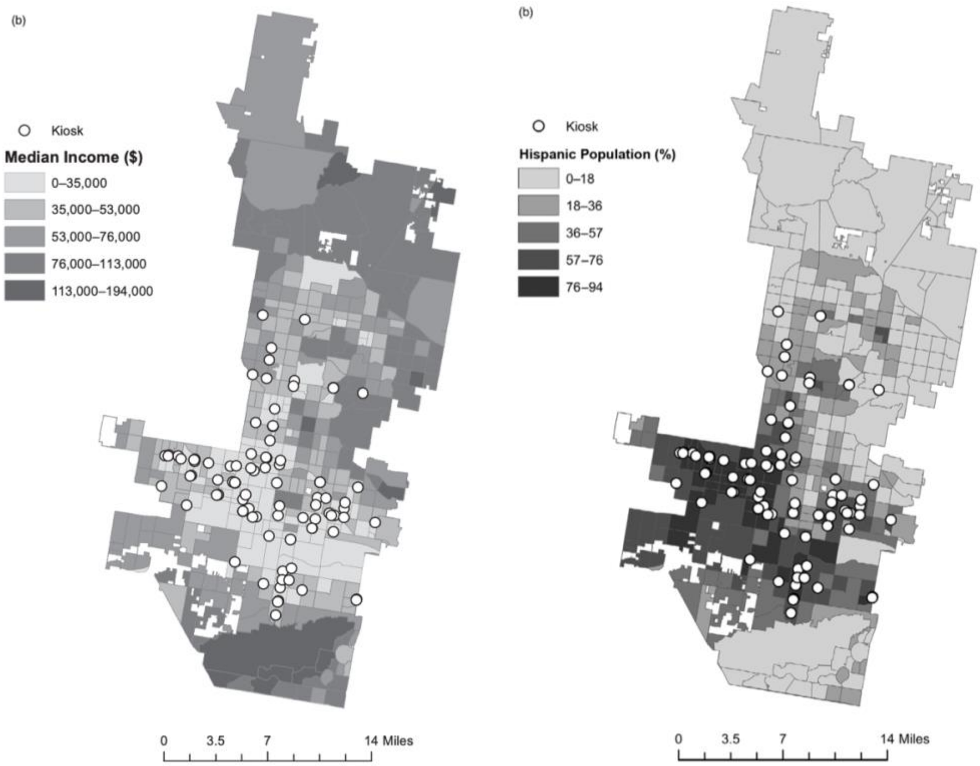

Figure 3, Kiosk Locations in Phoenix by Census Tract

Kiosk locations in Phoenix, AZ. Map a) shows location by 2016 census tract median income, b) shows location by percent Hispanic population (2016). Source: Teodoro et al. (2022)

Survey research has found that those who lack trust in water authorities are less supportive of DPR (Fielding et al., 2019; Ormerod & Scott, 2013; Ross et al., 2014; Stenekes et al., 2006). Research in Tucson, Arizona found that unsupportive residents were skeptical of scientific ability to detect and filter potential contaminants, suspicious of decision-makers' motives, and concerned about an overall lack of public voice in decision-making (Ormerod & Scott, 2013). An statewide survey in 2008 found that 60 percent of respondents oppose or strongly opposed wastewater reuse for drinking (Rock et al., 2012). More recently, Arizona Department of Environmental Quality (ADEQ's) commissioned public acceptance research to inform their DPR rule-making (Brand Outlook & HMA Public Relations, 2023). Leaders from private and public sectors were interviewed about their personal concerns and what they thought would pose the biggest barriers to DPR adoption. The most common concerns involved the cost to implement DPR facilities, the efficacy of the DPR treatment process, "the yuck factor" and trust in government. A representative sample of Arizona residents were also surveyed. Most respondents said they would be very likely or somewhat likely willing to drink DPR water. However, among respondents who consume bottled water, only 36 percent said they would be likely to consume DPR, whereas 54 percent said they would be unlikely to do so. Although survey results found no difference between Hispanics and Non-Hispanics regarding their likelihood to drink DPR water, 88 percent of Hispanic respondents said they avoided unfiltered tap water mostly due to safety and health concerns.[14] The summary report calls for special efforts to target Hispanic and Indigenous residents. One of the major recommendations: "Being able to let people taste the water will be integral to DPR gaining acceptance" (Brand Outlook & HMA Public Relations, 2023, p. 67).

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[14] Such a contradiction might be explained by the fact that many bottled water consumers do not recognize that they are typically drinking filtered tap water and are thus uninterested in the quality of utility services. This might even go a step further, from passive to active resistance to utility efforts to improve provision. As Teodoro et al. (2022, p. 29) write: "Indeed, distrustful citizen-consumers who exit for commercial providers may oppose efforts to improve government services because such efforts are seen as costly and futile."

A large swath of Arizonans has already demonstrated a willingness to commit additional resources to reduce their perceived health risks from tap water consumption. If Teodoro, Zuhlke and Switzer's hypothesis is correct, the introduction of a water supply that many find objectionable, such as DPR, is likely to prompt still further exit from tap water among socioeconomically marginalized residents. This situation has two serious potential outcomes: low-income households will expend more personal income for a lower quality product; and utilities will have less political support for their efforts to provide safe and adequate drinking water. Given the considerable costs involved in installing and maintaining an advanced water treatment facility capable of producing DPR, this should give pause to actors involved in DPR governance. This dissertation seeks to provide voice to bottled water consumers who might otherwise exit tap water under a DPR scenario.

CHAPTER 3

EMBODIED AND ENACTIVE COGNITION IN PRACTICE

Sustainable development aims “to meet the needs of the present without compromising the ability of future generations to meet their own needs” (World Commission on Environment and Development, 1987, p. ix). Towards this goal, sustainability scholars seek to understand how complex physical, biological, and social systems function so they may identify the drivers of unsustainable patterns of production and consumption. Given that most sustainability problems are human-caused, scholars often turn to research findings in psychology seeking in order to diagnose these and find solutions (e.g., Leiserowitz, 2006; Linder, 2022; Newell et al., 2014; Orlove et al., 2020). However, scholars may just as well turn to philosophy, which asks similar questions about what the experience of consciousness can teach us about the human condition (e.g., Käufer & Chemero, 2015; Thompson, 2011; Varela et al., 2016). They might also turn to practice theory, which is interested in everyday habits that shape patterns of production and consumption (e.g., Reckwitz, 2002; Rouse, 2023; T. Schatzki, 2011; Shove, 2022; Shove & Walker, 2007). Indeed, as this chapter demonstrates, psychology, philosophy, and practice theory are historically intertwined and have contemporaneously arrived at similar conclusions about what guides human action providing a new foundation for sustainability theory and practice.

The framework of human action assembled in this chapter is applied in the rest of this dissertation. The chapter begins with a brief overview of the historical lineage of theories of consciousness from the advent of psychology and phenomenological philosophy to their contemporary manifestations in embodied and enactive cognition. The naturalist orientation of these theories provides robust understanding of biological co-evolution, but less about why certain cultural institutions emerge and are maintained. So, this chapter next turns to sociologically informed practice theory, but finds that although stemming from philosophizing about bodily engagement with the world, practice theory has lost its focus on the body. To address this gap, the chapter returns to theories of enacted and embodied cognition to enhance how practice theory understands the situated body. The overview provided here serves to orient the reader towards the argument in later chapters that understanding human cognition as embodied, action-oriented, and situated in the social and ecological surroundings (humanature) can better inform sustainability's descriptive, normative, and prescriptive goals.

Defining and Studying Consciousness in Early Psychology

Psychology is a relatively young science; it only became its own discipline roughly 150 years ago. Before that, theorizing the workings of the mind, consciousness, and action was the purview of philosophers and theists. Early psychologists, therefore, sought to define a separate discipline based on experimental methods; however, many continued to draw on philosophical methods and findings to theorize the nature of consciousness.

Early psychologists were highly influenced by the evolutionary theories of Charles Darwin, but also his contemporary Jakob Johann von Uexküll. Uexküll challenged Darwin's view that natural selection drove evolution and offered an alternative account of effortful (agential and goal-directed) co-evolution between organism (or even cell) and environment (Michelini, 2020). Uexküll further theorized that everything an organism perceives makes up its "world-of-perception" (*merkwelt*) and everything an organism does comprises its "world-of-action" (*wirkwelt*); these together form one closed unit, the perceived world (*umwelt*). He distinguished between the *umwelt* and the molecular geophysical environment (*umbung*) (Michelini, 2020). Epistemologically, Uexküll's theory simultaneously legitimated introspection as a method of subjective inquiry into on organism's own umwelt, and mechanical instrumentation as a method of objective inquiry into the shared umbung.[15]

Furthermore, evolutionary theory supported naturalists' argument that all mental phenomena, even abstract mental processes, such as conceptualization, reason, and the soul, must be based in sensorimotor capacities (Johnson, 2006). Based on this, James (1890/1995) argued that "Psychology is the Science of Mental Life" and therefore should focus on "conditions," e.g., sensations, as well as "phenomena," e.g., "feelings, desires, cognitions, reasonings, decisions, and the like" (p. 1). James and others believed that all mental phenomena arise through association, such that, for example, concepts are given meaning through association with other concepts (Mandelbaum, 2022). However, from this shared belief in naturalism and associationism, psychologists developed very different theories about the workings of consciousness (Chemero, 2013). Wilhelm Wundt's Structuralist school was influenced by Descartes' mind-body dualism and followed Descartes' reductionist method, which sought to understand mental phenomena

[15] Von Uexküll's chief example was the tick, which can wait for years on a branch in order to fulfill its three functional cycles comprising a functional circle: first, a warm blooded animal provides a smell-based stimulus that prompts the tick to allow itself to fall; second, a temperature-sensitive organ provides feedback that it has, indeed, fallen onto a warm-blooded organism; and third, the tick uses its sense of touch to find a hairless spot where it digs its head in to suck the animals blood (Michelini & Köchy, 2020, p. 226).

by identifying their constituent parts (Chemero, 2013). Structuralists also adopted Hume's proposal of an isomorphic relationship between simple ideas and basic sense impressions (Mandler, 2007). The structuralist proposal, which came to be known as atomism, was that mental phenomena were meaningless sensations assembled into meaningful objects by association (Leahey, 2003). In the atomist view, mental phenomena were all distinct, thus could be combined to form new experiences without relevance to context and environment (Juarrero, 2000).

James's Functionalist school, on the other hand, followed holism in its efforts to reveal empirical laws of consciousness. Functionalists asked how a mental process operates, what it accomplishes, and under what conditions it appears (Mandler, 2007). The functionalist proposition was that we abstract parts of experience from a continuous unified whole based on associations between an observer's past and their present experience of the world (Hookway, 2006; James, 1890/1995). This proposal shifted focus from conceptualizing the environment and context surrounding an organism from something that is responded to, as reflexes would suggest, to something that is acted on with intentionality (Dewey, 1896; Hildebrand, 2011). As John Dewey (1896, p. 97) wrote, "The real beginning is with the act of seeing; it is looking, and not a sensation of light." The action-oriented view of perception was championed by American Pragmatists James, Dewey, and Charles Peirce, and in Europe by influential psychologist Franz Brentano, whose students included several psychologists who went on to establish the Gestalt School, including Carl Stump and his students Max Wertheimer, Wolfgang Köhler, and Kurt Koffka.

Gestalt psychology was a new take on consciousness. Early American Gestalt psychologist Robert Morris Ogden explained, “According to the Brentanian tradition it is not the content of experience but the experiencing, not the sensation but the sensing, that is factual” (Ogden, 1933, p. 151). James had earlier proposed *radical empiricism* to investigate the makings of actual, lived experience but Functionalists faced an epistemic challenge in designing non-reductive ways to study these processes (Hildebrand, 2011). Brentano proposed a “descriptive psychology” (Käufer & Chemero, 2015, p. 20), which applied careful observation and classification to mental experience. Gestalt psychologists built on Brentano’s method to investigate the mental structures that constitute experience of an objective world. They applied systems theory (by way of Wertheimer, who studied under physicist Max Planck) to clarify the mental structures that constitute experience of an objective world. The Gestalt School conducted experimental investigations into apparent motion, figure-ground relationships, perceptual grouping, and the principles of similarity, proximity, and functional closure.

For example, in Wertheimer’s experiments of continuous motion (the *phi* phenomenon), subjects viewing stationary images in rapid succession perceived them as moving (Leahey, 2003). Whereas Structuralists explained away such experiences as cognitive illusion, arguing there is no experience of motion given in consciousness therefore the motion is merely apparent, Wertheimer and his followers insisted that the experience of motion was real, although it did not correspond to any physical stimulus (Leahey, 2003). Based on this and similar investigations, Gestalt psychologists proposed that the mind actively organizes sensory input into coherent perceptual experiences that form meaningful wholes (*Gestalten*), famously interpreted as “the whole is greater than the sum of its parts” (Leahey, 2003). However, the epistemic challenge remained: if meaning only exists in relation, how can perception be examined? This empiricist challenge to the gestalt theory of situated perception was left unresolved, in part because the Holocaust forced many leaders of the Gestalt School to flee to the United States where their work found less support among university psychology programs modeled on the structuralist laboratories in Europe (Käufer & Chemero, 2015; Leahey, 2003; Spellman & Schnall, 2009).

American psychologists working in the functionalist tradition sought develop a scientific approach that sought to reveal internal mental processes through observable behavior rather than introspective methods, which were increasingly seen as unreliable (Spellman & Schnall, 2009). This approach, which came to be known as Behaviorism, translated sensation and sensing into the objective terms that could be defined based on biophysical reactions (Ogden, 1933). Behaviorists, like John B. Watson and B.F. Skinner, believed that behavior could be understood and predicted almost totally without reference to subjective experiences by examining the pairing of stimuli and responses through learning and conditioning (Spellman & Schnall, 2009). Behaviorists took an atomistic view of association, arguing that cognition is more of an epiphenomenon than part of a causal chain from information to action; therefore, there is no need to examine the mind (B. D. Jones, 2017). From the 1920s, this view dominated psychology, shutting the mind off as a subject of inquiry for an entire generation of psychologists.[16] Although producing many useful insights, the increasingly reductive methods of psychology could not explain how we abstract experience from a unified whole.

[16] Barrett (2018, p. 171) refers to this period as "the dark ages."

Phenomenology and Enactivism

While historical events relegated Gestalt psychologists' functionalist experiments to the sidelines of mainstream psychology and Behaviorism closed off psychological inquiry into the workings of the mind, philosophy was free to continue investigating experience through philosophical methods. Phenomenological philosophy emerged from the same intellectual milieu as Gestalt Psychology. Before becoming a student of Brentano, Edmund Husserl completed his doctoral thesis under Stumpf, one of the Gestalt School founders. Husserl, however, critiqued the notion that a Gestalt could be an object in the world (Käufer & Chemero, 2015). Husserl also dismissed as dualist Behaviorists' supposition that "psychophysical" investigations of the physical body could reveal the experienced body (Behnke, 2011; Hildebrand, 2011). Instead, he drew from Brentano's descriptive psychology to advance phenomenology as a set of scientific procedures one could undertake to examine the essential features of experience (Behnke, 2011; Käufer & Chemero, 2015).[17]

Aron Gurwitsch, who studied under Stumpf, was highly influenced by Husserl.[18] Gurwitsch emphasized that we perceive things in meaningful contexts and configurations rather than as isolated elements (Käufer & Chemero, 2015). Gurwitsch shared Husserl's scientific aspirations for phenomenology and sought to describe the underlying structures and patterns that govern how we perceive and make sense of the world (Käufer &

[17] Husserl specified a series of maneuvers a phenomenologist could take to analyze the body as directly experienced from within. The most fundamental of Husserl's procedures is called "phenomenological reduction" or "epoche," which involves setting aside assumptions about the external world and focusing solely on the phenomenon as it is experienced (Käufer & Chemero, 2015).

[18] Gurwitsch noted in Field of Consciousness (2010, p. 166) that as a natural science, the "explanatory phase of empirical and even Gestalt psychology had no relevance for phenomenology" (Moran, 2019).

Chemero, 2015). For instance, Gurwitsch proposed that experiences are structured as "phenomenal fields" consisting of organized wholes such that every experience has a horizon of implied meanings and experiences that extend beyond its explicit, immediate content and provide a broader context or background against which the explicit aspects make sense (Moran, 2019). This explains how, in visual perception we can perceive an object's back or its inside even if we cannot see them, and through multimodal perception a surface may be seen as rough or smooth without being touched. By defining this and other invariants of situated perception, Gurwitsch hoped to help phenomenologists "overcome socio-historical relativism" (Artese & Kiverstein, 2022, p. 220, footnote 1).

Husserl's student, [19] Martin Heidegger, argued that we encounter the world through practical involvement with objects and tools, a notion he called *Dasein*, often translated as being-in-the-world (Käufer & Chemero, 2015). For example, when using a hammer to drive a nail, we are not consciously thinking about the hammer; we are simply focused on the act of hammering the nail (Käufer & Chemero, 2015). Based on this, Heidegger concluded that we do not typically view objects in an abstract, detached manner (present-at-hand) unless something disrupts our ongoing activities or goals; instead, objects remain in the background of our awareness as ready-to-hand, enabling us to interact with the world effortlessly (Käufer & Chemero, 2015). From this, Heidegger proposed that experienced reality (*Dasein*) is shared, as skilled performance in the present moment simultaneously invokes a collective past and future (Käufer & Chemero, 2015).

[19] Husserl's influence was far-reaching in psychology as well as philosophy. Influential psychologist Wilhelm Wundt's introspective psychology, which focused on examining conscious experience, was influenced by Husserl's ideas.

Although, Heidegger centered the body in theorizing being-in-the-world, it was Maurice Merleau-Ponty who emphasized the world is "lived-through" the body (Leitan & Chaffey, 2014). In his most influential work, *Phenomenology of Perception*, Merleau-Ponty (1945/2012) built on Uexküll's earlier proposition to argue that human bodies, including their sensory organs and associated perceptual capacities, provide a common perceptual foundation upon which culture is established. This opened the door to examinations of how social structures and identity categories such as race, gender, sexuality, and class intersect with lived experiences (Käufer & Chemero, 2015). For instance, Merleau-Ponty's contemporary Frantz Fanon argued that his black body experienced a different world in colonial Algeria than white bodies (Käufer & Chemero, 2015). However, Merleau-Ponty, Jean-Paul Sartre, and other phenomenologists continued to neglect how cultural influences may shape embodied experiences, and vice versa (Cox, 2018). Nevertheless, phenomenology's distinct understanding of individual consciousness as skilled engagement with material surroundings was seen to offer insights into the structure of society.

Theorizing the Mechanics of Cognition

As Behaviorist psychology lost favor in the 1950s,[20] the new field of cognitive science returned to the mind as a topic of inquiry. The pioneers of the "the Cognitive

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[20] Stout (2019) writes:

> When B. F. Skinner, talked about behavioural conditioning in the 1950s and 1960s the political reaction against behaviourism became established. It didn't matter that Skinner's main political message was that punishment and negative conditioning generally were much less effective forms of conditioning than positive reinforcement. The very idea that scientists should be setting themselves up as an authority on how to condition people so that they behaved better had become anathema. (p. 23)

According to Stout, this backlash contributed to behaviorism losing favor among both the general public and psychologists.

Revolution" took inspiration from newly available computer technologies, which provided a powerful analogy for distinguishing physical brain's "hardware" from the cognitive "software" of mental states (Fincher-Kiefer, 2019). Herbert Simon, Alan Newell and other cognitive scientists developed a computational theory that conceptualized the mind as a top-down, central information processor that identified, evaluated, and selected optimizing strategies through sequential, linear processes (G. Wheeler, 2018). Cognitive phenomena, such as sensation, perception, attention, and memory, were believed to be atomistic and modular (Fincher-Kiefer, 2019). Furthermore, early cognitive scientists were mentalists, believing behavior could be wholly explained through mental states (Hatfield, 2017). While cognitive science later considered the environment's influence on action through Simon's theory of bounded rationality, [21] Simon vigorously rejected the body's role in cognition (Petracca, 2021). The almost complete ignorance of the body at the outset of cognitive science had long lasting effects on contemporary psychology (Gigerenzer, 2021).

Ecological psychology emerged in the 1960s and 1970s in reaction against the mentalism of cognitive science (A. Clark, 2001; Lobo et al., 2018; Thelen & Smith, 1994). Its main originator, J.J. Gibson, was a contemporary of Merleau-Ponty and was aware of his theories, but was a self-described "radical empiricist" and naturalist who saw himself as continuing the functionalist tradition of Gestalt psychology to understand perception from the ground up (Käufer & Chemero, 2015; Riley & Holden, 2012). Gibson's laboratory studies[22] documented that visual perception is produced through

[21] discussed more in Chapter 5

[22] Eleanor Gibson née Jack, J. J. Gibson's wife, deeply informed his theories (D. Proffitt & Baer, 2020). A psychological researcher in early childhood development, she was barred from pursuing her

continuous and active perceptual search (e.g., involuntary movements of head and eye). Based on this observation, Gibson theorized that actions influence the way we perceive the world, and in turn, our perception guides our subsequent actions, terming this *action-perception cycles* (L. Shapiro, 2019; J. J. Gibson, 1979/2014). In contrast to prevailing theories that assumed we perceive objects' biophysical qualities, Gibson argued that when we look at objects we perceive their *affordances*, which he defined as directly perceivable environmental opportunities for action (J. J. Gibson, 1979/2014). Affordances, like colors, are real, but wholly depend on the practices and abilities of the perceiver (Rietveld & Kiverstein, 2014, p. 338). For example, a pool of water affords swimming for a human, whereas it affords walking for a water bug (Gibson, 1979/2014). As Gibson wrote, "There is only one environment, although it contains many observers with limitless opportunities for them to live in it" (1979/2014, p. 126).

Gibson's proposed a body-based, algorithmic theory of cognition that was in direct opposition to computational claims that cognition is representational, and operates according to syntactic rules (Beer, 2000; Chemero, 2013). Although not formally affiliated with the cybernetics movement, Gibson's interests aligned with cyberbeticists' goal of developing the theoretical and mathematical tools to theorize how, through non-linear system dynamics, purpose and intentionality may emerge in humans and machines (Dupuy & DeBevoise, 2000). As part of this project, biologist Humberto Maturana and neuroscientist Francisco Varela (1980) sought to identify what distinguished living from nonliving systems, and introduced the concept of autopoiesis, which describes the

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own career until late in life yet contributed important works to the field (E. J. Gibson & Pick, 2003; E. J. Gibson & Walk, 1960) and was recognized with a National Medal of Science in 1992 (Rodkey, 2010).

characteristic of living systems to regulate and renew themselves so as to maintain the integrity of their structure (Maturana & Varela, 1980). [23] Other research in biology, ecological psychology, language processing, early child development, and robotics applied the mathematical models of systems theory to study how complex phenomena emerge from the interaction of multiple components, bringing new understanding to dynamical systems (Beer, 2000).[24] Today, complex adaptive systems provides the overarching framework for how dynamical processes evolve over time, give rise to larger patterns, and produce phenomena such economies and ecosystems (Preiser et al., 2018). Dynamical systems modeling is now prevalent in cognitive science and neuroscience, informing the study of many foundational problems in psychology, including perception, memory, decision making, learning, problem solving, and language (Riley & Holden, 2012). Complex adaptive systems has also been widely applied in sustainability science to theorize human-nature dynamics; however, the fact that both human consciousness and societal organizations arise through the same dynamical processes is not often discussed in sustainability (cf. Schill et al., 2019).

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[23] The opposite of an autopoietic system is an allopoietic systems, such as a car, which requires an external organizer and inputs for its assembly. The cognitive implications of autopoeisis were further developed in Varela, Thompson and Rosch's (2016) enactivist approach to cognition. However, the claim that autopoeitic were functionally closed came under challenge given that openness was understood as a core condition of complex systems (Cilliers, 1998/2002). Since then, Di Paolo (E. Di Paolo, 2018; E. A. Di Paolo, 2005) has argued that autopoeisis alone is not sufficient for life, but that living systems must also be adaptive, meaning they can change their boundaries when they approach the edges of their viability.

[24] Shapiro (2019; also, Shapiro & Spaulding, 2021) explains dynamical systems using the analogy of a centrifugal governor, which maintains the speed of a steam engine by adjusting the opening of a steam valve based on the speed of a spinning spindle connected to flyballs. When the valve opens, the flyballs rise, causing the valve to close, which slows down the spindle and makes the flyballs drop. This, in turn, opens the steam valve again, creating a continuous cycle. In contrast to a computational approach which would measure the engine's current speed, compare it to the desired speed, and calculate corrections, the centrifugal governor accomplishes its task without the need for a central processing unit, or even representations or calculations.

Embodied and Enactive Cognition

In psychology, inquiries into the causal mechanics of cognition have generated theories of *embodied cognition,*[25] which emphasize the body's role in perception and cognition. For instance, ecological psychologist Denny Proffitt et al. undertook a series of studies where they asked subjects to guess a hill's steepness (Bhalla & Proffitt, 1997; D. R. Proffitt, 2006). According to their findings, elderly people judged a hill as steeper than college soccer players; whereas those who recently ingested a caloric drink saw it as less steep, as did participants who had a friend present, and those who merely thought about a friend. These studies demonstrate that perception of an invariant objective stimulus (Uexküll's umbung) can vary based on one's biophysical and emotional capacities.

The embodied cognition research program was once a disorganized, fringe movement that included cognitive psychology's studies of perception, action, and language; social psychologists' theories of emotion; as well as studies from the fields of evolutionary psychology, animal behavior, neuroscience, philosophy, linguistics, robotics, and artificial intelligence. However, many of the principles of embodied cognition have become widely accepted in cognitive science and mainstream psychology (Petracca, 2021). Additionally, the various research findings from this research program have contributed to a wider "embodied turn" across the sciences aided by embodied cognition's productive interplay with phenomenologically informed investigations into the production of meaning (Chemero, 2013; Gallagher, 2012; A. Wheeler, 2016; M. Wheeler, 2013).

Francisco Varela, Evan Thompson, and Eleanor Rosch's (1992/2016) book, *The*

[25] Similar claims have been advanced under the terminology of grounded cognition (Barsalou, 2008).

Embodied Mind, introduced *Enactivism*[26] to theorize how organisms enact, or bring forth, their worlds through teleological activity. The book combines work in phenomenology, neuroscience, and situated robotics to upend the prevailing view in cognitive science that cognition involved discrete, representational cognitive processes (Käufer & Chemero, 2015). Whereas Gibson's "perceiver-dependent" worldview describes perception in individualistic and nonsocial terms (Artese & Kiverstein, 2022), enactivist theories of *sensemaking* offer an account of goal-directed perception of affordances that refers to a wider practical context for action.

For instance, Gibson's theory of affordance described perception as directed action but left unstated to what ends action is directed, beyond evolutionary success. Rietveld and Kiverstein (2014) put affordance theory in conversation with Heidegger's notion of enskillment to understand how an organism selects from a landscape of affordances:

> Experts… encounter an environment overflowing with affordances, and they single out from among the available affordances just those that are relevant to their interests, preferences, and needs (or what we henceforth refer to as "concerns") in the specific situation… More generally, as an individual acquires a skill, he or she becomes increasingly able to adjust his or her actions to the specific demands of the given situation in which she finds herself. What the skilled person has learned to do over the years feeds back into the way the meaningful world appears to her in perception. (p. 341)

Rietveld and Kiverstein (2014) illustrate the Enactivist view of human sensemaking as co-constituted with the ecological and social environments through instantaneous action-perception cycles and over evolutionary timescales.

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[26] sometimes referred to as 4E cognition for "enacted, embodied, extended, embedded"

This dissertation terms the disparate theorizing across embodied cognition and enactivism *embodied and enactive cognition* (EEC). EEC theorists share the rejection of classical information processing theories in cognitive science in favor of embodied theories that “put the brain back in the body” (D. Proffitt & Baer, 2020, p. 8). Beyond this minimum commitment, EEC theorists espouse a range of beliefs often characterized on a spectrum of “strong” to “weak” embodiment (Shapiro, 2019).[27] Proponents of strong embodiment (e.g., Chemero, 2011; Gallagher, 2017; Noë, 2006) locate cognition in embodied actions, which suggests we literally think and know with our bodies. Strong embodiment theorists (e.g., Chemero’s *radical embodied cognition*, 2011) advocate for non-conceptual (“mind-less”) knowing that views cognition as completely embodied, eliminating the need for representational thought. In contrast, proponents of weak embodiment argue that certain forms of higher order cognition—for example, logical or mathematical reasoning, thinking about imaginary things and counterfactuals, or long-term planning—are what Clark and Toribio (1994) refer to as “representation hungry.” In this view, the body merely causes or functionally accompanies brain-based cognition.

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[27] Shapiro (2019), in an effort to define the field, suggests the EEC research program includes the following claims:

- Conceptualization: The properties of an organism’s body limit or constrain the concepts an organism can acquire. That is, the concepts by which an organism understands its environment depend on the nature of its body in such a way that differently embodied organisms would understand their environments differently.
- Replacement: The array of computationally inspired concepts, including symbol, representation, and inference, on which traditional cognitive science has drawn must be abandoned in favor of others that are better-suited to the investigation of bodily-informed cognitive systems.
- Constitution: The body (and, perhaps, parts of the world) does more than merely contribute causally to cognitive processes: it plays a constitutive role in cognition, literally as a part of a cognitive system. Thus, cognitive systems consist in more than just the nervous system and sensory organs.

Over time, cognitive science has gradually assimilated these ideas so that all but the most radical school of embodied cognition makes space for representational thought (Petracca, 2021). Without necessarily advocating the realist accuracy of strong embodiment, this dissertation primarily adopts that thesis to draw the most contrast with cognitivist assumptions about human cognition perpetuated in sustainability science.[28]

More recently, EEC has embraced complex adaptive systems, which offers an overarching framework to describe how human-nature dynamics play out at the point of action, as well as how, through action-perception cycles, skilled engagement evolves and contributes to the formation of culture. On a macroevolutionary scale, over millions of years of learning in uncertain environments, single celled organisms exhibiting simple behaviors (e.g., orienting towards lights) evolved into humans with sensory and motor capabilities well-suited to adaptive behavior —to find food and mates, to avoid toxins and predators, and to solve the basic goals of organisms (Gigerenzer, 2021; Mastrogiorgio & Petracca, 2016). For instance, primates (including humans) are the only animals able to make smooth-pursuit eye movements, which are useful for tracking things of interest, with dexterous hands leading to dexterous eye movements, an example of how abilities cascade (D. Proffitt & Baer, 2020).[29] Increasingly sophisticated human sensorimotor capabilities provided for more elaborate communication and coordination.

Theorists have further elaborated how, as Mark Johnson (2006, p. 48) writes:

[28] The reluctance to outright claim strong embodiment should not cast doubt on that perspective; it may have more to do with the fact that, as is often the case, some philosophical propositions challenge the empirical abilities of positivist science.

[29] As Proffit & Drake explain (2020), you can try this by holding your finger in front of you and tracking it with your eyes without moving your head. In contrast, if you hold a treat in front of a dog and move it from side to side, they will track it by moving their head. It's not that dogs can't move their eyes, but they can only do so in fast, jerky eye movements called saccades.

"…everything we attribute to 'mind'—perceiving, conceptualizing, imagining, reasoning, desiring, willing, dreaming—has emerged (and continues to develop) as part of an ongoing evolutionary process in which organisms seek to survive, grow, and flourish within various environments." Emotion provides a specific example of how this might have come about. Damasio & Damasio (2018) posit a simple mutation proved adaptive by providing important feedback on internal and external biophysical states. This feedback was affect, the general feeling of excitement or calm (arousal) and pleasantness or unpleasantness (valence) one experiences at all times (J. A. Russell, 2003). Affective experience emerges from a continuous and shifting stream of interoceptive (internal bodily sensations) and proprioceptive (body's position and movement) perceptual information that draws on the same neurological and physiological processes involved in somatosensory processing (Hatfield, 2017; Marsella & Gratch, 2009). Emotions serve to categorize affective experiences and make them meaningful for action, as well as serving a coordinating function (Barrett, 2018; Carvalho & Damasio, 2021). Because cooperation is evolutionarily adaptive, the neural mechanisms of perception are acutely tuned to inter-human communication (Barrett, 2018). Emotions help us make sense of these intersubjective flows of information, and accumulate shared meanings over time, forming culture (Barrett, 2018; A. Damasio & Carvalho, 2013; Hutchins, 2014). Thus, the thinking goes,[30] on macroevolutionary timescales, emotions and culture co-evolved through the same complex adaptive dynamics by which human sensorimotor perception

[30] This account of emotions is not fully settled (see Barrett, 2018). Also, it should be noted that theoretical proposals by Barrett and Damasio would be classified as "weak" embodied cognition given they allow a role for representation in cognition. Nevertheless, this exposition illustrates the value of EEC as a general approach to formulate a naturalistic theory of how individual cognition and human culture co-emerged in response to environmental dynamics.

became sensitive to environmental features that supported survival (L. Shapiro & Spaulding, 2021). As this brief discussion illustrates, embodied cognition's commitment to naturalism and the enacted view of consciousness offered by phenomenological philosophy provides a useful entry point to theorize how, through goal-directed action in a complex environment, complex human society arose (Thompson, 2011; Varela et al., 1991/2016).

Putting the Body Back in Practice Theory

While Enactivists drew from the phenomenological philosophy of Husserl, Heidegger, Merleau-Ponty and Gurwitsch to derive naturalistic foundations for human society from bodily experience, later phenomenologists embraced the view that bodily experience was itself a product of human society. Judith Butler's (1988, 1990) applied phenomenology to point out how bodies are "gendered, classed, sexually-'oriented', aged, 'raced', with differing degrees of dis/ability and corporeal variation…and not always singular or individuated" (Allen-Collinson, 2009, p. 5). Practice theory provided a bridge between these two perspectives, asking how "both social order and individuality … result from practices" (T. R. Schatzki, 1996, p. 13). [31] Practice theory makes use of Heidegger's assertion that learning is a process of enskillment and also Pierre Bourdieu, who, in *Outline of a Theory of Practice* (1977), elaborated on "practical dispositions" and the concept of *habitus* to explain how agents produce and re-produce the social structures

[31] Schatzki distinguishes between "first generation practice theorists" Pierre Bourdieu, Anthony Giddens, Jean Lave, Judith Butler, Sherry Ortner, and Michel Foucault, and "second generation practice theorists" Andreas Reckwitz, Elizabeth Shove, Hubert Dreyfus, Joseph Rouse, and Theodore Schatzki (T. Schatzki, 2017, p. 26).

they inhabit through their everyday activities—or *praxis*.[32]

Thus, practice theory examines the skilled performance of practice to answer questions about the experience of lived reality. According to Reckwitz (2002, p. 249), a practice is a routinized behavior that includes several connected elements, such as "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." Shove, Pantzar and Watson (2012) distill Reckwitz's list of elements down to materials (objects, infrastructures, tools, hardware and the body itself), competence (the multiple forms of understanding and practical knowledge), and meaning (mental activities, emotion, and motivational knowledge); collectively. However, Nicolini (2017, p. 4) cautions that such discussions of practice "tends to foreground the content of practice at the expense of its inherently performative nature… turning practice into 'some-thing'" and advises practice theorists to focusing on performance to reveal the "the processual nature" of the practice approach.

Practice theory is not a really a theory claiming to be true (Reckwitz, 2002).[33] Rather, practice theory can be taken as a heuristic device in speculative enterprises; in other words, practice theory prompts us to ask, "What can thinking with practice help us

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[32] Practice theory draws on Bourdieu's concept of "field," which he explained using the analogy of a soccer field: players engage in the same game and their relative positions to each other are defined by past interactions and shape opportunities for future ones (Smets et al., 2017). "In short, their positions – and potential actions – are driven by their prior engagement with others in the practice (Bourdieu, 1977; 1993)" (Smets et al., 2017, p. 369). This resonates strongly with the participatory sensemaking view of interaction discussed in Chapter 6.

[33] Alternative terminologies include practice idiom, praxeology, practice lens and practice-based studies (Nicolini, 2017). See also Rouse (2022, p. 500):

> "Stephen Turner noted that "a large family of terms [are] used interchangeably with 'practices,' among them . . . some of the most widely used terms in philosophy and the humanities such as tradition, tacit knowledge, Weltanschauung, paradigm, ideology, framework, and presupposition" (1994, 2). Related concepts of performativity (Butler 1990, 1993) or enactment (Mol 2002) are prominent in feminist theory and science studies."

to do?" (Nicolini, 2017). The normativity of praxis both enables and limits the possibility of meaningful and practicable action by practitioners (Watson, 2016). Therefore, Shove, Pantzar, and Watson (2012) argue that the study of practice should investigate how, through practical performance, linkages between meaning, competences, and materials are made, reified, or dissolved. Practice-driven approaches adopted across the social sciences generate useful theorizing about social relationships (Nicolini, 2017).

However, practice theory has lost some of its earlier focus on human embodiment and embeddedness in the world suggested by its roots in phenomenological philosophy. Rouse (2023, p. 53) contends, "Many characteristic problems of practice-based social theories arise from not recognizing participants in practices as animals whose interactions are aspects of the intimate interdependence of living bodies with their biological environments." To remedy this, Rouse (2023) "draws on ecological-developmental biology, niche construction theory, and other work in evolutionary biology and related fields" (p. 10) to formulate a "naturecultural account of practices" that envisions competent performance as "not a static set of capacities, but a continuing realignment of skills and behavior with changing patterns of resource availability and behavior" (p. 286). Other practice-theoretical accounts, especially those emerging from organizational institutionalism, have emphasized that competent performance of practice involves emotional and aesthetic engagement with the material world (Harquail & Wilcox King, 2010; Scheer, 2012; Smets et al., 2017; Voronov & Vince, 2012). These contributions begin to align practice theory with the EEC view that human culture emerges, and changes, through coupled bodily interaction with environmental affordances. Conversely, a biologically-informed practice theory improves enactive accounts by providing a normative basis for action (Hutchins, 2014; Rouse, 2023; Sterelny, 2010).

Seeking to understand what constitutes practices, and the performances that contribute to their reproduction (or discontinuance), can provide insight into the constitutive entanglement between human bodily capacities and socio-material affordances. Joy Parr's (2010) book *Sensing Changes: Technologies, Environments, and the Everyday*, describes how this entanglement appears among communities learning to cope with catastrophic environmental contamination:

> We make meaning by doing and organize our awareness and skill through bodily practice. The body is a synthesizing instrument that defies the categorical and linear discipline of language and science. The environments and technologies with which we live, play, and work lead us to develop specific modes of bodily attention and perception. This tuned reciprocity among body, environment, and technology has historically allowed humans to feel at home, competent, and safe. (p. 4)

This dissertation makes use of the bridge Rouse has created between biologically informed practice theory and EEC to introduce an *embodied practice* approach that takes seriously the claim that humans "make sense" of the world through their bodies. The chapters that follow theorize practice as a coevolutionary outcome of human bodies' situated entanglements with sociocultural and biophysical surroundings (humanature). In the next chapters, this dissertation applies this embodied practice approach to investigate Central Arizona's transition to adopt wastewater as a drinking water supply. Findings demonstrate how viewing cognition as environmentally and socially situated sensemaking can inform the practices and theories of sustainability governance.

CHAPTER 4

HYDROLOGICS: THE INTERPLAY OF BODIES AND INSTITUTIONS IN SUSTAINABILITY TRANSITIONS

An estimated 3.6 billion people currently live in areas that experience water scarcity at least one month a year (UNESCO World Water Assessment Programme, 2018). As cities face the combined stressors of population growth, climate change, and increased competition for scarce water resources, new water management approaches are urgently necessary. Although managers recognize present and impending water challenges to water security, the range of acceptable policy options is constrained by mismatched public perceptions of the need for new water policies, the viability of water resources, and the trustworthiness of water managers (Gartin et al., 2010; Sullivan & White, 2019; White et al., 2019). Without new governance approaches, disconnects between management objectives and public perceptions may reduce the range of options available to managers.

One example of these disconnects can be seen in wastewater reuse, which has emerged as an opportunity to increase water use efficiency, especially in arid climates (Jiménez Cisneros & Asano, 2008). Advancements in science and technology have made it possible to treat wastewater and return it directly to the drinking water supply, a process known as direct potable reuse (DPR). Nevertheless, DPR faces strong barriers to public acceptance. A scan of the literature reveals that over seventy academic publications have been published since 1996 examining a wide array of factors that affect DPR acceptance. In this literature, public reluctance is frequently attributed to the “yuck factor," the visceral disgust many feel towards DPR. However, scholarship examining the broader socio-technical transition involved in DPR emphasize that acceptance is hardly ever one-dimensional or linear. Beyond concerns about technological risk, public opposition is often embedded in larger governance conflicts, for example about urban and regional growth (Meehan et al., 2013; Morgan & Grant-Smith, 2015; Ormerod & Scott, 2013; S. Russell et al., 2008; Stenekes et al., 2006). For instance, Meehan et al. (2013, p. 79) examined planned potable reuse projects in the United States and Australia and found that, compared with non-potable reuse, treating effluent to drinking water quality "requires greater levels of institutional control and thus concentrates power in the hands of water experts." Thus, when the public exerts their power in decision-making, it frequently involves organized resistance, such as ballot initiatives to ban expansion of potable reuse (Meehan et al., 2013). Critical analyses of failed consensus-building about DPR have added important complexity to intersecting socio-spatial inequalities involved in what is often simplified in the literature to "public acceptance." However, few provide insight into the practices and institutions that need to change to better account for differentiated emotional experiences in DPR decision-making processes (see Scruggs & Thomson, 2017 for a notable exception).

In the Phoenix, Arizona, metropolitan area, where non-potable and indirect potable reuse[34] are widespread and accepted, DPR has become a preferred strategy among many utilities facing impending water shortage. However, gaining support for the financial investments necessary for DPR is challenging in part because of the "yuck

[34] Indirect potable reuse involves an environmental buffer between the wastewater treatment plant and drinking water treatment plant. See the "Defining Wastewater-water Integration" in Chapter 2 for further detail.

response” and stigma associated with this form of wastewater reuse. Chapter 2 describes how, in anticipation of a time when DPR would be considered a necessary and financially viable water management strategy, in 1997, the state began to lay the formal institutional framework for DPR through a series of guidance documents. This effort led to a repeal of the statewide prohibition on DPR in 2018, at which point Arizona Department of Environmental Quality (ADEQ) indicated it would pursue formal rulemaking to enable regulations while utilities undertook novel public engagement activities to demonstrate the viability of a future with DPR. However, this rulemaking process was slow to get underway.

This chapter seeks to answer the question, *how do perceptions and feelings—emotions and bodily sensations—shape the transition to DPR in Arizona*, through an examination of the formal and informal ways that proponents sought to legitimate DPR. To establish the theoretical foundation for this inquiry, the chapter starts by reviewing how the organizational institutionalism and socio-technical transitions literatures conceptualize legitimation of innovation, paying special attention to how emotions and sensations (feelings) serve a constitutive role. This review identifies *embodied cognitive capacities* (Harquail & Wilcox King, 2010) as an integrative framework that draws from theories of embodied and enactive cognition (EEC) to locate feelings at the foundation of institutions. Next, a methods section describes how primary and secondary data was collected during a three-year study of a group of utility actors and other stakeholders in Central Arizona as they considered whether and how to implement DPR in their management territories. Then, the findings section reviews the strategies wastewater managers have adopted to alter wastewater institutions as DPR became an increasingly urgent priority in Arizona. A significant finding is that the feelings of a wide range of actors—including consumers, regulators, elected officials, environmentalists, developers, and water utility managers, operators, and communications staff—have contributed to the transition to DPR. Finally, the discussion describes the theoretical contributions of this research to inform theorize the micro-foundations of sustainability transitions and the legitimation of innovation and explores opportunities for expanding this work.

Theoretical Foundation

Doubly Embedded Actors and Institutions

When Arizona DPR proponents apply various strategies to legitimate DPR, they seek to intervene in individual perceptions and broader societal norms. To analyze these strategies, this chapter draws from *organizational institutionalism*, which seeks to understand the relationship between individuals and institutions.[35] Situated within *new institutionalism*, or *neo-institutional theory*, organizational institutional scholars' sociologically inspired investigations of strategic planning in organizations (e.g., Dimaggio, 1988; T. B. Lawrence, 1999; Zucker, 1987) illustrate how the "taken-for-granted quality" of institutions often makes changing them inconceivable (Zucker, 1977, p. 728). The construct *institutional logics* (Friedland & Alford, 1991, p. 243) was introduced to describe how actors are embedded in "socially constructed, historical patterns of material practices, assumptions, values, beliefs and rules" that structure their

[35] This dissertation follows institutional theory's definition of institutions as the formal and informal rules, norms, and structures that govern social behavior within a society or organization. Alesina and Giuliano (2015) note that outside the institutional literature, and in general parlance, informal institutions are often referred to as culture.

material experience and provide “meaning to their social reality” (Thornton & Ocasio, 1999, p. 804).

Organizational institutional scholars seek to understand the “paradox of embedded agency” (Seo & Creed, 2002), or how an actor *embedded* in institutional logics comes to challenge supposedly taken-for-granted rules, practices, and norms. *Institutional complexity* emerging from contradictory logics can spur actors to construct new institutions (Friedland & Alford, 1991; Maitlis, 2005; Seo & Creed, 2002; Voronov & Yorks, 2015). *Institutional entrepreneurs* are actors who recognize the value of resolving institutional complexity and deploy resources to influence their institutional context towards the adoption of new rules (Dimaggio, 1988). In the resulting view, actors are *doubly embedded* in institutional logics, meaning institutions shape actor agency to recognize and change institutional constraints (Hallett & Ventresca, 2006).[36]

Practice-driven institutionalism (PDI) applies practice theory to organizational institutionalism to articulate the conditions by which doubly embedded actors affect institutions (Lounsbury et al., 2021; Lounsbury & Crumley, 2007; Smets et al., 2017; Zilber, 2021). Empirical applications of PDI seek to understand *institutional work*, the purposive actions and regularized practices that create, maintain, and disrupt institutions (T. Lawrence & Suddaby, 2006). Institutional work brings attention to the material and symbolic practices of a wide range of actors, including those who play a supportive role to institutional entrepreneurs (T. Lawrence & Suddaby, 2006). PDI thus provides insight into how institutional logics are reproduced and homogenized among actors, often referred to as the *micro-foundations of institutionalization*. However, less work has been

[36] They also refer to this as “doubly constructed.”

done to reveal why certain forms of institutional work are more effective in institutionalization processes. For this, I turn to the literature on the legitimation of innovation in socio-technical transitions.

Legitimating Innovation in Socio-technical Transitions

Processes of institutionalization are a central concern of the socio-technical transitions literature, which draws from science and technology studies, organizational institutionalism, and studies of innovation, consumption, and entrepreneurship (Köhler et al., 2019). Socio-technical transitions are defined as radical changes that take place over long timeframes across interconnected societal systems, including technological, economic, institutional, environmental, and psychological systems (Loorbach & Rotmans, 2010). Applications of practice theory to socio-technical transitions expanded attention beyond innovative technologies and infrastructures, to the practices they produce, sustain, or disrupt (T. Schatzki, 2011; Shove, 2022; Shove & Walker, 2007).

Core to understanding transition dynamics is the concept of *regime*, defined as a dominant and stable system configuration enabling fulfillment of specific societal functions, such as water provision (Loorbach et al., 2017). Regimes are associated with institutional logics that become sedimented through the reproduction and homogenization of routines, technologies, laws, standards, and beliefs (Fuenfschilling, 2019; Fuenfschilling & Binz, 2018). Under some conditions, innovative ideas and practices can emerge from institutional niches to challenge regime logics, leading to widespread disruption (Rogers, 2003).

Institutional theory has aided scholarly understanding of why and how some innovations gain legitimacy. Regimes with institutional complexity and tensions may present more opportunities for radical transformation by supporting institutional plurality and increasing actor agency (Fuenfschilling & Binz, 2018; Fuenfschilling & Truffer, 2014, 2016; Hess et al., 2016). It is believed that actor agency can increase conflict, itself a source of innovation, and provide more rationalities for actors to draw from to make sense of and legitimate their actions (Fuenfschilling, 2019). The degree of preexisting alignment between a niche innovation and regime logics can determine the amount, and kind, of work institutional entrepreneurs must do to achieve legitimacy (Binz et al., 2016; Harris-Lovett et al., 2015; T. Lawrence & Suddaby, 2006). These entrepreneurs, guided by alternative logics, can create institutional pressures that, through cascading organizational responses, transition regime dynamics (Fuenfschilling & Truffer, 2014, 2016; Hacker & Binz, 2021; Smets et al., 2012). Ultimately, when regimes are perceived to be legitimate, their associated logics and practices are reproduced and stabilized with less likelihood that conflict or experimentation will lead to the creation of disruptive niche innovations.

In this way, organizational institutionalism's theoretical conceptualization of doubly embedded actors has aided socio-technical systems' understanding of legitimation. However, institutional and socio-technical systems scholars still tend to characterize institutions as primarily cognitive and reproduced and stabilized through discursive practices (Lok et al., 2017).

Embodied Cognitive Capacities

To better account for the many ways institutions are enacted, maintained, and transferred, Hallett and Ventresca (2006), introduced the concept of *inhabited institutions*. As Voronov & Yorks (2015, p. 579) explain, "[W]e need to understand how people experience the institutional arrangements that not only shape the resources available to them, but also make their lives meaningful and prime how they think and feel." Over the last two decades, organizational institutional scholars have been building out the inhabited view of institutions by paying closer attention to bodily sensations and their emotional resonance within practices of organizational sensemaking. Although not affiliated with this literature, institutional scholar Polski (2017, p. 43) draws from EEC to define institutions as:

> a signaling mechanism that helps actors coordinate behavior…[that may include]…language-based constructions such as policy statements, laws, regulations, norms, and standard operating procedures; [as well as] other symbolic representations such as numbers, signs, and computer code; images; sounds; gestures; odors; touch; flavor; and other mechanisms associated with sensation.

Polski's definition is applied in this analysis to provide an account of *how* institutions are inhabited.

Emotions, "as intersubjective, collective experiences" (Goodwin & Pfaff, 2001, p. 283), are increasingly seen as important signaling mechanisms, as well as factors in institutional stability and change. These ideas influenced Scott (2013b) to update his influential framework, "the three pillars of institutions," to better account for the ways that emotions serve to coordinate and regulate actor behaviors, and how emotions motivate entrepreneurial actors to change institutions in which they are disinvested, or maintain institutions to which they are attached (see Fan & Zietsma, 2017; Massa et al., 2017; Wright et al., 2017). As Lok et al. (2017, p. 592) notes, "At no time are institutions more fragile than when people no longer feel what institutions prescribe them to feel."

The role of emotions in motivating and regulating actor behavior is by now well established in the literature (Scott, 2013), but their constitutive role in shaping social orders is less developed (Zietsma et al., 2019). A small body of theory has begun to fill this gap. Institutional logics contain *emotional registers* that serve as prescriptions about what emotions are appropriate to express, or even to feel (Toubiana & Zietsma, 2017; Voronov & Vince, 2012; Zietsma & Toubiana, 2018). *Emotional competence*, the ability to experience emotions in alignment with institutional logics, is critical to the "capacity to belong in and inhabit an institutional order" (Voronov & Weber, 2016, p. 457). As these constructs illustrate, emotions play a structuring role in institutions, but more empirical and theoretical work is still necessary (Lok et al., 2017; Zietsma et al., 2019).

The emotional turn taking place in organizational and institutional theory is an important contribution. However, emphasizing emotions without attending to their underlying bodily sensations leads to an incomplete understanding of institutions. The sensory basis of emotions in institutional theory is often centered in investigations of materiality, where the material properties of spaces and artifacts enable the creation of meanings that move across space and endure over time (C. Jones et al., 2017; Nicolini et al., 2021). However, the material body itself is largely absent from this theorizing. In his theory of *habitus*, Bourdieu (1977) considered "the dialectical relationship between the body and a space," such as ways of walking, hand gestures, and facial expressions, to be critical in "the embodying of the structures of the world, that is, the appropriating by the world of a body thus enabled to appropriate the world" (p. 114). Habitus is one element of *institutional aesthetic* codes that provide "shared sensibilities" for how to represent the world, making peoples' "experiences and their associated patterns of representation, expression, and action not only cognitively comprehensible, but culturally resonant and meaningful" (Creed et al., 2020, p. 421). Aesthetic experiences are, therefore, key to all forms of sensemaking, not simply those with an obvious material dimension.

Empirical examinations of institutional aesthetics tend to concentrate on the symbolic rather than embodied dimension of experience. To rectify what Hassard et al. (2000, p. 5) refer to as "disembodied organizational analysis," institutional scholars increasingly draw from embodied ethnographic methods, such as enactive ethnography (Wacquant, 2015) and sensory ethnography (Hurdley & Dicks, 2011). However, while the resulting literature (e.g., Creed et al., 2020; Harding et al., 2022; McConn-Palfreyman et al., 2022; Meziani & Cabantous, 2020; Wright, 2019) centers on the senses, sources of meaning are primary credited to emotional resonance, rather than direct sensorial experience (W. E. D. Creed et al., 2020). This runs the risk of reifying the mind-body dualism these investigations seek to overcome (Gärtner, 2013).

By comparison, embodied and enactive theories of cognition (EEC)[37] understand cognition to be embodied, meaning that active bodily engagement with the internal and external environment is the basis of cognition. According to the theory of constructed emotion, for instance, emotions are a mechanism to organize the continuous stream of perceptual information into meaningful experiences (Barrett, 2018). For those seeking to understanding sensemaking in (de-)institutionalization, emotions *and* bodily sensations are key markers of meaning. The personal phenomenology of feelings (e.g., people experience them internally) can sometimes contradict their intersubjective and constructed nature. For this reason, Lok et al. (2017) call for organizational

[37] These theories are explained in more detail in Chapter 3.

institutionalism to adopt a relational approach to the study of emotions that moves beyond the individual to the "transpersonal."

This chapter adapts one of the only explicit applications of EEC theories in organizational institutionalism, Harquail and King's (2010) construct of *embodied cognitive capacities*. They describe "an ongoing, iterative, embodied cognitive process for the individual organizational member who draws on multiple modalities to assimilate the same organizational situation, with each [embodied cognitive] capacity mining different modalities of information and evoking a different perspective on that experience" (p. 1624). They theorize these modalities as four interlinked ways of experiencing: bodily-kinesthetic, visual-spatial, temporal-aural, and emotional. In their view, what information is gathered from the environment, and how it is understood, depends on one's embodied cognitive capacities, which are socially constructed and revised through participatory sensemaking.

Harquail and King's application of embodied cognitive capacities provides an integrative framework to investigate "the socially embedded, interdependent, relational, and emotional nature of persons' lived experiences of institutional arrangements" (D. Creed et al., 2014, p. 278). Furthermore, the construct of embodied cognitive capacities provides a means to analyze the double-embedding by which institutions shape individuals' capacities, limiting or enabling their agency to transform these same institutions. Through evolutionary processes, humans have acquired certain embodied cognitive capacities. Over a lifetime of practical engagement with their socio-material environment, an individual actor refines their embodied cognitive capacities to detect and respond to environmental and institutional signals, making certain possibilities for action, including imagined action, available or unavailable. Each instance of performance presents an opportunity to share, reify, or transform embodied cognitive capacities through a process referred to as *attunement*.[38] As the embodied cognitive capacities of the collective are attuned, institutions and practices change in response; and vice versa, as institutions adjust to endogenous or exogenous factors, individuals must re-attune their embodied cognitive capacities. However, this coupling of embodied cognitive capacities and institutions is not frictionless but produces institutional conflicts that actors must work to resolve. The analysis reported here examines the institutional work involved in transferring embodied cognitive capacities among individuals and groups, giving insight into the feelings at the micro-foundation of institutions.

Legitimating DPR

Only a handful of studies about DPR are informed by socio-technical systems or institutional theory (Morgan & Grant-Smith, 2015; S. Russell et al., 2008; S. Russell & Lux, 2009; Stenekes et al., 2006) and none of these substantively address the embodied aspects of this transition. Only research enterprise is clearly informed by organizational institutionalism: research conducted by Binz, Harris-Lovett, et al. examined the institutional work involved in legitimating DPR in a case study of California's DPR transition and concluded that more successful projects employ a diverse portfolio of legitimation strategies (Binz et al., 2016; Harris-Lovett et al., 2015). These studies point to the institutional work of actors, rather than larger struggles involving coalition-building or framing, as decisive factors in DPR legitimation (Binz et al, 2016). This is

[38] The term "attunement" is used in sensory ethnography to describe the shift that occurs when a change in bodily sensing practices brings new perceptual awareness of the environment (Parr, 2010; N. Shapiro, 2015; Stewart, 2011).

important because, as Binz et al. (2016) point out, California's legitimation involved a small group of powerful individuals involved in utilities, industry, and regulatory agencies. They observe, "While their favorable social position enabled them to quickly push their agenda into the legislative process and coordinate the sector-wide legitimation strategy, their close interpersonal connections might also undermine the emerging sector's credibility in the long run…" (Binz et al., 2016, p. 29). However, by focusing exclusively on managers in their empirical explorations on institutional work, they reify the "heroic" entrepreneur tradition (Hardy & Maguire, 2017). Furthermore, since neither paper explicitly includes the body or emotions in their analysis of practice, they only capture part of what makes some legitimation strategies more effective than others. For example, Harris-Lovett writes that providing tastings of DPR is a cognitive legitimation strategy that demonstrates how "an innovation meshes with the end user's daily life experiences and cognitive frames" (Harris-Lovett et al., 2015, Table 1). Yet, little explanation is provided for why any single strategy provides more cultural-cognitive legitimacy than another. Tastings deserve special attention as a legitimation strategy, since many researchers suggest they are key to gaining consumer trust (Binz et al., 2016; Eckl et al., 2023; Harris-Lovett et al., 2015; Smith et al., 2018). However, few have studied this form of embodied decision-making in any detail (Ellis et al., 2019; Nancarrow et al., 2008; Po et al., 2005), and none have done so using actual DPR, perhaps because there are very few projects with regulatory permission to serve it to the public.

These previous studies of DPR institutions add valuable insights to aid researchers and practitioners, but more work is needed to understand the micro-foundations of this socio-technical transition. Most prior empirical studies were conducted post-hoc (Binz et al., 2016; Harris-Lovett et al., 2015; Meehan et al., 2013), are based on proposed or theoretical DPR projects (Ormerod & Scott, 2013), or are conducted in another supra-institutional setting (e.g., Australia, Morgan & Grant-Smith, 2015; Russell et al., 2008; Stenekes et al., 2006). Research findings reported in this chapter mitigate the limitations of these previous studies in two ways. First, the data informing the study presented in this chapter was collected contemporaneously with an active transition to DPR in Central Arizona. Second, this research involved a broad set of actors, including many actors who were not members in the niche network of DPR innovators.

Methods

Although Arizona has an important history of state-led initiatives in support of sustainable water management, actors working in local and regional water management are primarily responsible for implementing reforms (White et al., 2015). This research, therefore, focuses on the institutions and practices of urban water managers and other stakeholders as they considered whether and how to advance a transition to DPR. Research activities were granted an exemption by the Arizona State University institutional review board (Appendix C).

Data Sampling, Sources, and Collection

Based on preliminary research and consultation with local water experts a theoretical sampling approach (Eisenhardt & Graebner, 2007) was taken to select municipalities representing a range of institutional capacities and stages of DPR development. To identify municipalities' institutional capacities for managed water transitions, the researcher applied a typology that defines urban water management organizations' sustainability based on their performance on key sustainability variables (R. R. Brown, 2008). The final sample of twelve municipalities was selected to include a range of intentions related to DPR, including municipalities known to be planning to pursue DPR, those with no stated intentions to do so but who might benefit from this form of wastewater reuse, and those with no stated intention or clear need to add DPR to their portfolios. Four municipalities declined to participate in the study, resulting in final sample of eight municipalities, plus one private water provider. This approach resulted in a sample of municipalities that represented a breadth of positions and institutional capacities related to DPR, including four with active intentions to pursue DPR.

Table 1, Ethnographic Data Collection

Interviews	
Environmental NGOs (3 Organizations)	4
Water Policy NGOs (3 Organizations)	3
Public Water Providers (8 Municipalities)	18
Private Water Provider	1
Residents	2
Consultants	3
Regulators	3
Total	34
Participant Observation Events	
Public meetings	24
Private meetings	9
Webinars	16
Conferences	7
Total	56

In recognition of the polycentricity of water and wastewater governance (Pahl-Wostl, 2009), additional stakeholders selected for interviews included representatives of state and local regulatory organizations, a private utility, environmental advocacy organizations, private consultants, policy advocacy organizations, and residents appointed to utility governance committees (Table 1). Interview subjects were purposively sampled for their involvement in wastewater management based on their job title or through personal referral (snowball sampling, Bernard, 2011).

Semi-structured interviews. Primary data collection included interviews conducted with at least two representatives from each municipality, and some subjects were interviewed two or three times. These interviews followed a semi-structured protocol, and generally lasted 60 minutes, although some interviews were shorter or longer depending on interviewee availability. The interview script asked interviewees about the historical development of wastewater management; the technical, regulatory, financial, consumer factors that may challenge the adoption of DPR; how they are making decisions about whether, and how, to pursue or support DPR; and how they coordinate, formally or informally, with others in the management of wastewater or DPR.

In situ observations. Additionally, primary data collected at public meetings provided important insight into organizational strategies and institutional conflicts. Participant observations were collected at nearly all public regional and state-level discussions of DPR during the study term, as well as many national stakeholder meetings (Table 1). To collect robust information on municipal decision-making, the researcher was granted permission to observe one utility's internal planning meetings as they planned one DPR project and deliberated about how best to pursue others. Participant observations were collected using a semi-structured protocol to ensure the consistency of observations across events (Creswell & Poth, 2018). Appendix A details the annotation rubric for these various data types.

Data Analysis and Interpretation

Transcribed interviews, interview notes, participant observation field notes, and collected documents were subjected to qualitative content analysis (Bernard et al., 2016). These data were imported into qualitative coding software MaxQDA, where they were systematically analyzed using an inductively and deductively generated codebook. A priori codes based in theoretical assumptions discovered during preliminary research (Manheim & Spackman, 2022) formed the foundation of this codebook, which included codes for the emotional and sensorial experiences of actors adapted from sensory science (Barwich, 2020) and sensory anthropology literatures (Ballestero, 2019; D. D. Jackson, 2011; Parr, 2010; N. Shapiro, 2015; Sobrino, 2023) literatures. Additional codes specific to urban water governance were adapted from a document analysis on land and water use planning in the study region (Quay et al., 2018). Codes to capture processes of social legitimation were adapted from Scheufele et al.'s (2021) typology of effective public engagement in emerging technology. Inductive codes were temporarily added during coding when no match could be found in the code book. If these codes were found to be relevant in subsequent coding, they were permanently added to the codebook and previously coded data was recoded for these themes.

Textual data. Secondary data collection included existing local and state policy materials, organizational management plans and any supplementary resources accessible via the organization's website, and publicly available planning documents pertaining to

DPR. This data was then cross-referenced with information obtained from primary sources, as well as other pertinent industry literature and established scientific research.

Findings: Working to Innovate Wastewater Institutions and Practices

This section draws from collected data to present a detailed account of how perceptions across a range of stakeholders have actively shaped Central Arizona's transition to DPR. This analysis is presented in two sections. The first section describes how DPR has become the preferred strategy of actors associated with Arizona's water management regime. The second section illustrates how wastewater managers came to realize that advancing DPR in Arizona would require innovative interventions.

How DPR Became a Regime Solution, and Conundrum, for Water Scarcity

At the start of each interview, wastewater management stakeholders were asked to reflect on previous management approaches to wastewater. Nearly all interviewees recounted how, in accordance with dominant institutional logics of wastewater, they historically saw treated wastewater (effluent) as "nuisance water" and enacted organizational strategies aimed to "get rid of it" as efficiently as possible (WWGI09). The resulting wastewater management arrangements mostly involved coordination with other utilities, irrigation districts, and government agencies to dispose of effluent as efficiently as possible. When groundwater restrictions went into effect in the 1980s, priorities shifted to put effluent to use in irrigation or industry. As the value of wastewater increased, however, the practices and logics of wastewater managers changed. As one water manager recalled, "[B]ack in the day, it was okay to put a bunch of reclaimed [water] on big areas of turf, but now maybe it's, like, reconsidering the whole thing, right? Like, maybe there shouldn't be even that much turf, even though you are irrigating it with reclaimed" (WWGI25). A shift in practices occurred as wastewater practitioners began to adopt new logics that understood wastewater as fit for any purpose, including drinking water, with adequate treatment.

For managers operating in Arizona's institutional and climatological context, wastewater reuse offers significant advantages. First, for water managers dealing with unprecedented uncertainty in inter-annual surface water supplies, the "steady" supply of wastewater from homes and businesses represents a "consistent supply" that can help stabilize water portfolios (WWGI19, WWGI20). According to one utility manager, "[I]t's a little tough to do planning when you don't know the certainty of supply… [I]t's almost a certainty that the uncertainty is probably going to drive a faster turn towards DPR" (WWGI07). Second, the novel resource-rights arrangements of effluent gives ownership to the entity that treats the water. From the perspective of water managers contending with uncertain groundwater availability and variable surface water supplies, the consistency and legal security of wastewater presents an opportunity to increase their sense of control (WWGI09). For this reason, wastewater has become an important component of most utility portfolios, with 90% of wastewater in the study area reused (Arizona Department of Water Resources, 2022).

Non-potable reuse is limited by the geographical reach of dual pipe systems but once treated to potable standards effluent may be put to any use. Wastewater managers initially sought to convert effluent to potable water through indirect potable reuse (IPR) through aquifer recharge or surface water exchange. However, surface water exchanges are difficult to secure, and aquifer recharge is not available to all utilities because of lack of space, hydrogeography, or groundwater contamination.[39] For these and other reasons, many municipalities facing water resource challenges have a strong interest in DPR, but until recently the substantial capital and operating costs of advanced water treatment trains, in addition to public antipathy, have inhibited them from pursuing it.

The institutionalization of wastewater as drinking water brought utility managers into contact with consumers in new ways. As one manager recounted, “I don't think at the time we really had given a lot of thought to what it was going to take in terms of public perception” (WWGI19). As this comment intimates, the organizational and material reconfiguration of wastewater resulted in a conflict between “old” and “new” wastewater institutions and practices. As one manager put it in 2021:

> You have two obstacles: one is financial, and one is public perception… And when you start running the numbers on DPR, you go, all right, listen, this is just a whole bag of worms. I'm not going to go pay the money, deal with the public perception issue, and do all that, because I have these other cheaper water resources. And then you're going to go to council and go, hey, we would like our water rates raised to be able to pay for this DPR plant that we don't need yet. That's a résumé moment. They send you somewhere else to be a director of a smaller town. (WWGI07)

The social legitimacy of DPR therefore depends, first, on convincing other reuse actors, politicians, regulators, and the public that water technicians and technologies are capable of sufficiently cleaning wastewater to meet the safety and quality standards of potable supplies. Secondly, legitimating DPR requires demonstrating that the financial costs associated with facility construction and operation are better than those for alternative

[39] These issues are discussed in more detail in Chapter 2.

water supplies. Without these two critical components of social legitimacy, entrepreneurial water managers who advocate for DPR risk their reputations.

In the face of these obstacles, utilities that stand to benefit from DPR have, until recently, opted for IPR. One manager explained, "[H]aving the environmental buffer is a lot easier to step across the public acceptance threshold" (WWGI25). Utilities also alter their plans for DPR to make them more acceptable to hesitant consumers. According to one manager, "In our master plan we are looking at direct plumbing to do DPR as an option… [T]o make sure it's accepted to the public we would plumb it back around to the front of the drinking water facility" (WWGPO14). At least two other utilities in the valley are considering a similar arrangement, which amounts to treating the water twice as much as would likely be required by regulators. As these comments make clear, utilities adjust plans to minimize negative public perceptions.

Different Actor Orientations Towards DPR

Municipal utilities stand to benefit the most from implementing DPR regulations and, thus, municipal water workers and elected officials have been driving these efforts in Arizona.[40] As municipal utilities push reforms to formal and informal institutions necessary to begin DPR, other actors respond based on their own assessment of the

[40] Private utilities are less involved in advancing DPR in Arizona. Based on ownership structure, utilities' rates are regulated slightly differently by the Arizona Corporation Commission (ACC). Due to the additional oversight provided by the elected leadership of public utilities, their rates typically consider prospective factors about the investment needed for future water service. In contrast, when presenting proposed rate changes to the ACC, private utilities may only factor previous expenditures and rates (rate base calculation), which typically results in a 5–6-year lag between rates and present-day operations (WWGI08). Therefore, private utilities tend to invest capital up front and then demonstrate that it is "used and useful" to justify including that cost in rates. This makes it difficult for private utilities to justify investing in large capital-intensive projects, such as DPR, based on expected future need (WWGI08; WWGI09). As one public utility employee explained, "But if it was available to them, or somebody sold it to them, I think [private utilities] would be open to buying it and using it" (WWGI09).

possibilities and risks associated with DPR. Engineering consultancies often work side-by-side with municipalities and university researchers to provide technical support during the regulatory process. Because of the considerable liability exposure these firms take on when designing a treatment plant, their governance structures essentially prohibit them from working in an unregulated context (WWGI30; WWGI25; WWGPO09). Engineering firms therefore volunteer to craft regulatory pathways with the expectation that a functional permitting process will open new market opportunities for their companies to design, install, and sometimes manage these facilities (WWGI30).

However, not all utility employees are DPR evangelists, and some are even non-believers. Based on conversations with water utility staff, it’s clear that many utility employees involved in directly managing and operating wastewater and drinking water treatment facilities are reluctant about DPR. Some utility engineers consider the public preoccupation with biological contaminants to be misguided (WWG17). As one pointed out, “There are a lot of things that we don't test for and that we also don’t treat for" (WWGI15). Given that DPR requires utility technical staff to take on new public outreach roles, not helping them over their personal discomforts with DPR can have dire consequences. One reuse industry communications consultant recounted:

> One agency that I worked with, the tour was led by the guy who was in charge of the facility. On the tour, someone raised their hand and asked him, ‘Would you drink this water?’ And he said, ‘No, I can't get the toilet out of my mind.’ And turns out there was a reporter in the tour, and this was a lead story. Everyone needs to be comfortable with this. (WWGPO11)

For this reason, a leading reuse consultant advises utilities to begin their DPR outreach efforts with their own employees, “Your employees are people too” (WWGPOP01).

Whereas utility technical staff usually have engineering degrees or extensive experience with treatment works, utility communications staff do not typically have technical backgrounds and therefore, in private, often respond to DPR more as consumers than as utility professionals. A utility communications staff person recalled her own initial discomfort with DPR, and recounted, “I told a fellow co-worker of mine who was new to the department, and she was like, ‘Ew’” (WWGI01). Because of this, it may be easier for utility communications professionals to understand the complexities of consumer DPR hesitancy than their technical colleagues. As one utility engineer explained: “I just look at it and go, all right, it's just technology and its proven technology, and we can do this safe and all of that” (WWGI07). However, since water utility leadership almost always have engineering backgrounds, utilities tend to consider outreach to be of lower priority than engineering in planning for DPR projects, despite warnings to the contrary from national water reuse practitioners.

Often overlooked in discourses about public perceptions of DPR is the reluctance of regulators. A national leader explained to the audience at the 2021 national WateReuse Association conference, “The obstacle is not just public perception but also regulatory perception—they are there to protect public health but also follow the public [and may say], ‘I just don't think the community is going to accept this.’” This study’s findings suggest that regulators were more likely than engineers, water utility employees, or university researchers to express hesitancy related to the technical risks associated with DPR. For instance, one regulator commented: “Personally, I want it to have gone through the most protective treatment process. As a normal human being everyone wants that. According to internal conversations, we are not up to that level yet" (WWGI23). Regulators' personal reluctance is heightened by their professional responsibility to enact and enforce regulations protective of human and environmental health (WWGPO11). And due to turnover among regulatory agency staff, departmental expertise on DPR has varied, leaving them at times without adequate internal resources to vet industry sponsored proposals (WWGI26).

Environmentalists are somewhat conflicted about DPR. Most major environmental NGOs in Arizona have endorsed DPR policies at various points because of their potential to reduce pressure on surface water supplies (WWGI12; WWGI15; WWGI28). The environmentalists interviewed recognize the value that effluent-fueled wetlands and streams have for wildlife habitat, and many shared the concern that, as a result of reallocating effluent from waterways to cities, these habitats are likely to reduce or disappear altogether (WWGI12; WWGI15; WWGI28).[41] Environmentalists were also concerned that locking in effluent demand might create supply-side lock-in and reduce utility incentives to conserve water (WWGI12; WWGI15; WWGI28).[42] As one observed, "We keep seeing urban water use declining, right? Like, we're adding more people, but our use is staying the same—declining in some places. And so, what are the impacts of that when planning for DPR?" (WWGI28). Despite these concerns, environmental organizations have limited capacity to participate in DPR directly and have therefore

[41] At the Tres Rios wetlands created by the effluent produced at the 91st Avenue Wastewater Treatment Plant, the endangered Yuma Clapper Rail (Rallus longirostris yumanensis) has been spotted. Reduced effluent flows may affect the habitat of this endangered bird.

[42] As one utility employee explained, "And so, we're seeing now that it's modeling, you know, that we're kind of flatlined on the wastewater. We're just hopeful we start seeing an increase. That means people have to use more water" (WWGI04).

ranked it low among their other priorities in Arizona (WWGI15). Furthermore, as one environmentalist put it, they are "recognizing a lot of these utilities are our partners and just being careful" (WWGI28). Over time, the landscape-level changes associated with reallocating effluent to urban use may challenge existing partnerships between environmentalists and cities and reduce important wildlife habitat.

Building a Normative Network of DPR Proponents

A small number of institutional entrepreneurs are regularly involved in efforts to advance DPR in Arizona. Having interviewed or observed most of these individuals, it's clear the drive is personal. As one Arizona reuse leader explained:

> For me, I grew up here in the desert and I'm very aware—watching how Phoenix in particular—the Phoenix area, the metro area, has exploded as I've grown up and lived here… [T]hat's what gets me up and staying up late and working on weekends on this stuff. Just because I want to see it succeed. I think it's a good thing for us. (WWGI25)

Many echoed the view that maximizing wastewater reuse is the "right thing to do" in a water scarce local (WWGI19). Others discussed how "exciting" it is to be involved with new technology (WWGI10). One utility engineer remarked: "[I]t's kind of like cutting edge…. [W]e talk about 'One Water' all the time, right, and now it's just taking it to the next level…" (WWGI09). According to another engineer, this enthusiasm is contagious, "It's hard not to become obsessed, because everyone around you is obsessed too." (WWGI10). These factors motivate the strong personal commitment many reuse proponents feel to advance DPR in their organizations.

Professional reuse organizations provide important forums for stakeholders to acquire the practical knowledge and confidence to address the concerns of various actors regarding DPR. Policy think tanks, such as Water Research Foundation and National Water Research Initiative, publish white papers and hosted webinars addressing various technical, regulatory, and public perception concerns related to DPR. However, these are rarely accessed by local leaders, whereas the national WateReuse Association's webinars and Arizona chapter meetings are well-attended. The annual Arizona WateReuse symposium held each summer in Flagstaff, Arizona is an important forum to build personal networks and influence the DPR landscape (WWGI01). As much as the technical evidence, the professional networks featuring credible peers helps establish the technical legitimacy of DPR. According to one water manager, another benefit of attendance is to "have the regulator's ear, listen to what they are looking at and where their thought process is…to be heard and influence the outcome of…rulemaking" (WWGI20). Conference keynotes feature endorsements for DPR by elected leaders of Arizona's national, state, and local governments. Through this conference, DPR proponents work to establish the social legitimacy of DPR among their peers.

The Arizona WateReuse meeting in Flagstaff also stands out for its playfulness and camaraderie. For instance, as illustrated in Figure 4, each year the conference kicks off with a DPR water balloon fight, and two long-standing board members contribute kegs of home brewed DPR beer that is shared at a word-of-mouth hotel room gathering. Although open to all, primarily the niche network of DPR actors participate in the water balloon fight and home-brew. These activities therefore hold much more emotional resonance for proponents than other conference attendees. At the 2022 conference, a table of state agency employees expressed skepticism about the water balloons. One commented, "I'd want to know what purpose it [the effluent] was treated for," and another said, “I’d want to not get it in my face” (WWGPO08). The various activities at Arizona WateReuse foster an emotional connection to the materiality of DPR water and build social bonds among participants, but mostly serve to reinforce the normativity of membership in the niche network of DPR proponents.

(a)  (b) 

Figure 4, Directly Experiencing DPR at Arizona WateReuse Association

The annual symposium of the Arizona section of the WateReuse Association begins with a DPR water balloon fight, pictured in (a) courtesy of Arizona WateReuse. Evening activities include a keg of homebrewed DPR beer chilled in the bathroom of a hotel room, shown in (b).

The other significant source of information and coalition-building around DPR is Central Arizona’s municipal water advocacy organization, the Arizona Municipal Water Users Association (AMWUA). In 2019, AMWUA began hosting regular meetings to coordinate messaging about DPR.[43] These were described as “a safe place for people to come and really honestly talk about issues,” including “sharing messages and brainstorming together and having conversations” (WWGI07). The need for a safe space to discuss DPR indicates the vulnerability these actors felt about being “the tip of the spear” (WWGI08). As one member explained, this was due to the pressures of negative public perception:

> I think that's why [DPR] is not high on the list of things to discuss on a cooperative basis between utilities. It's a little bit like standing on the cliff waiting to jump off. The dare with your buddies. No, you go first! No, you go first! Right after you, you know? (WWGI08).

These meetings broke the protective silence and accelerated niche planning about DPR. AMWUA also stepped in with a communication campaign that aimed to raise regional awareness and confidence in DPR as a viable water resource strategy without drawing attention to any single municipality (Tenney, 2019).

The social network building, cultural activities, and technical knowledge-building at WateReuse and AMWUA have been critical to establish the technical legitimacy of DPR among niche actors. As one utility engineer explained:

> [S]ometimes when you have to do something brand new that you've never done before, your first thoughts are those naysaying ones. But if you can go through those and come up with responses to those, you've slowly worked your way into the more positive speech, because you go, okay, this is possible. Now, since I know it's possible, now since I know everyone is committed to making this possible, what can we do? (WWGI10).

[43] West Valley Water Users Association, representing water utilities in the western part of Maricopa County, began a DPR working group soon after (WWGI09)

As a result of this collective learning process, deliberations about DPR in Arizona water management circles have shifted from technical questions (e.g., “Can we do it?”) to normative questioning (e.g., “Should we do it?”) and operational planning (e.g., “How can we do it?”). As a result of network building through AMWUA and WateReuse, the normative network of DPR proponents gained the confidence to pivot outwards towards public engagement.

Risks Related to DPR

In AMWUA’s monthly meetings, its staff and membership emphasize the need to carefully manage the risks water scarcity poses for the regional reputation: “This valley is looked at as a whole, so it's important that none of you is facing challenges meeting the demands of your customers because that will reverberate on national news and international news” (WWGPO29). Therefore, although municipalities compete to attract investment, they also collaborate and pressure each other to manage against scarcity to avoid negatively affecting the regional reputation. However, the water quality uncertainty related to DPR presents new risks for utilities and the region. One utility engineer explained, “And the consequences of making a slip-up and having some project out there that gets ahead of itself or whatever, some mechanical failure, and somebody gets sick. That's what we don’t want to happen” (WWGI11). Discussions about appropriate requirements in DPR regulations often anticipate the consequences of under-regulating, both in terms of human and environmental health and for regional and local reputations.

California has several facilities already capable of producing DPR. Arizona’s DPR advocates have strongly argued against going the “California way” and adopting their “prescriptive approach” to treatment technology: “We certainly don't want to compromise public health protection by any means. But we're going to need to probably get a little bit creative there that will open the door for some innovation in that space of operations, laboratory resources, things like that" (WWGI25).[44] However, using new technologies or combinations of technologies in such high-risk applications is daunting even to seasoned professionals. The state's recent regulatory roadmap therefore proposes an adaptive approach, reducing piloting requirements as treatment technologies are demonstrated to be successful in real-world applications (Arizona Department of Environmental Quality, 2023).

A similar tension exists around whether Arizona should include rules requiring public outreach in regulations. One engineering consultant explained why he did a turn-around to support mandated outreach: "[I]f you don't do the public outreach, you run a really, really high risk of your project going south and getting derailed" (WWGI25). Arizona actors are aware of a history of public opposition to DPR projects from San Diego, California in 1999 (Hartley, 2006; Marks, 2006) to Tampa, Florida in 2023 (Kephart & Nelson, 2022) that has disrupted and compromised water authority plans. On the other hand, some Arizona DPR proponents believe that, due to the necessity of pursuing DPR, "If we don't have the public support now and our elected support now, we will eventually have it" (WWGI18). The perceived reputational risks, as well as a belief in the inevitability of DPR, creates some reluctance to prioritize labor intensive

[44] Water treatment efficacy is discussed in terms of log reduction values, which measure the ability of a treatment train or a treatment process to remove or inactivate microorganisms such as bacteria, protozoa and viruses (Arizona Department of Environmental Quality, 2023). The proposed compromise solution provides two paths to utilities: follow a standard minimum log reduction for viruses, Giardia, and Cryptosporidium of 13, 10, 10, respectively, which requires no site-specific monitoring; or establish site-specific log reduction targets based on specific concentrations detected over time in treated wastewater, with minimum log reduction thresholds for viruses, Giardia, and Cryptosporidium, as 8, 6, 5.5, respectively (Arizona Department of Environmental Quality, 2023).

institutional work to build DPR's social legitimacy. However, to ensure the success of a transition to DPR, some reuse proponents have overcome their reluctance and begun doing "things we're not used to doing but we know we have to do" (WWGI29) in the public engagement space. This has involved experimenting with new ways to engage various stakeholders on the quality and value of DPR.

Establishing the Legitimacy of DPR to Produce Quality Drinking Water

Before commencing formal rulemaking, ADEQ sought to begin "normalizing perceptions about DPR" across the state (WWGPO20). To encourage DPR demonstrations, the agency introduced a DPR pilot program, and invited Scottsdale Water to secure a provisional permit to install a small treatment train at their facility. Scottsdale was an ideal partner given that its advanced water treatment facility already produced DPR quality water for IPR. As their director explained, "We have facilities that have been operating for two decades. Why not use our facilities to help DEQ train?" (WWGI23). Scottsdale Water's established track record meant there was very little risk of system failure that would affect public trust in DPR. However, in becoming a figurehead in the state's DPR efforts, Scottsdale took on some reputational risk. As a neighboring utility employee commented about Scottsdale, "I would say they are on the leading edge of this kind of effort, and they will probably bleed a little. And we're going to be on the dull edge of it, hopefully, when we roll by a few years later" (WWGI09). At the same time, piloting DPR regulations enabled Scottsdale Water to continue to assert its local and national reputation as a leader in reuse (WWGI16).

Scottsdale's was not the first DPR facility permitted in the state for demonstration purposes. In 2017, inspired by a similar project in Oregon, a coalition of reuse proponents centered around Tucson secured a temporary DPR permit for a mobile treatment plant. The Pure Water Brew Challenge treatment trailer traveled the state filtering effluent from local wastewater plants to supply to brewers competing in a statewide reuse beer competition. In Phoenix, a local brewer produced a "Tres Rios Porter" from one of the city's wastewater treatment facilities (WWGI10).[45] However, one condition of the permit was that the trailer could only provide DPR water to brewers, not the public, and the resulting reuse brews could only be served to attendees at the 2018 WateReuse Conference in Tucson, AZ.

Scottsdale Water, on the other hand, wanted their pilot to reach as many members of the general public as possible. Therefore, the permit Scottsdale negotiated with ADEQ allowed them to serve up to 1500 samples of water each year, but an unlimited number of water-based beverages (personal communication with Scottsdale Water). Scottsdale Water used this permit to undertake Central Arizona's first public outreach about DPR, the 2019 One Water Brewing Showcase. In addition, Scottsdale's pilot DPR treatment train features a drinking water fountain, pictured in Figure 5, where facility tour attendees can sample DPR water (WWGPO20). Scottsdale's pilot DPR facility has become a focal point for DPR engagement efforts in Arizona.

[45] One Phoenix Water employee commented, "So my only complaint about it is that we did a Tres Rios porter and I felt like we should have done a lighter beer instead of a darker colored beer, but you know, it all goes down the same at the end." (WWGI10)

(a) 

(b) 

Figure 5, Facility Tour and DPR Tasting at Scottsdale Water

In (a), visitors to Scottsdale Water's permitted DPR pilot facility are shown the various stages of treatment that make wastewater suitable for drinking. At the end of the tour, a drinking water fountain, (b), serves chilled DPR for tour-goers to sample.

Various actor groups have benefited from attending tours of Scottsdale Water's advanced water treatment plant. As one utility leader remarked, "I take staff there… It's something I may even invite council to one day just so they can see this is what we're going to do in our pilot. [It] just kind of helps to get eyes on it" (WWGI20). In addition to new technologies, DPR requires new job responsibilities and ways of working for technicians (WWGPO11). Seeing a functioning advanced water treatment facility "allows facility operators to become familiar with the treatment train and instill confidence" in DPR (WWGPO10). Given that new operator responsibilities may also include outreach, by hosting professionalized tours of their facility, Scottsdale models how to properly engage the public about DPR.

However, stationary advanced water treatment works have limited usefulness in establishing social legitimacy. As two utility communications employees remarked:

> [W]hen you have specific things like a facility tour or a demonstration, you are only going to get a very specific type of person…That is not the person that we are really working to try to reach (WWGI01).
>
> [I]t really is about getting into the communities and getting to where the people are, because if we just put something on our web page or just put something up on social media, that's really not going to do it. (WWGI09)

Some utilities have therefore shifted engagement strategies from passive public communications to more active engagement approaches. The most popular of these among reuse proponents is tastings of DPR water, beer, and other water-based beverages, which provide a portable way to engage consumers. As one reuse professional explained, his utility has shifted priorities from "seeing is believing to tasting is believing" (WWGPO11). Tastings provide opportunities to experience the results of treatment rather than the works themselves, and because they are usually hosted by utility professionals: "[T]hey can see it, taste it, look at it, touch it, and understand what the process is and ask all the questions they need to ask" (WWGI09). As much as DPR beer tastings have proved to be popular with consumers, utility employees enjoy them too. As the director of Scottsdale Water explained, "[W]e had our booth where we could talk to folks and tell them about the water that those beers were based on. We had an enjoyable time; our staff had an enjoyable time" (WWGPO20). By repeatedly providing DPR tastings, Arizona reuse proponents are realizing not only that directly experiencing DPR increases comfort among hesitant consumers, but that promoting DPR through tastings can be a positive experience for utility workers, too. As a result, tastings have become one of the dominant ways that proponents work to normalize DPR perceptions in the study region.

Furthermore, treatment demonstrations and DPR water tastings have proven very effective at attracting positive media and public attention compared to traditional engagement methods (WWGPOP08). Through reuse beer fests, Arizona reuse proponents discovered the charisma of the brewing industry and beer itself. As public personalities with a clear stake in water security and some familiarity with water treatment technologies (WWGPO12), brewers are ideal spokespeople for DPR (Manheim & Spackman, 2020). Once on board, brewers participated in media surrounding the various reuse brew festivals and shared their enthusiasm for DPR with their customers. One reuse brew fest organizer commented, “I can't express enough the power of the communication of these brewers with the community to get people on board with this project” (WWGPO10). As coalitions of local business leaders, brewers’ advocacy can be quite important in policy. One Oregon innovator in reuse beer espoused at the 2021 WateReuse conference, “[B]y the time we had the hearing, we had hundreds of brewers and public coming to DEQ [Department of Quality] saying we want this” (WWGPO10). Because tastings are compelling for many actor groups, by expanding opportunities to taste DPR water, reuse advocates hope to build coalitions of supporters who, they hope, will come to demand DPR.

Scottsdale’s water tastings and beer festivals have had a multiplier effect across the reuse landscape in Central Arizona. Scottsdale Water presented about their brew fest experience in national and local forums at least four times in 2020. To extend the reach of tastings, Scottsdale Water, as the only permitted advanced water treatment facility in the state, frequently provides DPR water for others to use in their outreach. High visibility actors are often targeted, such as when Phoenix Water brought bottled DPR to their city manager ("His reaction was, 'It tastes like water'" WWGPO50), or when Scottsdale Water invited elected officials to sit as judges for its DPR beer tasting competition. State agencies have also utilized tastings, such as when ADEQ official offered Scottsdale Water's bottled DPR water at an event (WWGPO29). In conversations, meetings and webinars, various actors tell and retell stories of consumers' benign reactions to sampling DPR water or beer. Through repeated enactments of "tasting is believing," utilities demonstrate to a broad spectrum of stakeholders the efficacy of advanced water treatment to produce quality water.

These early successes may have led some utility managers to believe that DPR has already attained socially legitimacy. As the director of Scottsdale Water explained, "For Scottsdale, because we have been doing this and working on our public relations, we have citizens that just think that's what we're already doing. And we are but it's only on a small demonstration scale" (WWGPO18). Scottsdale's 2023 Community Survey asked residents about strategies "to help with our ongoing water shortages" and found that 88 percent of respondents "strongly support" or "somewhat support" the municipality "adding ultra-purified, recycled water to supplement its water supply" (personal communication with Scottsdale Water).[46] By providing actual and imaginary experiences with DPR, Scottsdale may, in fact, have achieved widespread legitimacy for its planned DPR expansion. On the other hand, utilities without permitted demonstration facilities

[46] Other research informants questioned these results, pointing out the lack of clarity around "ultra-purified, recycled water" containing wastewater, and the drought-related framing (WWGPO11; WWGPO09).

have had limited ability to conduct demonstrations with their consumers. Some utility actors hope that Scottsdale's successful engagements have increased legitimacy of their projects. For instance, one water manager commented, "What Scottsdale is doing at their water Campus is really helping us. As [DPR] gets out there, more and people start understanding what we are doing, they get more comfortable with it" (WWGPO14). However, when someone raised a similar point at an industry meeting, an ADEQ employee pointed out, "The culture of Scottsdale is very different from other cities" (WWGPO29), referring to the high household income compared to neighboring municipalities. Moreover, a utility consultant argued against making assumptions about the DPR outreach to date:

> I think whatever outreach has been done, they've definitely reached the people on this call, other consultants, municipal leaders. But I don't think the public at large has had the opportunity to see, feel, touch the kind of stuff going on in a demonstration facility… (WWGPOP06)

Providing insufficient opportunities for consumers to directly experience DPR may leave utility proposals vulnerable to authentic or pernicious public questioning about the water quality produced by advanced water treatment facilities.

Establishing the Value Proposition for DPR

Following the success of the Pure Water Brew Challenge and One Water Brewing Showcase, water reuse proponents expected ADEQ to immediately proceed with replacing the pilot DPR program with a permanent regulatory rule (WWGPO29). However, ADEQ was slow to begin the rulemaking process, which was attributed to capacity limitations (WWGI26; WWGI27) but was also due to lingering hesitancy among regulators about public readiness (WWGPO11). The prolonged delay became a major obstacle to a handful of powerful utilities that had already worked advanced water treatment facilities into their capital plans, as well as the major water engineering consulting firms who were under contract to design and install them and the real estate developers reliant on secure water supplies. In 2022, AMWUA responded to utility complaints by coordinating a legislative campaign to "provide some of the justification, the need for direct potable reuse regulations" (WWGI25). Arizona DPR proponents saw themselves as telling the Arizona legislature that the public was ready for DPR. One utility manager noted, "Even though there is still some squeamishness publicly, I think just people's attitude has changed a little bit, just recognizing that that is part of the future, or present" (WWGI15). That year, a bill was passed mandating ADEQ to begin the formal rulemaking process for DPR before year's end (HB 2129 amending Ariz. Rev. Stat. § 49-211).

With state rulemaking underway and a successfully operating demonstration project in Scottsdale, utilities became less concerned about the reputational risks associated with planning advanced water treatment facilities. As Central Arizona utilities sought to secure their water supplies against the long-standing Colorado River drought, several began to seriously analyze the financial justification for DPR as compared to other water supply alternatives. However, without an final regulatory rule, utilities were hesitant to publicly discuss their plans. According to one water utility manager, regulatory uncertainty invited questions from the public such as, "Why am I paying money for [municipality] to investigate something that can't be permitted?" (WWGI16). Another manager laid out the consequences of not having ready answers, describing a “lack of readiness to engage the public in that discussion. Because the public has expectations, and those expectations can get people voted out of the city council or get people fired” (WWGI05). Instead, utilities advanced plans for DPR out of public view in closed-door meetings with individual council members (WWGI19; WWG07), or in less-attended public meetings, like council retreats (WWGI20). Some utility managers preferred to “bury” funding for DPR-related infrastructure in capital improvement planning without making it clear that the infrastructure will enable DPR (WWGI07; WWGI20; WWGI23). As one utility manager explained, “[I]n our current master plan, while it doesn't say DPR, reclaimed water—every drop—is assumed to be a potable supply for build out” (WWGI21). These maneuvers were taken, as one manager explained, because “I don't know how to lay out to my city council how long this is going to take and what investment it's going to take” (WWGI08). This decide-inform-defend approach to infrastructure planning has been widely panned by water reuse industry consultants, who advise beginning robust public engagement early in the planning process (Millan et al., 2015; Tennyson et al., 2015), yet has remained the dominant strategy among many Central Arizona utilities considering DPR.

Figure 6, A Depleted Lake Mead

A view of the Hoover Dam and the Colorado River showing water levels at the lowest they have been since the dam was constructed in the 1930s. Source: Krol (2022)

It became considerably easier for utilities to justifying investment in advanced water treatment, despite regulatory uncertainties and lack of public acceptance, after the Bureau of Reclamation declared a Tier 1 and Tier 2 shortages on the Colorado River (US Bureau of Reclamation, 2021). Media coverage around these events, which ubiquitously featured the “bathtub ring” around a depleted Lake Mead, pictured in Figure 6, prompted widespread reflection among residents and pundits on the meaning of drought for routine practices of drinking, swimming, bathing, watering landscapes, and economic development. One utility communications manager described this period as an inflection point for DPR’s financial justification:

> Well, from what I've seen, based on the Colorado River shortage and the Stage 1 water alert that the City of Phoenix issued in June of last year, the public is pretty sensitive to that topic. Right? I mean, running out of water is a serious matter…I think it presents an opportunity for DPR where people would be more willing to invest, or let their city invest, in a project like that, and provide a product, you know, DPR to them, where normally they would have maybe rejected it because it was too costly or because of the ick factor. So, the circumstances, I think, make the timing ideal for DPR. (WWGI26)

With regional drought at crisis levels, DPR's value proposition became clearer to governance actors and the public.

The Bureau's shortage declarations brought considerable attention on water managers' activities. Managers sought to assure the public and political leadership that they have been preparing for this eventuality. AMWUA-sponsored messaging on drought emphasized, "we're kind of trying to frame it in a way that expresses urgency but not an emergency" (WWGI06). As one water manager explained: "I will say that it's freaking a lot of utilities out. Because while it is public knowledge, I think having the public being able to see potentially how at risk those portfolios are is making everybody nervous" (WWGI17). However, he added, now managers "can get traction to push some of their management strategies forward" (WWGI17). One management strategy was to communicate, as one informant put it:

> [T]he days of the cheap, plentiful water supplies are over. We are all going to be looking for what's the next bucket. Where is that coming from? And each one of those is going to be more expensive than what we've been used to. (WWGI08)

Messaging the likelihood of increased costs has been a key strategy of water utilities during the Colorado River crisis, and one that has served to overcome some political and public concerns about costs associated with DPR.

For many water utilities in Arizona, the drought “provided the opportunity to take advantage of a crisis and encourage the public to think broadly [about water security]” (WWGPO10). Compared to other augmentation options discussed at this time, as one water manager put it, “the only water we have in the short term is DPR" (WWGPOP14). Municipal and state water leaders therefore seized on DPR as an opportunity to demonstrate proactive planning at a time when many were questioning their decision-making. In Scottsdale, although they had earlier denied an intention to pursue DPR beyond their demonstration facility (WWGI16), municipal messaging about drought planning included their intentions to pursue DPR (Scottsdale Water, 2023), and utility leadership soon after announced that they will implement DPR in the next three years (WWGPO09). Phoenix Mayor Kate Gallego’s 2022 state of the state address centered DPR as a marquee initiative of her administration (Gallego, 2023).

Notwithstanding, drought-related exigencies may not be a reliable strategy for establishing social legitimacy for DPR. As a communications specialist pointed out, it may not be wise to overemphasize scarcity because this erodes public confidence in utility management; instead, she suggested, “The messaging should be, ‘We manage the resource to its full use so you can stop worrying about it’” (WWGPO11). Another utility communications employee noted that presenting DPR as “we're reusing this water because this is all we've got to use…It just makes it sound—you're presenting it on a garbage can lid” (WWGI19). Therefore, utilities seek to steer public DPR discourse to the value that DPR offers for water security. Yet, some managers worry that support may erode once consumers and elected officials understand the costs of constructing and operating these facilities. In Australia, after the Millennial Drought abated, consumers questioned the necessity and costs of potable reuse projects advanced during drought (C. West et al., 2019). Fully legitimating DPR requires utilities to obtain broad political and public support not only for the acceptability of DPR water, but also for the substantial investment involved in constructing and operating an advanced water treatment facility.

Utilities employ several strategies to emphasize DPR's value. DPR is often referred to as "recycled water" to emphasize its role in making more efficient use of water resources. These narratives situate DPR within a larger trend of "mining" valuable resources from the wastewater stream. For instance, in public communications about DPR, Phoenix Water officials point out that they are already "recycling" biogas, sold to a natural gas supplier, and sewage sludge, sold to farmers, and that these earned revenues allow them to minimize rate hikes (WWGPOP14). These value-oriented narratives are also compelling to financiers. As one utility employee explained, effectively arguing that advanced water treatment increases sustainability can help make facilities more affordable:

> [W]e are in a water resource challenged area, and being able to do a 'One Water' concept really creates a greater sense of water security. And those types of sustainability arguments have really been meaningful to bonding agencies, rating agencies, and investors in terms of looking at water and wastewater infrastructure investments. They want to know that what you're doing is increasing the water security and sustainability for populations… (WWGI19)

Given that better financial terms reduce the costs of government borrowing for utility investments, utilities are right to emphasize the benefits of investing in infrastructure to increase water resiliency. Similar narratives of sustainability and resiliency have been mobilized by national advocacy groups like WateReuse to leverage unprecedented federal investment in DPR infrastructure. Regardless of the validity of claims that DPR increases sustainability, the perception that it does may work to lower the cost burden on utilities and ratepayers thus increasing its legitimacy from an economic value perspective.

Ultimately, the future orientation of much DPR planning makes it possible for reuse proponents to project social legitimacy as already attained. As one utility manager explained:

> [W]hen I talk to existing council members… I always talk to them like, yeah, we're doing DPR. I don't play it up and go, so, are you okay with it? No, we talk like it's an inevitable thing and it's just going to come and you're going to be fine. We don't try to make it sound like it's a big thing…. and they all just nod and go, 'Okay, well, you guys are on it.' (WWGI07)

By convincingly constructing a future where DPR is taken-for-granted rather than a reason for alarm, water managers may take one step closer to this future but may inadvertently take two steps backwards on its legitimacy. Examining the institutional work of proponents to legitimate the possibility, inevitability, and even desirability of DPR reveals embodied cognitive capacities at the micro-foundation of institutionalization.

Discussion: Working to Legitimate DPR Through Embodied Cognitive Capacities

Despite being technologically viable since at least the 1980s (Miller & Sayre, 1985), DPR contradicts sedimented logics around appropriate wastewater and drinking water practices. Thus, while DPR transitions involve innovative technologies, it is the disruption to institutions and practices that presents the primary obstacle to its legitimation. According to Suchman's (1995, p. 574) classic definition, legitimacy is "a generalized perception or assumptions that the actions of an entity are desirable, proper, or appropriate within some socially constructed system of norms, values, beliefs and definitions." Legitimacy is therefore a personal, felt experience rather than an expressive, mental one (Haack et al., 2014). However, in the socio-technical transitions literature, legitimacy is often conceived as a teleological property of innovation, something an innovation attains rather than a feeling bestowed upon it. Even in practice-driven approaches, legitimacy of innovation is often analyzed through the doings and sayings, rather than feelings of actors, limiting researcher understanding of institutionalization processes. Instead, this chapter argues that legitimacy occurs when one's *embodied cognitive capacities* are aligned with one's experience of socio-material reality. Applying this construct in a practice-driven institutional analysis of Arizona's DPR transition reveals new facets of institutionalization. Tracking how, through practice, embodied cognitive capacities become attuned and transferred among different actor groups reveals the feelings at the micro-foundation of institutional persistence and change and provides a more detailed account of how certain institutions come to dominate a field.

Aesthetic Institutions and Embodied Cognitive Capacities

Disgust for DPR is the dominant institutional logic in Arizona. Arizonan's daily practices of "flush and forget" (e.g., disposing household and human waste down the drain) reinforce wastewater as an abject object (Meehan et al., 2013; Ormerod, 2016). Wastewater's abjection is institutionalized through formal rules mandating its containment and separation and informal rules that govern the behavioral norms and aesthetic institutions surrounding waste, such as feeling disgust for bodily discharges. The maxim "once contaminated, always contaminated" (Fallon & Rozin, 1987) informs the practical assumption that wastewater can never be clean. Through a lifetime of practice, Arizonans, including some working in water and wastewater institutions, acquire the embodied cognitive capacities to detect and respond appropriately to dominant aesthetic institutions of wastewater, including feeling fear and disgust for DPR. This bundle of institutions and practices is referred to here as DPR-as-wastewater.

The competencies of DPR proponents, on the other hand, are attuned through training and experience to the possibility that, with appropriate treatment, wastewater can become safe for any use. Wastewater-for-drinking is therefore the prevailing aesthetic institution of DPR proponents. A key component of group membership is the competency to perform praxis in alignment with wastewater-for-drinking aesthetics, for instance, sampling DPR water without feeling concern for any ill-effects. These practices and informal institutions form the moral foundation of proponents' advocacy for formal institutions supportive of DPR. Nevertheless, before they acquired the embodied cognitive capacities to appropriately detect and respond to the aesthetic properties of DPR, proponents were almost certainly attuned to the dominant DPR-as-wastewater logic. This means that, at some point, these individuals acquired embodied cognitive capacities to automatically feel and act towards DPR as drinking water rather than abject object. This section discusses how institutionalization appears to occur.

As DPR proponents have discovered, it is possible to change embodied cognitive capacities to acquire new competencies to perform feelings and actions related to DPR. All practical engagements are opportunities for individuals to refine their embodied cognitive capacities to detect and respond to institutions; additionally, each instance serves to share, reify, or transform these institutions. In this way, embodied cognitive capacities are transferred between individuals as a broader group of individuals become attuned to the legitimacy of recycling wastewater into drinking water as “the way we should do things.”

Discovering the most effective means to legitimate DPR has been a learning process for utilities, instigated by the insufficiency of existing outreach apparatuses to institutionalize new wastewater institutions. Wastewater managers came to realize that transforming dominant institutionalized DPR disgust would require innovative interventions to attune consumers’ embodied cognitive capacities to aesthetic institutions and practices of wastewater-for-drinking. Through national reuse networks, some Arizona DPR proponents learned of the success of a practical intervention, especially DPR water and beer tastings, to institutionalize wastewater-for-drinking among participants. Arizona’s Pure Water Brew Challenge was the first attempt to replicate this intervention in the state. The reuse industry stakeholders at the WateReuse conferences in Flagstaff already adhered to the wastewater-for-drinking logic but few had had the opportunity to practice the drinking competencies associated with this logic. As the multiple anecdotes of wastewater professionals who refuse to sample DPR demonstrate, informal institutionalization of wastewater-for-drinking is incomplete without the acquisition of embodied cognitive capacities, attuned through practical experience, to sense and respond to DPR according to this logic.

The Pure Water Brew Challenge furthermore provided utility actors the opportunity to populate "off-the-shelf" practices with new meanings and performances (Suddaby et al., 2013, p. 334). Here, and later at Scottsdale Water's advanced water treatment facility tours and One Water Brewing Showcase, utilities could "learn more about the practice itself, about others' reactions to it, and about potential ways to reduce complexity by adapting the practice to balance constituents' interests" (Raaijmakers et al., 2014, p. 40). In tastings of DPR water produced by Scottsdale Water, many reuse proponents in Arizona have had the opportunity to participate in routine performances of "tasting is believing" with different consumers. Repeated enactments of "tasting as believing" and retelling stories about these experiences have helped DPR proponents gained confidence in the material qualities of DPR water, as well as in the capacities of consumers to appropriately detect and respond to these qualities. As utilities began involving the general public in tasting practices, aesthetic institutions of object-wastewater began to give way to wastewater-for-drinking as legitimacy diffused across individuals. However, social legitimacy is still far off, and until embodied cognitive capacities to relate to wastewater-for-drinking are broadly shared, this transition is far from stable. For this reason, reuse actors desire increased regulation, not for themselves but to prevent others from causing a "slip-up" detrimental to human health. Any such shock would likely jolt at least some consumers' embodied cognitive capacities back to their former habitual attunement.

Increasing awareness among Arizonans of the possible impacts of drought aided the growing attunement to wastewater's value as a drinking water supply. Drought involves sensory experiences of desiccated landscapes, dry air, empty taps, and emotional experiences of anxiety and dread. For water providers, the lost sense of control was particularly visceral. Water providers were therefore eager for emotional and sensorial relief from drought, even if it meant supplanting other feelings, like disgust. Utilities' drought management discourses emphasized both their skill at securing new water supplies and the exigency of consumers adopting new water use practices. This institutional work provided the cultural-cognitive legitimacy for the necessity of adopting this "water supply of last resort" (National Research Council, 1998, p. 15). A central observation of this research is that, while utility's regulatory and political gains during this time were important to instill cultural-cognitive legitimacy, formal DPR institutions followed on the repeated enactments of "tasting is believing" that attuned consumers', producers', and regulators' embodied cognitive capacities to a new institutional aesthetic of wastewater. Only after utility leadership gained confidence that Arizona's dominant aesthetic institutions could transition to wastewater-for-drinking did they breathed new life into regulatory efforts. This discussion illustrates how embodied cognitive capacities make clear the double-embeddedness of actors in institutions, and how this double-embedding affects the legitimation of innovation.

Embodied Cognitive Dissonance: Institutional Work to Resolve Conflicting Logics

A key insight of organizational institutionalism is that institutional change is precedented on contradictions resulting from conflicting institutional logics (Seo & Creed, 2002). For example, according to the dominant logic of Arizonans, wastewater is abhorrent and should be contained and avoided, whereas according to the logic of DPR proponents, wastewater "should be judged by its use, not its history" (WWGPO14). Recognizing institutional conflict often involves highly emotive processes (Lok et al., 2017); resolving them therefore involves institutional work of equal emotional resonance. Considering how institutional conflict produces *embodied cognitive dissonance* refocuses attention on the role of feelings in detecting and resolving institutional conflict. Institutional work in response to embodied cognitive dissonance can either turn outward to reshape institutions, or inward to adjust embodied cognitive capacities. Examining institutional work to resolve embodied cognitive dissonance therefore provides insight into the micro-foundations of institutionalization.

Because DPR strongly contradicts "the way we should do things" across many social organizations, niche actors worked to advance infrastructural, operational, regulatory, and cultural institutions supportive of DPR in many parallel domains. However, due to the engineering inclinations of most DPR entrepreneurs, the physical domain received far more attention than the social realm. The institutional work to legitimate DPR was at first focused on regulatory re-definition of DPR as an allowable ingredient in drinking water. These efforts targeted the supra-structure of formal DPR institutions by "defining (and re-defining) boundaries and frameworks within which new institutions can be formed" (T. Lawrence & Suddaby, 2006, p. 222). Notable achievements during this phase were incorporating DPR into guidance for state water policy, the draft regulatory framework, and the repeal of the legislative prohibition on DPR. However, the reach of these achievements was limited to government, and these government-involved efforts stalled when state regulators failed, during three consecutive legislative cycles, to prioritize limited agency resources to finalize provisional DPR rules.

This research finds evidence that state's lack of follow-through was at least partly due to the personal hesitancies of state actors who were responsible not only for their formal mission to protect human and environmental health, but also their informal mission to govern in accordance with dominant institutional logics. This latter mission required regulators to anticipate consumers' future embodied cognitive capacities; however, the personal phenomenology of experience makes it hard to embody others' feelings. Therefore, in their efforts to anticipate what "the community is going to accept," regulators may have drawn from what they themselves would accept. It was therefore regulators who instigated Scottsdale's institutional work to normalize perceptions of DPR (WWGI23).

As regulator hesitancy makes clear, DPR proponents needed to undertake targeted institutional work with technical and non-technical water governance actors. The activities at the annual symposium of the Arizona WateReuse chapter in Flagstaff, Arizona provide an illustrative example of how DPR proponents worked to resolve the embodied cognitive dissonance between water governance actors' actual embodied cognitive capacities and the normative aesthetic institutions of wastewater-for-drinking. This small conference fosters social connections between institutional entrepreneurs and potential initiates into the *normative network* (Lawrence & Suddaby, 2006) of DPR supporters. Presentations and keynotes by powerful and respected figures lend cultural-cognitive legitimacy to the normative network. However, for many attendees, the association with power is insufficient to overcome embodied cognitive capacities to relate to wastewater as always-contaminated. Therefore, the Flagstaff conference also includes several rituals that serve to infuse "the normative foundations of an institution into the participants' day-to-day routines and organizational practices" (Lawrence & Suddaby, 2006, Table 1.6.2). Rituals provide inspiring emotional experiences by which organizations translate emerging practices for particular members of audiences (Massa, 2017). At Arizona WateReuse, rituals, such as the DPR water balloon fight and home-brewed beer, where network leadership enthusiastically comes into direct contact with DPR water, serve to demonstrate normative embodied cognitive capacities towards DPR as an unobjectionable and even fun, rather than abhorrent, object.

Through trainings, networking, and direct and indirect encounters with DPR, Arizona water governance stakeholders acquire the technical, social, and emotional resources to challenge hegemonic institutional orders that prescribe feeling and acting towards wastewater as abject. These experiences accumulate over time to attune wastewater governance actors' embodied cognitive capacities such that DPR no longer provokes dissonance but becomes a taken-for-granted part of the drinking water supply. Examining both the acquisition of embodied cognitive capacities and when they produced dissonance provides a micro-foundational perspective on the institutional work involved in legitimating innovation.

Conclusion

This research investigated how perceptions have shaped the transition to DPR in Central Arizona. The conclusion of this analysis is that perceptions have been both preventative and enabling in this transition. Institutionalized logics of wastewater's abject materiality have slowed the adoption of DPR by as much as three decades. Despite DPR's increasing legitimacy in water management circles, some water governance actors remained hesitant. Therefore, proponents found it necessary to undertake innovative institutional work to establish DPR's legitimacy among water professionals, in addition to the public at large.

In contrast to the technocratic tendency to value technical over experiential knowledge, utilities' most successful legitimation strategies attune consumers' embodied cognitive competencies acquired through everyday drinking water practices to the possibility that wastewater can become drinking water. As a result, alongside the regional socio-technical transition taking place to adopt wastewater as a drinking water supply, a transition is taking place in how utilities understand and engage consumers in water management. However, adoption of experiential engagement practices is uneven and their deliberative value is limited, with some utilities acting in the previous decide-inform-defend mode of governance. Therefore, this study concludes that embodied capacities associated with wastewater-for-drinking institutions are far from stabilized, representing a significant source of risk for utilities moving forward with limited or provisional social legitimacy in this transition.

This chapter contributes to the organizational institutionalism and socio-technical systems literatures in numerous ways. Empirically, this research demonstrates that examining embodied cognitive capacities of a broad set of governance actors can add important and generally overlooked information about processes of institutionalization and what makes certain forms of institutional work more effective than others. Theoretically, embodied cognitive capacities can usefully extend several key constructs in institutional theory. In analyses of institutional complexity, logics are often conceptualized as exogenous to actors, obscuring the contestation and competition often involved in securing the right to impose meaning onto other actors (Lounsbury et al., 2003; Voronov & Vince, 2012). In the embodied view, institutional logics are most sensorially and emotionally evocative to those with similarly attuned embodied cognitive capacities. Institutional work, therefore, involves the various ways actors mobilize to attune embodied cognitive capacities among actors. Methodologically, attending to how the feelings-work of various practitioners stabilizes or changes institutions can better represent the double-embedding of individual agency and institutional logics. Embodied cognitive capacities to detect and competently respond to institutional signals are acquired, reified, or lost through bodily engagement with the environment (including the social environment). Analyzing the competencies reproduced through routinized performance incorporates the body and emotions into practice-driven institutional accounts of how institutional change may be possible within taken-for-granted institutions.

Several opportunities for further study were identified while doing this research. Given the impending institutional conflicts predicted for DPR as stakeholders realize the potential impact that facility construction and operation may have on rates and the reallocation of effluent to drinking water supplies may have on landscapes, it will be worth investigating how consumers and environmentalists respond as these projects are brought out for public debate. Such an investigation would benefit from quantitative analysis, including economic and biophysical modeling, to understand how financial and effluent flows may be re-distributed under different wastewater management configurations, and the likely environmental effects of these changes. Research could also more fully employ practice-theoretical research methods by examining the work boundary-spanning actors perform in their everyday activities to manage institutional complexity. For instance, observing how communications staff at agencies or research organizations (e.g., Water Research Foundation) mediate between consumer logics, engineering logics, and environmental logics could bring new insights to the institutional work involved in "translation-as-practice" (Smets et al., 2017).

Another possible research direction is to compare the Phoenix AMA's DPR initiatives to those in other Arizona locations, such as the Tucson AMA, and the municipalities of Flagstaff, and Cottonwood, to understand how local drivers and institutions influence DPR development within the same supra-institutional field, and how institutional work varies with context. Expanding data collection to include municipal planning documents could provide additional perspective on how formalized land and water management institutions relate to organizational effluent management strategies.

While it may be true that potable reuse "schemes rely on existing, large-scale, centralized infrastructure; retain techno-scientific expertise and state control; favour augmenting supply over mitigating demand; and ultimately preserve the political economy of water consumption" (Meehan, 2013, p. 79), this research offers a silver lining. Through detailed analysis of the practices of reuse practitioners as they work to legitimate DPR in the face of institutional resistance, this study finds that actors across the wastewater governance field are developing new competencies. Specifically, utilities are attentive to the feelings of consumers and are innovating new methods for engaging their embodied cognitive capacities in governance. The rest of this dissertation explores utilities' increasing reliance on practical engagement with feelings, such as through DPR tastings. Chapter 5 asks why experiential engagements with DPR have proved more successful than previous methods of public outreach, tracing one explanation to the normative assumptions of rationality informing these various forms of engagement. Chapter 6 discusses an experimental method to co-attune embodied cognitive capacities through the design and implementation of practice-based interventions in DPR practices and governance.

CHAPTER 5

JUDGING JUDGEMENT: NORMATIVE DEFINITIONS OF RATIONALITY, AND WHAT THEY DO IN THE WORLD

As an action-oriented science, sustainability science problematizes patterns of human activity resulting in environmental degradation and prescribes correctives to increase the likelihood of sustainability (Caniglia et al., 2021; W. C. Clark et al., 2016; Fazey et al., 2018). The efficacy of these interventions depends on accurately understanding why humans act as we do and the relationship between human actions and the environment, which inform ideas about how we *should* act. This chapter examines how normative understanding of rationality shape the types of interventions selected to advance sustainability goals, with implications for the efficacy of interventions. This require moving from the descriptive modes of philosophy, psychology, and institutional analysis into the normative mode of rationality.

Normative behavior has long been a topic of scientific examination; nevertheless, globally accepted models of what constitutes right, or rational, behavior are lacking. Many sustainability scholars criticize prevailing models of rationality as premised on unrealistic assumptions about real-world circumstances and human cognitive abilities (Constantino et al., 2021; Schill et al., 2019; Schlüter et al., 2017, 2019). For instance, rational actor theory assumes that humans have perfect access to information and unlimited reasoning capabilities, whereas the theory of bounded rationality accepts that reasoning is limited but considers it to be an individualistic and cognitive process. These assumptions may be useful in generating theoretical understanding of decision-making, but nevertheless have frequently been applied to real-world behavior and to generate policy recommendations with real-world impacts. As a result, many sustainability scholars (e.g., Bercht & Wijermans, 2019; Constantino et al., 2021; Schill et al., 2019; Schlüter et al., 2017, 2019) have pointed to a gap in understanding about how human cognition and behavior interacts with social and ecological dynamics to produce maladaptive outcomes. Prepared with a better understanding of rational thought and action, sustainability scholars and practitioners hope to implement policies that effectively foster sustainable human-environment interactions (Hampton & Adams, 2018; Mair et al., 2019).

Despite growing consensus on the need, no universal notion of rationality has supplanted prevailing rational actor and bounded rationality models. It's worth recognizing that models of cognition are abstractions based on whatever properties are most relevant to a culturally situated observer (Gershenson, 2003, 2013). Models of rationality, on the other hand, reflect but also shape culture, especially how human capabilities are conceptualized and what is deemed "reasonable" thought and action[47] (Papadopoulos, 2018). Efforts to define rationality attempt to make the world more intelligible, predictable, and controllable (Schafer, 2018). Thus, narratives of rationality are a source of epistemic power (K. Jones, 2004). In the governance of risk, these narratives have been used to reduce the multiple sources of information that divide subjective risk assessments into those deemed "reasonable" (scientifically derived) and "unreasonable" (all others) (Fischer, 1999; Stenekes et al., 2006). According to this logic, environmental knowledge gained through inherited and lived experience is often deemed

[47] … and even the boundaries of what it is to be a "human," which is addressed in this chapter's Conclusion.

less valid than the knowledge scientists acquire using laboratory equipment and sensing technologies (N. J. Bennett, 2016; S. Harding, 2015; Latour & Woolgar, 1986; Tengö et al., 2014). Post-normal science (Funtowicz & Ravetz, 1993), however, has unsettled previously assumed epistemic hierarchies and complexity science has introduced alternatives to governance goals of prediction and control (Cosens et al., 2021; Preiser et al., 2018; Scoones & Stirling, 2020). However, a pluralistic, complex understanding of rationalities has yet to take hold in the popular and scientific imagination. Therefore, prevailing models of rationality will likely continue to be applied, with consequence for epistemic justice in policy and society more generally.

Through a comparative analysis of various utility-sponsored efforts to advance the direct potable reuse of wastewater (DPR) in Central Arizona, this chapter answers the question, *what normative understandings of rational human behavior guides utility strategies to increase the public acceptance of DPR*? This analysis illustrates the limited applicability of rational actor and bounded rationality theories in utilities' most successful outreach efforts and concludes these must be informed by different assumptions. The chapter collects these assumptions into the framework *embodied rationality,* which defines rationality as competent adaptation in response to social and environmental constraints and opportunities for action. As the discussion will show, embodied rationality can be applied not just to consumers judging DPR, but also to utility workers planning DPR outreach activities, and to the management structures that govern drinking water.

The chapter begins with some brief background on public perceptions of DPR, and then describes the methods used to generate case study data. The research question guides a chronological analysis of the main scholarly definitions of rationality that have been applied to policy: probabilistic rationality (including rational actor theory), bounded rationality, heuristics and biases, and embodied rationality. For each theory or framework, the chapter first presents an overview and then describes how it has informed DPR outreach strategies in Arizona. The goal of this analysis is not to make straw men of previous normative rationalities, but to situate them in a historical project of defining rationality based on culturally relevant parameters and goals. The rest of the chapter discusses embodied rationality's theoretical foundation and draws from observations of Arizona utility workers' most successful public engagement approaches to argue for its real-world relevance in sustainability scholarship and policy. The conclusion considers how adopting embodied rationality can advance transdisciplinary sustainability scholarship and practice. This chapter provides the theoretical and empirical foundation for the action research described in Chapter 6, where embodied rationality is the guiding assumption for the design of practice-based interventions that aim to enhance DPR deliberations in Arizona.

Case Study Background: DPR Hesitancy

Contentious water governance debates make clear the need to revise notions of rationality. In these settings, the technical basis for decision-making tends to be characterized as value-neutral and more informative than experiential knowledge, which is often characterized as irrational and ill-informed (R. Brown et al., 2011; Meehan et al., 2020). This is particularly true in the scientific and popular discourse surrounding DPR perception. Whereas non potable reuse of wastewater for landscape irrigation, industry, and non-contact household use (e.g., toilet flushing) is widely accepted, DPR faces significant barriers to public acceptance. Foremost among these is the “yuck factor,” which refers to the strong disgust many feel for proposals to reuse wastewater as a potable supply (Fielding et al., 2019; Millan et al., 2015; National Research Council, 2012). Epistemic knowledge hierarchies and popular suspicion of emotions as a source of bias can lead reuse industry actors to dismiss emotional responses to DPR as “irrational” rather than seeking to understand how these may reflect rational concerns (Morgan & Grant-Smith, 2015; S. Russell et al., 2008; Stenekes et al., 2006).

An informal scan of the literature reveals that over 70 academic research articles have investigated public acceptance of potable reuse, mostly in the United States and Australia. The thrust of this research asks, “Why is it that people can see the logic in using recycled water but remain reluctant to use it?” (Po et al., 2005, p. 14). This literature explores many factors considered relevant to DPR acceptance: educational attainment, socioeconomic factors, cultural background, knowledge of reuse, experience with drought, environmental concern, pricing concern, disgust sensitivity, general risk perception, and health risk perception (Ellis et al., 2019; Fielding et al., 2019; Morgan & Grant-Smith, 2015; Po et al., 2005; Ross et al., 2014; S. Russell & Lux, 2009; Siegrist & Hartmann, 2020; Stenekes et al., 2006). One of the few strong and consistent findings of these investigations is that support for wastewater reuse decreases as applications become more personal such that, for example, irrigating fruit trees with reclaimed water is more acceptable than irrigating vegetables that grow close to the ground (Dolnicar & Hurlimann, 2009). Similarly, support for indirect potable reuse (IPR) is consistently higher than DPR. In IPR, treated wastewater is passed through an environmental buffer and acquires positive associations with "naturalness" that substantially increases public acceptance of the resulting water (Ellis et al., 2019; Haddad et al., 2009; Tennyson et al., 2015). In DPR, wastewater undergoes advanced water treatment and is served directly back into the drinking water supply. The advanced treatment processes involved in DPR are highly technical and unfamiliar to most consumers, who may not even know the source of their current drinking supply, nor the processes involved in conventional water treatment (Millan et al., 2015; S. Russell & Lux, 2009).

Regulations typically dictate the various levels of treatment necessary for each reuse applications based on thresholds for tolerable annual risk of infection for each pathogen. However, a smaller body of research of DPR acceptance indicates that, although the "yuck factor" certainly plays a part, there are a range of other motivations for consumer hesitancy towards DPR, including distrust of government and science, suspicions about policymakers' motives, and questions regarding the need for new supplies (Ormerod, 2016; Ormerod & Scott, 2013). This scholarship situates utility efforts to legitimate DPR as a new use of wastewater against a historical backdrop of sociopolitical conflict and contestations over power and authority. Conflict is low when utilities' and regulators' formal risk analyses aligns with consumers' intuitive analyses, such as consensus over the need for increased treatment when wastewater reuse involves potential or actual ingestion. However, conflict can arise when these risk analyses are misaligned. For instance, in debates over IRP versus DPR, consumers may see IPR as superior due to involvement of an environmental buffer, whereas many scientists, regulators, and utilities, increasingly aware (and made responsible for) cycles of environmental pollution, have discarded the notion that "dilution is the solution to pollution" in favor of closed loop DPR systems. In such debates, water utility employees are uncertain how to expend scarce resources to increase trust among skeptical populations.

In Arizona, IPR is an established, and generally accepted practice (Rock et al., 2012). However, many municipalities in Central Arizona prefer to pursue DPR because it provides flexibility in reuse options, maintains legal control of effluent, and because of technical challenges related to IPR in this region.[48] At least four water providers in the region expect to include DPR in their portfolio in the near to mid-future. These utilities are actively deciding how to best establish the legitimacy of DPR among consumers in their service territories. As the following analysis demonstrates, the normative model of rationality adopted by utility employees informs different consumer outreach strategies with potential consequence for the success of these outreach efforts.

Case Study Methods

The primary data informing this research was collected and analyzed as described in Chapter 4. Data collection included 34 semi-structured interviews with regional DPR stakeholders, including 14 interviews with representatives of the four utilities actively planning for DPR and in-depth ethnographic observation at private meetings of one utility planning a DPR facility. These ethnographic data provide insight into how local stakeholders understand their consumers' decision-making processes and how this understanding guides utility strategies to increase DPR acceptance. Participant observations at 47 public events included national and local conferences of reuse

[48] See Chapter 2 for a more detailed discussion.

proponents, industry-sponsored webinars, and internal meetings with industry experts where best practice guidance was shared about the strategies utilities *should* apply in increasing DPR acceptance. These data were supplemented with texts collected from academic and industry publications about DPR perceptions, local and national media coverage of DPR, and DPR planning documents collected from municipal and state agency websites. Contrasting industry guidance with how local stakeholders translate and enact this guidance on the ground provides a rich body of evidence from which to draw conclusions about the normative standard rationality guiding utilities' DPR engagements.

Probabilistic Rationality: A Model of Standard Rationality

Contemporary scientific and popular understandings of rationality stem from formal inquiries in Western philosophy into what counts as "true" thoughts or judgements (Gigerenzer & Selten, 2001). According to this tradition, theoretical or epistemic rationality is concerned with what is rational to believe and involves theoretical reasoning (Stout, 2019). Pre-19th Century, epistemic rationality was often pursued through phenomenological inquiry into what constitutes objective ("absolute") versus subjective reality (Daston, 1988). In this sense, to call something "reasonable" is "to say that it is in accordance with a properly functioning faculty of reason (however this is understood)" (Schafer, 2018, p. 506). Practical rationality, on the other hand, is concerned with what is rational to do, or intend or desire to do, involving practical reasoning about the correspondence between plans and intentions (Stout, 2019).

Inquiries into the modes of reasoning capable of producing true knowledge led to the "age of reason," a period spanning the 17th and 18th Centuries known as the

Enlightenment (Schafer, 2018). In the face of increasing questioning of the rationality of human intuitions, a new understanding of reasonableness took shape (Schafer, 2018). Empiricists, including John Locke, David Hume, and George Berkeley, emphasized the importance of direct experience and observation as the basis of knowledge. Starting in the mid 19th century, Enlightenment emphasis on the self as the locus of truth began to give way to suspicions of the self as the corruptor of truth. Scientists strove to remove the self, replacing personal observation with instrumental observation as the favored technique of truth-finding (Daston & Galison, 2007). By applying experimental methods to the study of phenomena and increasing reliance on mathematical probability and inferential statistics, scholars of the era hoped to reduce the corrupting influence of flawed human reasoning (Daston, 1988).

In response to concerns about objectivity, the originators of what came to be known as *classical probability theory* strove to represent reality with mathematics. Blaise Pascal, Jakob Bernoulli, and Pierre Simon Laplace labored over a model of rational decision, action, and belief under conditions of uncertainty in order to “reduce this prosaic good sense to a calculus” (Daston, 1988, p. xi). When these mathematicians’ model of rationality under uncertainty[49] “did not square with those intuitions, they tinkered with the model to bring about a better fit” (Daston, 1988, p. xii-xiv). Over time, an accumulation of paradoxes when reasoned judgement did not lead to actors to choose as these theories predicted[50] led post-Enlightenment scholars to abandon the endeavor to

[49] e.g., expected-value theory, expected utility theory
[50] e.g., Bernoulli’s paradox, St. Petersburg paradox, Allias paradox, Ellsberg paradox

define a universal definition of reasonable intuition (Gigerenzer & Selten, 2001; Schafer, 2018).

During the intervening century there were few breakthroughs in the project of defining rationality, as philosophers and economists largely took it as a tautology that any and all behavior could be described as rational (Sent, 2018). In the late 19th Century, as psychology attempted to distinguish itself from philosophy through alignment with the natural sciences, inferential statistics of probability theory strongly influenced experimental design (Gigerenzer, 2007). Within this context, the debate between the Functionalist psychologists, who claimed conscious experience was continuous and could not be broken out into discrete chunks, and the Structuralists, whose atomistic approach assumed parts could be ascertained prior to the whole of experience,[51] largely came down to the possibility of demonstrating these theories empirically using laboratory methods (Käufer & Chemero, 2015). More suitable to lab-based experiments the Structuralist approach prevailed, leading to the rise of behaviorism, which dominated psychology from the 1920s to the 1950s.

Prominent Behaviorist, B.F. Skinner, thought his and others' findings about the effect of environment on behavior challenged the prevailing view of completely free and rational individuals (Chatterton, 2016). As Skinner famously stated, "A person does not act upon the world, the world acts upon him" (Skinner, 1971, p. 90). The resulting view of rationality, *comprehensive rationality*, assumed that individuals have fixed preferences and seek to optimize between these preferences and the alternatives before them to maximize their goals (Diver, 1981; B. D. Jones, 2017). According to behaviorists

[51] See Chapter 3 for a more extensive description of Structuralism and Functionalism

normativity was “the rubric under which to discuss how one ought to behave if one wants to behave rationally” (Sent, 2018, p. 1375). However, behaviorists’ efforts at ‘behavioral modification’ or ‘behavioral engineering’ to bring about more rational behavior (e.g., through negative conditioning or positive reinforcement) conflicted with an increasingly anti-authoritarian student population on college campuses where most such research took place leading to a popular backlash that contributed to behaviorism losing favor among both the general public and psychologists (Stout, 2019).

Whereas before, psychologists and classical economists had maintained a distinction between the normative domain and descriptive domains, behaviorists’ attempts to define normative behavior brought description and prescription into close contact (Stout, 2019). Before this time, normative discussed what was good, fair, just, or ethical in other ways (Hands, 2001) and early attempts at prescription, or “the ‘rationalization’ of rationality” (Schafer, 2018, p. 516), were limited by the mathematics of the time. This changed in the 1940s when John von Neumann and Oskar Morgenstern (Von Neumann & Morgenstern, 2007) formalized rational choice theory in the context of game theory and decision-making under uncertainty and soon after Paul Samuelson (1954) introduced a theory of revealed preference formulation of utility. These theories shifted economists’ focus from reasoning to choice outcomes, with the former treated (as it was in behavioral psychology) as outside the scope of theorizing (G. Wheeler, 2018, p. 20). By assuming the logical omniscience of rational actors, it was then possible to develop axioms (rules) for preferences structuration that could be mathematically represented in a utility function. What came to be known as the field of decision theory within neoclassical economics offered a powerful mathematical toolbox for modeling normative judgement in situations of constrained choice and logical omniscience[52] (Gigerenzer, 2021; G. Wheeler, 2018). Game theory provided social scientists a simple yet powerful model to represent the structure of interactions so as to theorize how individuals end up stuck in patterns of collectively self-defeating behavior (Heath, 2020).

Economists today discuss the rational actor as *homo oeconomicas* to underscore that assumptions of rational choice theory were never meant to describe how real people make decisions in most real-world situations (Gigerenzer, 2021; G. Wheeler, 2018). Since at least Hayek (1945), it has been well understood in economics that individual actors' limited access to information affects the movement of economic systems. Early classical economists were therefore careful to limit applications of utility but neoclassical economists have made probabilistic rationality a benchmark across problem domains and probabilistic rationality has become the norm in economics, psychology, and many related fields (Samuels & Stich, 2004; Stein, 1997). According to the normative universal rationality in these fields, "to be rational is to reason in accordance with principles of reasoning that are based on rules of logic, probability theory and so forth" and exceptions, or "violations," are a failure of rationality or even evidence of "irrationality" (Stein, 1997, p. 4). Probabilistic rationality may be useful to assume in modeling decisions, but ultimately a human decision-maker will need to decide, and their decision-making will likely not proceed according to the predictions of probabilistic rationality.

[52] such as "small worlds" experiments where all variables and outcomes are known

Probabilistic Rationality: Optimization in DPR Decision-making

Water providers see DPR as a water resource strategy that maximizes the utility of effluent by applying it to the “highest and best use” as potable water (WWGI11, WWGI13, WWGI19, WWGIPOP14). According to one utility engineer,

> [W]hen we first started to talk about the idea of DPR, it was really more in response to what we perceived as a potential challenge from a water resource perspective, as well as a treatment perspective in terms of, if you're anticipating additional treatment… [w]hat do you do with what's left? (WWGI19).

However, this engineer soon discovered that public decisions about DPR involve criteria many utilities consider irrelevant to water resource management. Although water resource management decision-making may be guided by choice optimization, it would be misguided for utility workers to assume that consumers seek only to maximize their personal utility.

Early adopting utilities initially seemed to characterize DPR acceptance as a linear optimization problem. This assumption presents consumer decisions as a tradeoff between water security and water quality, depicted in the simple model of consumer choice presented in Figure 7. According to the logical axiom of utility maximizing humans, Arizonans facing water scarcity can choose to downgrade their expected utility by accepting lower water quality or quantity, or find ways to push the curve outwards, for example through augmenting with DPR or desalinated seawater.

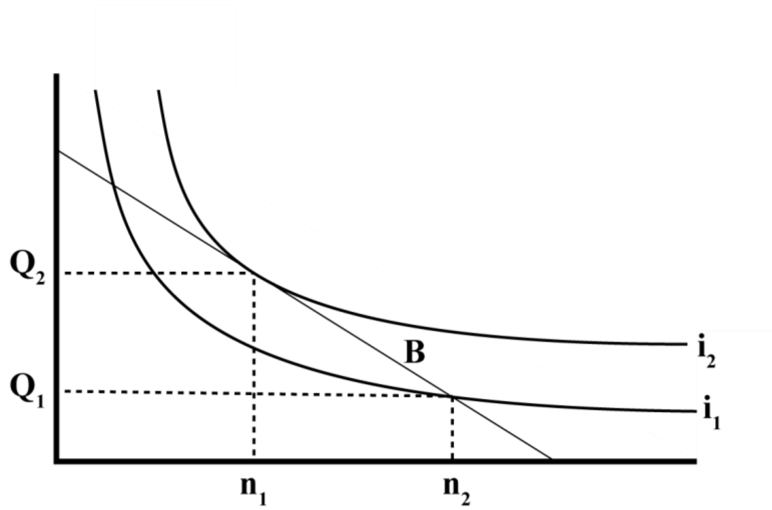

Figure 7, Indifference Curve for Water Quality and Quantity

A simple model of consumer choice. In Figure 7, the vertical axis and horizontal axes represent, respectively, the quantity (Q) and quantity (n) of water. The dashed diagonal line (B) is the consumer's budget function, which reflects all possible combinations of Q and n that she may purchase. The two indifference curves (i) represent present drinking water (i_1) and DPR (i_2), which is assumed to increase the quality and quantity of available supply. The dashed lines represent the points of greatest utility where B crosses i_1 and i_2 resulting in the points of tangency (n_1, Q_1) and (n_2, Q_2). In this depiction, (n_2, Q_2) is further from the origin than (n_1, Q_1), so i_2 represents greater utility for this customer.

Given this expected utility curve for DPR, it is reasonable for water providers to attempt to increase consumers' expected utility of DPR by emphasizing the water quality and quantity benefits of adopting DPR. As one water utility professional explained, "It's safe and can be done and it's a responsible thing to do. It essentially creates a new water resource. It's renewable, it's safe, and it just makes sense" (WWGI18). By highlighting the quality of DPR water through terms like "safe" and emphasizing the expansion this "new water resource" could provide to the existing water supply portfolio, utilities hope that consumers will agree that "it just makes sense."

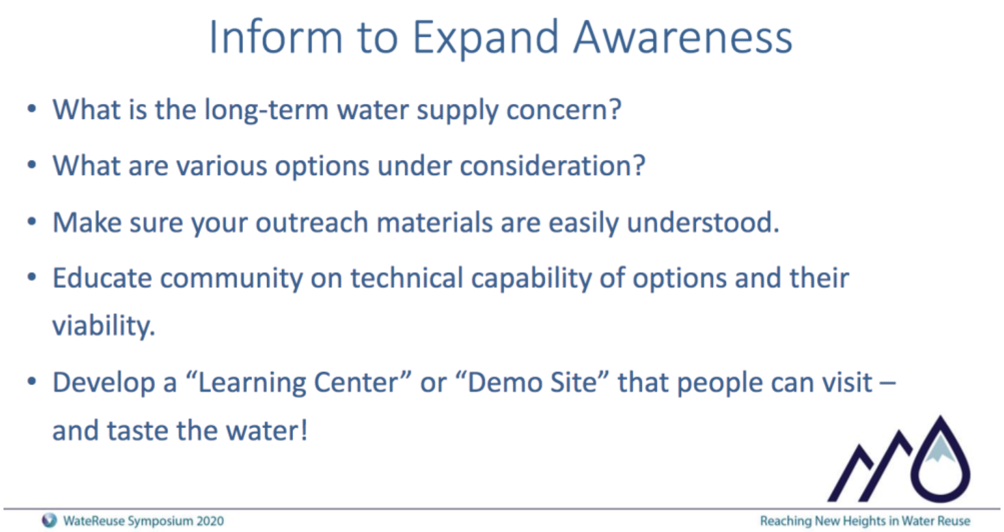

Figure 8, Presentation Slide from Conference of DPR Proponents

A slide from a session entitled "Public Outreach Lessons Learned in Implementing Potable Reuse Projects" presented by an industry leader in DPR outreach to attendees at the 2020 WateReuse Association conference.

Assuming that consumers are utility maximizers led early adopting utilities to prioritize technical education (Stenekes et al., 2006). Their educational efforts assumed that consumers possess a knowledge deficit that can be corrected by providing more accurate information. This assumption persists but has since made room for alternative explanations. For instance, Figure 8 depicts a slide from a session entitled "Public

Outreach Lessons Learned in Implementing Potable Reuse Projects" presented to a 2020 conference of water reuse leaders that primarily emphasizes the importance of utilities communicating the benefits of DPR to regional water quantity and addressing quality concerns (WWGPO12). However, information-only interventions have found limited success in increasing support for DPR (Haddad et al., 2009; Tanner & Feltz, 2022). Instead, information provision is considered most beneficial as a secondary approach to other engagement mechanisms (e.g., facility tours and tastings), or targeted at certain stakeholder groups (Ross et al., 2014; Smith et al., 2018). While it remains essential that outreach efforts provide accurate and accessible information about DPR, the ultimate benefit of these efforts may be to build trust in the relevant authorities through the demonstrated use of procedures perceived as fair (Fielding et al., 2019).

Bounded Rationality: The New Normative Standard Rationality

As policymakers have increasingly applied probabilistic rationality to real-world problems, it has attracted broad criticism, including from social scientists. Accumulating evidence from laboratory and real-world research on decision-making conflicted with the predictions of rational actor theories (Lerique, 2022). For instance, in natural resources management, Garrett Hardin (1968) had claimed a "tragedy of the commons" would be the inevitable result of utility maximizing "selfish" humans' rational actions. Elinor Ostrom drew from extensive research in the management common pool resources (for reviews, see Basurto & Ostrom, 2009; Ostrom, 2014) to refute Hardin's claim and instead argued that, for certain contexts (typically, homogenous user groups managing a bounded resource), communities may effectively manage a resource without formal (outside) recognition of the resource users' rights (Ostrom et al., 1999; Ostrom & Cox, 2010). In an effectively managed commons, individual agency is subsumed in the satisfaction of collective goals. Modeling collective agency has helped "solve" some of the behaviors rational actor models produce that standard Game Theory cannot account for (Lerique, 2022). The fact remains, however, that rational actor models only consider proximate causes of behavior and ignore more distal influences (e.g., social patterning) that may be relevant in analysis (Ingold, 2000; Scott, 2013a). Furthermore, even the decision-making of statistical experts does not conform with statistical principles (Kahneman, 2011). On these grounds, scholars have challenged whether Bayesian statistics are an accurate—or even helpful—model for cognition (Gigerenzer, 2000) and whether choice optimization (maximizing) is, in fact, the universal goal of decision-making strategies (Gigerenzer & Selten, 2001). In light of these challenges, many have concluded that even if *Homo econs* reason according to probabilistic rationality, homo sapiens clearly do not.

Beginning in the 1950s, in recognition of a need for a model of rationality based on how actual humans make decisions in the real world, Herbert Simon and a group of collaborators began building a model of human decision-making grounded in observation, rather than logical axioms. Simon used the analogy of scissors to conceptualize rationality as the nexus of cognitive abilities and task environment: to understand how it cuts, one cannot look at only one blade (A. Newell & Simon, 1972, p. 55). Simon's theory of bounded rationality describes how limitations of time and attentional resources 'bound' choice optimization in uncertain task environments (Simon, 1997). According to bounded rationality, an agent's rationality depends on their successful adaptation to a given task environment (Mastrogiorgio & Petracca, 2016;

Petracca, 2021). For instance, the limited cognitive resources of ants are sufficient for ants to succeed—i.e., to survive—in their environment (Simon, 2008). Thus, bounded rationality judges an individual or species' given choice strategy, what Simon termed its *decision heuristic*, based on the likelihood that it achieves a given goal in a given environment (Petracca, 2021). Simon's proposal replaced the optimization problem of maximizing expected utility with a simpler decision criterion he called *satisficing* or selecting the optimal choice outcomes given constraints (Simon, 1956). In other words, instead of assuming that means and ends are fixed in decision-making, Simon et al. contended that, at the moment of choice, humans adapt strategies and goals based on information that is made salient by the choice context (Chatterton, 2016). Bounded rationality was a very successful research program with implications for psychology, organizational theory, economics, and real world policy-making, ultimately earning Simon a Nobel Prize in economics in 1978.

Bounded Rationality: Consumers and Policy Actor Hesitancy Towards DPR

According to bounded rationality, making accurate and complete information about water quality and quantity available to consumers does not necessarily mean it will be accurately and completely applied in their decision-making. One water policy expert expressed her frustration at how often she is asked, "[I]s our drinking water clean?… It's like, go check your provider's EPA reports." But, she explained, "I'm really amazed at how many people don't check the information that their water provider has online about water quality" (WWGI02). However, having access to this information does not mean it will be understood. As utility communications professionals attest, it can be extremely challenging to convey the appropriate technical detail in a way that is accessible to consumers. One communications officer put it this way, “All of this nuance just makes the communications far more difficult. If I've got to teach the public about DPR versus IPR, that's tough… What water is coming out of my tap and how did it get there?” (WWGI29). Consumers have varying levels of background knowledge and interest in learning about water and given other demands on attention and time, they have limited resources to expend in addressing their questions about DPR, however important they may feel these to be. Providing complete information is therefore a strategy largely unavailable to utility actors in a world of satisficing consumers.

In selecting the best strategy to promote DPR, water providers intuit consumers’ bounded rationality when anticipating the pitfalls of information-based strategies. Although providing water quality and quantity information could fill a knowledge gap that (theoretically) limits rational actors from selecting the optimal choice, promoting the quality gains of DPR risks undermining consumer confidence in conventional water supplies. As one utility employee commented:

> [W]e can go too far in touting how great this water is. And only a fraction of our customers will be getting it initially, and then at some point the other ones will feel like, ‘What the heck? Is this water less adequate than that one?’ (WWGI19)

Water providers are also reluctant to draw attention to water scarcity, as it could reduce consumer confidence in providers’ ability to appropriately manager water supplies. As another utility employee explained, “[We need to be] getting away from scarcity. The messaging should be we manage the resource to its full use so you can stop worrying about it" (WWGPO11). These comments point to the larger landscape of trust and competition against which utility policymaking takes place.

As utilities anticipate the outreach efforts that will be required for DPR, information provision is only one among many approaches. One utility employee explained:

> I think it's going to be demonstration and leadership. I think this city probably needs to do something like what Flagstaff did in which the leadership of the city is going to step up and drink that beer. Do whatever you need to do. I think it cannot be a brochure that's mailed out as a singular effort to convince people. I don't think that will be enough. I think you need to get hands on. I think you need to put it on video. I think you need to get it on Facebook. (WWGI05)

For those who are highly resistant to DPR, a more direct approach may be required. One utility employee described their "soft" approach to targeted outreach, "Making sure we reach out to them and sit down with them and even one on one...to talk about what we're trying to do. Talk about what this means for water quality. Are you guys comfortable?…Go through that with them" (WWGI18). Utilities' multiple communication mediums, varied engagement activities, and strategic identification of high-needs populations demonstrate that, rather than conceiving of consumers as optimizers, they instead understand them to be satisficers situated in contexts that "bound" their choices.

Nudging: 'Heuristics and Biases' Applied to Policy

On the one hand, recognizing humans as boundedly rational has softened normative notions of rationality in academic, policy, and public discourse; on the other hand, it has hardened normative notions of *irrationality* in the public sphere. Daniel Kahneman and Amos Tversky (Kahneman & Tversky, 1984, 1984; Tversky & Kahneman, 1974, 1992) were among the first who attempted to apply bounded rationality to develop new theory (G. Wheeler, 2018). Kahneman and Tversky were fascinated by situations where decision-makers' choices systematically deviate from the predictions of expected utility theory (Kahneman, 2011). They attributed some of these deviations to loss aversion, which makes people more sensitive to the prospect of losing objects or money rather than gaining them. They also observed that people tend to evaluate prospective options based on a reference point, such as one's current wealth, and people's sensitivity to gains and losses diminishes relative to this reference point. In addition, they found that people systematically underweight high probability events and overweight low probability events. Building on these observations and on bounded rationality, Kahneman and Tversky proposed prospect theory (1974), later refined to cumulative prospect theory (1992). This innovation and their related work on framing effects (1984) ultimately led Kahneman to be awarded a Nobel Prize in economics (by then, Tversky was deceased). By modeling decision-making based on a value function, Kahneman and Tversky returned economics to theorizing reasoning rather than only choice (G. Wheeler, 2018), and pioneered the new field of behavioral economics.

Kahneman & Tversky's enthusiasm for identifying systematic deviations from utility maximizing choices attracted other researchers to join their effort to document a litany of so-called fallacies and cognitive biases affecting decision-making (Samuels & Stich, 2004). The validity of findings produced in the ensuing *heuristics and biases* research program have been widely criticized, even as it has significantly influenced how irrationality is conceptualized in scientific and popular discourse (Kahneman, 2011; Lopes, 1991; Samuels & Stich, 2004). It is therefore worth describing some of these critiques to demonstrate that commonly accepted notions of reasonable judgements and their supposed opposite, irrationality, have been established on shaky ground.

Some of these critiques have been directed towards Kahneman and Tversky's novel experimental between-subject research design[53] and their use of problem studies, in which a question, informed by a logical or parametrical frame, is posed to different groups of subjects so as to compare their responses (Lopes, 1991). In the set-up of these studies, there are only two possible results: one that is standardly rational and leads to the correct response and one that is heuristic and leads to an incorrect response (Lopes, 1991). However, while some results of studies in the heuristics and biases research program could be replicable within the same experimental design,[54] when the experimental questions are altered to be more complete or intuitive, people's reasoning was often more rational according to probabilistic rationality (Samuels & Stich, 2004; Spellman & Schnall, 2009). As Spellman and Schnall (2009, p. 128) write, "humans were not irrational, these experiments just made them seem that way."

The emerging fields of evolutionary and ecological psychology suggested that at least some of the heuristics leading to sub-optimal outcomes in the laboratory may be optimal in the evolutionary context (Samuels & Stich, 2004). By providing the appropriate environmental structure for information sampling (an approach Todd and

[53] In the established standard at the time, the within-subject experimental design used since 19th century psychophysiological studies to detect thresholds for sensory stimuli, individual subjects respond to dozens or even hundreds of abstract stimuli generated by systematic variation of the parameters believed to affect the measure under study.

[54] See Krueger & Funder (2004) for meta-reviews of experimental replicability of the "heuristics and biases" research program)

Gigerenzer (2003) term “repairing the scissors”), researchers have documented many reasoning and decision-making problems in which people's intuitive judgments do not deviate from appropriate norms of rationality (Lopes, 1991; Samuels & Stich, 2004; Spellman & Schnall, 2009; P. M. Todd & Gigerenzer, 2003). In this view, evolution has provided humans with an “adaptive toolbox,” including “fast and frugal” heuristics that make efficient use of attentional resources (Gigerenzer, 2004). Since the heyday of the heuristics and biases research program, newer methods have provided further evidence to undermine its conclusions about human irrationality. Brain imaging of subjects during decision tasks shows the complexity of adaptive decision-making leading up to conscious choice (Harmon-Jones et al., 2015; Soon et al., 2013; Voigt et al., 2019). Just as these findings were coming under attack in psychology, however, the “irrationality view” was taken up in legal and economic theory, ultimately making its way into government policy (Spellman & Schnall, 2009).

Decades later, the assumption is now well-established in policy circles that boundedly rational humans need to be protected from their own irrational tendencies (Thaler & Sunstein, 2008). An offshoot of behavioral economics, decision science has innovated so-called de-biasing approaches that seek to “steer” people towards behaving as probabilistic rationality would predict (P. M. Todd & Gigerenzer, 2003). Fundamentally, this approach ignores the logical fallacy in assuming that policy recommendations may be made by any group of actors, if all humans, including policymakers, have access to the same information and reason the same (Sent, 2018).

Notwithstanding these criticisms, one widely adopted policy approach is known as *nudging*. Premised on bounded rationality and libertarianism’s emphasis on free will and autonomy, nudges aim to alter choice environments to make it easy for actors to make normatively good decisions while maintaining their freedom to choose as they will (Thaler & Sunstein, 2008). The libertarian paternalism behind nudging rests on the assumption that policymakers know what is in people's best interest (Lichtenberg & Shafir, 2013), which has brought criticism about whether such behavioral manipulation is justified and, if so, to what ends (Bornemann & Burger, 2019; Bovens, 2009; Gigerenzer, 2015; Hausman & Welch, 2010; Lepenies & Małecka, 2019; Rizzo & Whitman, 2019; Sugden, 2018). Some charge that these strategies violate individual agency by intentionally exploiting heuristics and biases to influence choices, while others argue that, by not providing full and transparent information, these strategies violate the commonly accepted moral obligation to allow actors to make self-determined, informed decisions in accordance with one's own values. Others meanwhile contend that applications of nudging are justified in cases where individual behaviors come at the expense of collective well-being, for instance green nudges that seek to alter individuals' anti-environmental behaviors in order to reduce widespread ecological harm (DesRoches et al., 2023). This debate about nudging cuts to the heart of the social contract, highlighting questions of power and authority at its foundation.

Nudging: De-biasing Wastewater Disgust

Many participants engaged in the action research discussed in Chapter 6 agreed with this person, who suggested, "Just add it [DPR] to my water and don't tell me" (ARES). This statement may seem to suggest that default nudges where consumers are automatically enrolled in a DPR program could be an effective way to legitimate DPR among a utility's consumers. However, utilities are right to be cautious of this approach. One study (Tanner & Feltz, 2022) experimented with a default DPR nudge by informing subjects they were automatically going to begin receiving DPR water in their tap water. Although research subjects were able to opt-out, few did. Thus, the results found that defaulting people into the reuse program was associated with greater acceptance. However, rather than taking this as an indicator of success, the authors suspect that "not providing relevant information might have partially infringed upon an individual's ability to truly make an informed, autonomous decision in some cases" (p. 408). The paternalism inherent in nudging runs the risk that, if it were perceived to override individual autonomy to make an informed, self-determined decision, such an intervention could seriously backfire in some contexts (Bornemann & Burger, 2019; DesRoches et al., 2023; Rizzo & Whitman, 2019; Sugden, 2018).

The socio-political setting of Arizona appears to be just such a context. Whereas historically, American utilities have had wide latitude to unilaterally decide about water practices, negative public reactions to perceived violations of informed choice (e.g., utility decisions to alter water supplies through chlorination or fluoridation practices, Sellers, 2004) indicates a changing landscape of trust against which water policy decision-making takes place (Bruvold et al., 1975; Melosi, 2000; Millan et al., 2015). According to a recent statewide survey sponsored by ADEQ, 39 percent of respondents mentioned "government trust issues" as the biggest barrier to DPR adoption in their community (Brand Outlook & HMA Public Relations, 2023). The ADEQ researchers attributed the lack of trust in government to "a political divide" that causes "instant opposition" if the entity presenting scientific water facts is associated with a particular “political team” (Brand Outlook & HMA Public Relations, 2023, p. 17). As a result, according to one DPR stakeholder interviewed as part of this assessment, “People will say: ‘I don’t trust that it will be this simple. I don’t trust it will be safe and I don’t trust that the government knows what they are doing’” (Brand Outlook & HMA Public Relations, 2023, p. 53). DPR proponents interviewed in that research were aware that, as one put it, “the trust thing is… a challenge that local government and statewide and then national government is always kind of trying to overcome” (WWGI01). Consumers’ existing lack of trust for water providers indicates that, for many Arizonans, a default nudge may be perceived as a violation of bodily autonomy. As a result, in DPR policy circles, nudges have not been discussed much.

Nudging is a deficit approach to rationality that characterizes lacking information and attentional resources as justification for policymakers to decide for consumers. A different policymaking approach emerges when cognitive deficits are instead seen as assets, as Gigerenzer’s adaptive toolbox suggests. Whereas a deficit approach might lead a utility to assume that consumers lack information about water quality, utilities using an asset-based approach emphasize that treated effluent is already present in their drinking water supplies because of what is known as unintentional, or *de facto,* reuse. As one utility employee explained, “Most people have no idea that the city of Las Vegas treats their wastewater and puts it into Lake Mead” (WWGI05). As another commented:

> And so that [Colorado River] water has already been coming to the valley through the Central Arizona Project for decades, right? … All across the United States, water is returned to rivers and drawn out downstream [to be] used again… I mean, how many times is water used by the time it gets to New Orleans? (WWGI20)

Emphasizing de facto reuse shows people that have already adapted to water reuse without any observable ill effects, and that it's a widespread practice (Rice et al., 2013, 2016). Another employee takes a similar approach in describing the difference between DPR and IPR to consumers: "It's just now instead of the ground filtering it and doing what it's done, now we're just taking it directly and then just adding additional treatment processes to get it through and bring it to drinking water quality" (WWGI09). These discursive strategies build on the experiential knowledge of consumers to contextualize an otherwise unfamiliar practice.

With potable reuse projects coming online in California, Texas, and Colorado, many reuse proponents expect the increased availability of direct and secondary experience with DPR to make it much easier to demonstrate its safety and value. The best practice literature has started to reflect more lessons learned from successful interventions in the field (e.g., Distler & Scruggs, 2020; Eckl et al., 2023; Scruggs & Thomson, 2017). According to reuse proponents, among the most effective public engagement approaches is providing samples of DPR water. At an industry conference, one reuse consultant was asked, "Is it necessary to have a pilot or demo project?" To which the consultant responded, "The most important part is you are giving a chance to taste the water. People say, 'It tastes just like water.' Well, it is water!" (WWGPO12). As demonstrated in Chapter 4, tastings are particularly effective because they are mobile, they are universal in that everybody drinks water, and they afford partnerships beyond industry spokespeople, such as with beer brewers, who can communicate the value of DPR in new ways. According to several reuse proponents and consumers engaged in this research, even if someone refuses to sample DPR water themself, it is compelling to see others, especially respected public figures, drinking DPR water. As a means for consumers to taste the water supply of the future, DPR tastings provide an important chance for consumers to learn their own adaptive capacity—as well as to actually adapt their capacities to respond differently.

Embodied Theories of Rationality: A Proposal for Standard Rationality

While lacking a normative theory of rationality is perhaps not a barrier for the descriptive work of social scientists, it poses a serious challenge for the prescriptive aims of sustainability scientists and policymakers. Theories of rational choice and bounded rationality are not "wrong," but they rely on classical models of brain-based cognition. Since Simon's death in 2001, advancements in neuroscience and dynamical systems models have instigated an "embodied turn" in cognitive psychology, summarized in Chapter 3. Meanwhile, psychology has come to understand emotions as essential to, rather than separate from, cognition. Theories such as the affect heuristic (Finucane et al., 2000; Slovic et al., 2007) have led to a complete revision of earlier understandings of judgement and decision-making to characterize emotions as integral to, not corrupting of, human reasoning (Lerner et al., 2015; Weber & Johnson, 2009). As Kahneman (2002) later conceded, the availability heuristic may be better understood as the affect heuristic.

Several scholars have recently drawn from contemporary understanding of the dynamic, body-based, emotional, and situated nature of perception to propose new takes on standard rationality (Petracca, 2021). These proposed frameworks are paradigmatically different from the autonomous faculty of reason conceptualized by linear, cognitivist models of rational or boundedly rational actors, or the adjudication of rationality in the heuristics and biases research program. Theories of rational choice and bounded rationality are premised on methodological individualism, which places primacy on individual actions in analyzing a situation (Heath, 2020). Standards of rationality are different if you consider sense-making to be a collective, rather than individual enterprise, and if emotions and sensations are considered credible as sources of knowledge (K. Jones, 2004). As Jones (2004, p. 311) writes, "[O]ur knowledge is made possible through epistemic dependencies on others. We routinely rely on others for information that we cannot acquire ourselves, in both everyday and formal contexts of inquiry." Furthermore, the site of rationality changes depending on whether cognition is considered to be located solely in the body or whether it extends to the material and social surroundings (Gallagher, 2018a).

Embodied and enactive cognition understand experience to be co-constructed between an organism and its surrounding environment, resulting in a view of reasoning as inextricably situated (De Jaegher & Di Paolo, 2007; Gallagher, 2008) and potentially extending beyond the body proper (A. Clark & Chalmers, 1998; Noë, 2010; A. D. Wilson & Golonka, 2013). Defining a standard rationality premised on relational ontologies is important to redefining what is considered rational action in policy design, with potential for reshaping epistemic hierarchies beyond the sphere of governance.

The following sections review various proposals for rationality generated by scholars in the research program of embodied and enactive cognition (EEC)[55] and then synthesizes these into a normative universal, *embodied rationality*. The proposition here is that embodied rationality provides a way to assess the "fit" between task demands and

[55] See Chapter 3 for a full review.

embodied cognitive capacities.[56] The chapter then presents evidence of how embodied rationality has been applied in DPR policymaking to generate public engagement approaches that are superior to the strategies informed by assumptions of rationality reviewed above. The chapter closes by briefly considering how embodied rationality could provide normative support for adaptive policy approaches in sustainability science.

Ecological Rationality

Gigerenzer et al. (Gigerenzer & Selten, 2001; Gigerenzer & Todd, 1999) draw from ecological psychology to propose *ecological rationality* as an update of Simon's bounded rationality research agenda[57] (see also, Mastrogiorgio & Petracca, 2016; Petracca, 2021). *Embodied heuristics* exploit sensorimotor capacities to reduce cognitive task demand (Gigerenzer, 2021). For example, by using the gaze heuristic, a baseball player running to catch a fly ball keeps her angle to the ball constant until the point of interception; no knowledge or prediction about the landing point is required (Gigerenzer, 2021; Gigerenzer & Selten, 2001). Rather than a linear choice optimization problem, embodied heuristics utilize the body to produce environmental information necessary to make good decisions (Gigerenzer, 2004, 2007; Gigerenzer & Todd, 1999).[58] The conclusion here is to act rationality is to maintain proficient interaction with the

[56] Embodied cognitive capacities was introduced in Chapter 4 to refer to an individual's or collective's capabilities to detect and respond to signals from the internal and external environment. Embodied rationality discussed here provides the normative framework to determine the adaptive attunement of embodied cognitive capacities to respond to environmental affordances for action.
[57] They characterize this as an attempt to "repair" bounded rationality by "putting the body at the pivot point of Simon's scissors."
[58] Petracca and Grayot (2023) call this approach, which considers the coupling between organism and the biophysical and social environment (humanature) as the space of rational action, "the naturalization of rationality."

environment so as to adaptively and continuously coordinate one's embodied cognitive capacities according to environmental constraints (Rolla, 2021).

Embodied Rationality According to Spellman and Schnall

Spellman and Schnall (2009) agree "that perceptions of environmental characteristics are not 'objective,' but are the result of pragmatic and functional demands for specific actions embedded in specific environments" (Spellman & Schnall, 2009, p. 136). For example, Proffitt et al.'s hill studies (Bhalla & Proffitt, 1997; D. R. Proffitt, 2006; Schnall et al., 2010) demonstrate that people's physical and psychosocial resources moderate their perception of their environment.[59] Based on the evidence on embodied perception, they argue that "even seemingly objective aspects of the physical environment, such as the distance to a target, or the steepness of an incline, involve the subjective experience of the body that perceives the environment" (p. 137). Therefore, to better reflect how people make judgements in the real world, embodied rationality should consider how the informational, temporal, cognitive, and other constraints on action relate to formation and achievement of adaptive goals (Spellman & Schnall, 2009).

Embodied Rationality According to Gallagher

The last five years have seen several authors extend these previous conceptualizations of ecological rationality and embodied rationality. Shaun Gallagher (2018, p. 86) defines *embodied rationality* in terms of affordance theory:[60] "[W]e can think of reasoning as the ability to differentiate which affordances to respond to, and how

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[59] These studies of slant perception are discussed in more detail in Chapter 2.

[60] Discussed in Chapter 3, affordances are perceiver-dependent environmental opportunities for action. Affordance theory (Gibson, 1979) argues that we look at objects we perceive their affordances.

to go about responding to them." Gallagher locates reasoning in the various modalities and spatialities of embodied action. For example, he notes how, when reaching for a banana, the hand forms a different grip based on the reacher's intention, whether it be to eat it, to pretend it's a phone, or to throw it at someone. Based on this, Gallagher (2018a) concludes:

> The hands, and more generally, the body and its movement in this regard are rational and perform a kind of 'manual thinking' (Bredekamp 2007) that integrates its action across all perceptual modalities. Thus, we have a rationality involved in touch and haptic exploration, hand-mouth coordination, hand-eye coordination… (p. 89)

According to this view, rationality no longer solely takes place in the brain or at the moment of choice selection, but rational action extends through space and time as the body competently responds to its environment.

Radically Enacted Rationality

Rolla (2021) draws from nonrepresentational theories of direct embodied cognition (Chemero, 2011, 2013) to propose *radically enacted rationality*. Rolla's proposal (2021) builds on principles of self-organizing, dynamical systems (recall the analogy of the Watt's governor provided in Chapter 3) to assesses rationality in terms of evolutionary adaptation:

> Over short timescales, the interplay between organism and environment depends upon anticipation, action, response and adjustments, which in turn lead to further anticipations and so on (over broad timescales, interactions of that kind cause phylogenetic [species-level] adaptations that allow the organism to thrive more efficiently in its niche). (p. 5579)

In his writing on bounded rationality, Simon (1997) observed an ant's use of a small set of simple heuristics and bodily and communicative capacities to navigate a complex environment. According to Rolla's (2021, pp. 5584–5585) view, Simon's ant is reasonable, but humans are *more* reasonable[61] because they "have a wide array of abilities and their combinatory result is potentially infinite, thus enabling innumerable ways of coping with dynamical environments, including ones never encountered before." Embodied rationality thus incorporates a commitment to naturalism while avoiding a reductive view that negates the exceptional (though possibly not unique) achievement of human self-reflective consciousness.

Situated Normativity

None of these theories of embodied cognition explicitly addresses free will, leaving open the door to challenges on the grounds of determinism. Gibson's *affordance theory* (1979/2014) provides a way to maintain individual agency and opportunities for creative action within a constrained set of action possibilities. As Gallagher and Ransom (2015) point out:

> An individual's occurrent affordance space is defined by evolution ([e.g.,] the fact that she has hands), development (her life-stage—infant, adult, aged), and by social and cultural practices (and their normative constraints)—all of which enable and constrain the individual's action possibilities. (p. 341)

Through practical learning, an individual acquires *skilled agency,* the capacity to detect the "solicitations" of one affordance over another, and to perform the solicited actions in

[61] Rolla (2021) uses "rational" here, but in keeping with the definition provided at the beginning of the chapter, "rationality" should be reserved for judgements of reasoning abilities insofar as they represent a match between plans and intentions.

accordance with socio-cultural practices (Bruineberg & Rietveld, 2019; Gallagher, 2018a; Rietveld, 2008). *Situated normativity* is the skilled agency of an individual "to distinguish correct from incorrect, better from worse, optimal from suboptimal, or adequate from inadequate activities in a specific, concrete material setting" (Rietveld & Kiverstein, 2014, p. 332). Situated normativity includes the unreflective, yet reliable, performance of activity in accordance with sociocultural customs, while preserving the ability to respond to specific details of particular situations in potentially unconventional ways (Rietveld, 2008; Rietveld & Kiverstein, 2014). Chapter 4 discusses the specific embodied cognitive capacities involved in detecting and responding to signals from the internal and external environment in accordance with situated normativity, which makes certain possibilities for action, including imagined action, available or unavailable, imaginable, or unimaginable.

Practical Rationality

According to Stout (2022),[62] *practical rationality* applies to actions performed in accordance with normative judgements that they are the right way to bring about a goal. Stout (2022) distinguishes between being *subject* to rules and norms such that they *cause* action,[63] and being *sensitive* to them such that they *suggest* action.[64] Stout's practical

[62] Whether or not one considers Stout's theorizing as part of EEC depends on the success of his attempt to rescue behaviorism, which, he claims is premised on the same theoretical landscape and empirical commitments as direct perception. Alksnis & Reynolds (2021) and Legg & Reynolds (2022) agree with this contention.

[63] I have substituted "action" for "behavior" in this retelling of Stout's theory because, in this dissertation, I reserve the term "behavior" to segment multiple action-perception cycles over time or across individuals. For example, numerous action-perception cycles form a gestalt (e.g., "tasting behavior") which are themselves constituents of the embodied cognitive competencies included in the assemblage of materials, and meanings that comprise practices.

rationality, therefore, preserves the free will of actors in two ways. First, it is possible for actors to "fail" by being insufficiently sensitive to rules and norms. Indeed, "action acquires its very reasonableness from taking into account these social rules and guidelines for behavior" (Scott, 2013a, p. 83). Second, Stout (2022, p. 90) writes, "The rules themselves are up to us—they are of our own making; this is what it is to be free autonomous agents." Unlike axiomatic rationality premised on predetermined rules, the rules in Stout's practical rationality are dynamic, providing an emergent, open-ended, and adaptive definition of rationality. Accordingly, "[B]ehaviour is governed by the rule: do what rationality demands. That is different from being governed by rationality directly" (Stout, 2022, p. 106). Practical rationality, per Stout, provides an account of how socio-cultural affordances emerge from within the individual *and* are co-constituted through social and environmental relations (see also Rouse, 2023; and Schatzki, 2002, who theorizes teloeaffective structure as the normative link between practice and ends).

Embodied Rationality in this Dissertation

To various degrees, the models of embodied, ecological, radically enacted, and practical rationality reviewed above share a situated view of rationality that is continuously revised through the interplay of body and socio-environmental context. From this point of departure, this chapter synthesizes these contributions into the following definition of *embodied rationality*: To act rationally is to adaptively attune one's embodied cognitive capacities in accordance with socio-material constraints and

[64] This is similar to affordances, which provide opportunities for action but do not themselves determine action.

opportunities so as to maintain competent performance of actions. This implies that the more attuned an organism's embodied cognitive capacities are for coping in dynamic environments, the more rational it can be said to be (Rolla, 2021). Rationality in this view can be located in all action, from the most basic forms of sensorimotor engagement with one's environment (e.g., grasping an object) to reflective thought. Rationality is also not exclusively the domain of humans but is present in the behavior of all sentient organisms. Acting rationally is to behave in accordance with shared social norms, but it may be rational for skilled individuals to deviate from these norms in response to particular material or sociocultural affordances; indeed, such spontaneous departures are an important source of novelty and adaptation. With this definition in hand, the chapter next illustrates how embodied rationality can be applied in policymaking.

Embodied Rationality: An Innovation in DPR Governance

Many of the newer strategies that DPR proponents favor seem to accept consumers' feelings of hesitancy rather than treating them as evidence of irrationality. Communication strategies emphasizing de facto reuse and IPR draw on present-day experiences of wastewater reuse to provide evidence of its acceptability in drinking water supplies, thus establishing a continuity between present and future water supplies. DPR tastings, meanwhile, provide an opportunity to directly experience the water supplies of the future. During Scottsdale, Arizona's flagship Canal Convergence festival, their water utility, Scottsdale Water, hosted a One Water Brewing Showcase where tens of thousands of residents had the opportunity to taste DPR water and beer. These and other experiential engagement activities, such as treatment demonstrations and facility tours, provide an accessible way for consumers to learn about DPR, and for utilities to learn about consumers' hesitancies. In tastings, this two-way communication can be impersonal, but in more traditional modes, such as community and one-on-one meetings with utility spokespeople, the physical presence, confidence, and care of utility employees can help build trusting relationships with hesitant consumers. All these approaches are examples of applying embodied rationality to benefit policymaking. However, there is reason to wonder about the reach of normative standards of embodied rationality in water governance.

This research noticed a strong difference between technical experts, who are usually engineers, and communications experts, who usually have non-technical backgrounds. This is important because, except for public information officers, almost all senior managers at the municipal and private water utilities engaged in this research have engineering backgrounds. Communications experts therefore hold comparatively little power in administrative hierarchies and tend not to be involved in strategic planning around DPR (WWGPO07). Whereas the utility employees on the technical side of utilities tend to believe "we can get there" (WWGI25), those on the communication side have more awareness of the complex social issues that may confound this goal. For example, as one communications professional observed:

> Historically, there has been a perception of that the local government has either tried to, or in some way, shape, or form provided, a different type of service in a certain neighborhood, versus in another neighborhood, when we know that that's not always the case. Obviously, it's not the case, but there are other factors that play into development and things like that, which have perception of better-quality water here versus there. So, I

> think that kind of drives people into questioning more. If you have a slight variation in color or the bubbles or anything like that, I think certain areas would be more alarmed than others. (WWGI01)

Given that environmental justice concerns were a significant factor in loss of support for a prior DPR proposal (e.g., San Diego, Hartley, 2006), it is important that local reuse proponents consider such factors. In comparison, take the observation of this utility manager:

> I just look at it and go, oh, well, that's just DPR. Other people do it. Let's just go build a plant. Hook it up to the pipe, and let's roll. So undoubtably my little engineering mind has me underestimating the effort that will likely need to go into that. Luckily, I have other people that work for me that aren't engineers and they are all looking at me going, you better worry about this. (WWGI07)

Awareness of public reluctance helped this utility employee recognize his own bounded rationality. Therefore, it seems possible that direct and secondary experiences with the successful experiential interventions in DPR may eventually lead him and others like him to also embrace embodied rationality.

Notwithstanding the extent of uptake among individual practitioners, unless embodied rationality is adopted more broadly as a normative universal in drinking water governance, utilities may still be accused of paternalism or even of manipulating the public into acceptance. As Chapter 4 reports, most utilities pursuing DPR in the study area are well into planning their facilities yet have actively worked to keep these plans out of public discourse. This reflects the decide-educate-announce-defend (DEAD) approach common in the industry (Booher & Innes, 2005; Fielding et al., 2019). However, because of strong public resistance to DPR, the best practice literature cautions against taking a DEAD approach and instead advises utilities to involve community residents early in planning and update plans according to community feedback (Tennyson et al., 2015). Other Arizona utilities have adopted more collaborative approaches to DPR planning. For instance, Tucson, located in Southern Arizona, recently released their *One Water Draft Master Plan* (Carollo Engineers, 2023). The result of 4 years of community-involved planning, the report states, “To maximize the use of recycled water in the future with either IPR or DPR, Tucson Water must also be proactive with respect to the water quality expectations of the community” (pp. 3–17). Tucson provides a practical example of how Central Arizona utilities can foster inclusive participation, although it may be challenging to adopt for utilities that have set their sights on DPR as it involves relinquishing some power over the ultimate outcome of decision-making.

The governance approach adopted in Tucson draws from integrated water management, a subset of adaptive water management. Integrated water management recognizes the uncertainty and variability inherent in water systems and therefore includes mechanisms for actors to monitor and adjust strategies over time based on new information and changing conditions (Bell, 2017; Paulson et al., 2017). Including diverse stakeholders in monitoring and planning increases knowledge flows and ensures that decision-making considers different perspectives and priorities. With shared roots in complex adaptive systems, embodied rationality provides support for adaptive water governance practices. Integrated water resources management is a policymaking approach that recognizes decision-making bodies, like individual decision-makers, to have embodied rationality, and puts in place mechanisms to aid these bodies to achieve good outcomes.

However, it's worth noting that integrated water management often relies on typical stakeholder selection practices, meeting formats, and language-based forms of discourse. This approach ignores the corporeal body's role in decision-making and runs the risk of professionalizing rather than democratizing participation. Scholars Morgan and Grant-Smith (2015) studied a failed DPR proposal in Toowoomba, Australia, and identified several procedural failures that may be remedied by wider adoption of Arizona utilities' innovations. First, Morgan and Grant-Smith (2015, p. 1783) point out the need for a shared language between scientific and lay participants that allows "discussion of the otherwise unspeakable... [such that] shared emotions (such as disgust) may provide the coordinating mechanism." As seen in Arizona's DPR tastings, the a sample of DPR can be an experiential boundary object that enables effective coordination despite differences in knowledge and experience.[65] Furthermore, because "there's no accounting for taste," DPR tastings create an aesthetic platform that validates dissent.

Second, Morgan and Grant-Smith (2015) observe that considering science as equal to other knowledge practices establishes the legitimacy and credibility of all participants. Arizona utilities' use of tastings carved out a space for pluralism in a technocratic water management paradigm. However, they are rarely seen as a governance mechanism. Rather than simply serving as one-directional outreach, DPR tastings could be a means for utilities to gather information about consumers' experiential knowledge and the embodied foundation of their hesitancies. This data gathering already happens informally, since the social setting of tastings requires servers to positively engage with consumers' "yuck" responses, leading them to learn about the embodied rationality of

[65] Boundary objects (Star & Griesemer) are shared artifacts or concepts that help social groups with diverse perspectives and purposes can effectively communicate and collaborate.

consumer hesitancy. By adding formal methods to collect and preserve this experiential data, utilities can demonstrate to consumers that their experiences matter and are being considered in decision-making.

As Chapter 4 demonstrates, utilities adapt planning in response to anticipated consumer responses, but do so in reaction to or in avoidance of negative feedback. Making consumer concerns and hopes tangible in the present and formalizing these as co-learning processes may provide valuable information for decision-makers while increasing the social legitimacy of utility plans. The use of tastings cannot stand in for the full implementation of participatory water governance, which is still aspirational among most Central Arizona utilities, if it is considered at all. Adaptive management requires going even further to yield power to decide the goals and priorities of planning. Even as it might seem that these utilities are far from adopting these innovations in water governance, Arizona utilities that implement DPR tastings already incorporate embodied rationality as a normative standard in DPR outreach. Given this, it is less far-fetched to imagine utilities extending embodied rationality to other dimensions of decision-making, and ultimately implementing adaptive water management as a governance paradigm.

Limitations

It is beyond the scope of this research to determine whether a standard of rationality premised on embodied and enactive cognition is ‘truer’ than competing models. However, normative universals of rationality are less about absolute than relative truth. One of the main arguments for the continued use of rational choice models in governance is their ability to produce testable hypotheses. While this chapter demonstrates that this is not such a strong argument after all, it cannot claim embodied rationality provides equivalent predictive models. Embodied rationality does not produce testable hypotheses and is therefore a "framework" rather than a "theory." While theoretical axioms about embodied rationality may be proposed by artificially segmenting off a portion of reality, or by applying evolutionary methods as is done in the work around embodied heuristics or agent-based modeling, such proposals should always be seen as tentative and subjected to testing in real-world settings, which will almost certainly complicate the neat linearity of such axioms. While the inability of embodied rationality to produce testable propositions may be a deficit for some applications, the pragmatic objective of this project sought to describe rather than predict rational behavior in order to prescribe normative action for sustainability. In this case, embodied rationality departs from previous efforts to define rationality so as to make the world more intelligible, predictable, and controllable. Instead, embodied rationality follows the claim that "the world is its own best model" (R. A. Brooks, 1990, p. 5). Applying embodied rationality to both individuals and governance structures supports knowledge co-production processes that involve a broad array of actors, use boundary objects to increase the pluralism of decision-making, and increase action-perception cycles at the system scale through iterative, adaptive management practices.

Conclusion

This chapter set out to define a normative standard rationality that more accurately represents actual human thought and action to inform the design of sustainability interventions that enable society to "meet the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987). The limited success of sustainability policies may be due to sustainability science's assumption that humans behave as theories of rational actor and bounded rationality would predict (Bercht & Wijermans, 2019; Constantino et al., 2021; Schill et al., 2019; Schlüter et al., 2017, 2019). Through a review of how utility workers engage the public about DPR, this chapter identifies the insufficiencies of previous models and the approaches they inform. Experiential forms of engagement, such as DPR water tastings, have been particularly important in building the legitimacy of DPR as a water supply option. However, there is little justification for the success of this approach in extant notions of rationality. Therefore, this chapter synthesizes a proposal, grounded in embodied and enactive cognition, for embodied rationality: rationality is the adequate performance of action relative to an organisms' embodied cognitive capacities and its environmental affordances.

Embodied rationality is a radical departure from previous standard universal rationalities in that it is dynamical where they are axiomatic but provides support for established lines of thought in sustainability, making it a natural fit for sustainability research and practice. With shared roots in complex adaptive systems, embodied rationality can help sustainability scholars address some of the theoretical difficulties in conceptualizing socio-ecological systems dynamics. While many claim that human cognition is an important driver in maladaptive dynamics, few scholars have investigated how "inner processes" shape "outer processes" in SES (cf. O'Brien & Hochachka, 2010;

Wamsler et al., 2021), and still fewer theorize this co-production in ways that challenge the binary of inside-outside altogether (cf. Wyborn, 2015).

EEC takes a complex adaptive systems approach to theorize how humans' action-perception cycles shape, and are shaped by, individual and collective behaviors, in addition to environmental feedbacks. This supports Schill et al.'s (2019) suggestion, also rooted in complex adaptive systems, that through processes of socio-ecological co-evolution, humans are "enculturated" in broader cultural contexts and "enearthed" in their biophysical environment in ways that reinforce SES patterns. Embodied rationality provides a normative framework to evaluate the social and evolutionary "fit" between a specific action or pattern of enculturation and an ever-evolving landscape of environmental and social affordances. However, despite this understanding, complex linkages can create unexpected feedbacks, making it difficult to intervene in SES (Preiser et al., 2018). Again, embodied rationality can help by providing support for complex adaptive systems approaches to governance, such as integrated water management. Another example, transitions management, explored in more detail in the next chapter, makes use of adaptive planning to iteratively experiment, monitor, and learn, in order to foster the emergence of optimal governance strategies (Loorbach & Rotmans, 2010).

Embodied rationality also provides support for new sustainability paradigms. By applying embodied rationality to understand cycles of co-production in humanature, it becomes possible to identify and intervene in maladaptive system dynamics without reinforcing dualistic separations of human-nature, self-other, or body-mind. In this way, embodied rationality can support recent calls in sustainability science "to develop distinct normative, methodological and ontological roots for relational values" (S. West et al., 2018, p. 36). Embodied rationality can also be found in efforts to reformulate ecosystems services (Raymond et al., 2018), advance a "dwelling perspective" as an alternative to planetary boundaries (Cooke et al., 2016), and define how "sense of place" emerges to make place attachment a powerful stabilizing force in sustainable development (Masterson et al., 2017; Raymond et al., 2017; Stedman, 2002). These themes are discussed more in the conclusion of this dissertation.

As this brief discussion demonstrates, embodied rationality not only advances sustainability theorizing but provides a better foundation than rational actor or bounded rationality for sustainability science's prescriptive project. The next chapter illustrates this in further detail.

CHAPTER 6

MATERIAL CO-PRODUCTION: CO-DESIGNING PRACTICE-BASED INTERVENTIONS FOR SUSTAINABILITY TRANSITIONS MANAGEMENT

In the United States, national and local governance actors recognize that widespread transitions are necessary to mitigate and adapt to the worst effects of climate change (USGCRP, 2023, 2023). Large-scale sustainability transitions of energy, food, transportation, employment, communications, and other socio-technical systems involve alterations to physical infrastructures—as well as consumption patterns, daily habits, personal and collective identities, social norms, and values (Shove & Walker, 2007, 2010). Proposals that seek to reform ingrained practices frequently provoke strong negative emotions (Mair et al., 2019; Martiskainen & Sovacool, 2021). In response to this dynamic, policymakers may pursue policies with less effect on everyday life, and potentially less impact on societal sustainability.

One example of this dynamic can be found in the arid southwestern United States, where utilities have delayed adding recycled wastewater into the drinking water supply. However, amidst regional megadrought, this strategy, known as direct potable reuse (DPR), is increasingly seen as a necessary way for water managers in arid regions to enhance the resiliency of water supplies. Best practice guidance for integrated management of wastewater and water, such as One Water, manage for uncertainty through adaptive planning (Larson et al., 2015; Paulson et al., 2017). Within these management frameworks one key strategy, echoed by reuse industry consultants in conferences and webinars, is to involve consumers early in planning so that utilities can adapt to their concerns. Despite the benefits of this strategy, Central Arizona utilities continue to follow the outmoded decide-inform-defend approach to water governance. As documented in Chapter 4, several utilities have built, or are planning to construct, DPR facilities with little public input.

Until recently, utility sponsored DPR outreach and engagement has relied on the provision of technical information and normative messaging, such as, “All water is recycled.” However, reuse proponents increasingly recognizes the value of providing the public with opportunities to directly experience DPR through treatment demonstrations and tastings (Eckl et al., 2023). Among utilities from Oregon to Berlin, one popular strategy is to produce beer from DPR, which is then served to consumers. Reuse beer has been popular with beer drinkers but may be less effective with the highly hesitant consumers that utilities most need to engage. Recognizing the limitations of a one-size-fits-all approach, utilities are unsure how to develop locally appropriate opportunities to directly experience DPR. As Chapter 5 observes, tastings are applications of embodied rationality because they are inherently pluralistic, embodied, and deliberative; yet utilities rarely see these as bi-directional engagements rather than one-directional promotion and education. This demonstrates the need for an approach that utilities can use to develop contextually specific engagement strategies premised on embodied rationality.

The transitions management literature has similarly identified a need for strategic approaches that establish the necessary local preconditions for successful interventions (Wolfram, 2016). Scholars have advanced practice-based action research as a means to foster sustainability transitions from the ground up (Geels et al., 2016; Hof et al., 2020; Rauschmayer et al., 2015). Especially for highly novel innovations, an emergent learning-by-doing approach is necessary to tailor an innovation to the local context (Bulkeley & Castán Broto, 2013; Geels et al., 2016). Practice-based intervention (PBI) is a recent strategy that aims to advance sustainability transitions by promoting reflexivity on practices that contribute to unsustainability (Laakso et al., 2021). However, extant PBIs reported in the literature tend to operate at very local scales, either as grassroots transition experiments (Bos & Brown, 2012; R. R. Brown et al., 2013; Savini & Bertolini, 2019; Von Wirth et al., 2019) or by targeting household or consumer behavior (Godin et al., 2020; Sahakian & Wilhite, 2014; Wallenborn & Wilhite, 2014). These locally specific efforts can be difficult to "upscale" to achieve widespread sustainability transitions (Laakso et al., 2021; Naber et al., 2017), highlighting a need for PBIs that target practices with widespread reach.

This chapter responds to these needs by proposing a novel transitions management strategy, *material co-production*, that targets the practices of governance actors. In material co-production, diverse stakeholders collaborate on an experiment to accelerate social learning about a proposed sustainability transition, while governance actors simultaneously engage in learning-by-doing about the benefit of collaborative practices. Material co-production departs from previous upscaling research focusing on governance actors (e.g., Hoolohan & Browne, 2020; Hyysalo et al., 2019) by including non-governance actors in experimental practices. It applies design research methods to involve policy opponents, as well as proponents, in collaboratively designing a PBI about the proposed transition, which is then deployed with many directly affected individuals to prompt reflection and gather feedback on the proposal earlier in the policy development timeline. This approach enables more robust and authentic deliberations about a proposal by including the emotional and experiential knowledge of a wide range of people. Material co-production is therefore a *governance PBI*, a novel type of PBI that applies a practice-informed approach to collaboratively develop transition policies that are responsive to socio-cultural context.

This chapter begins with an overview of practice theory, transitions management, and social learning, describing how these frameworks provide the theoretical foundation for PBI methods and how design research has been expanding the suite of methods to bring participants' sensations and emotions into participatory sense-making practices. The methods section reviews how material co-production was used in the research to produce a PBI about DPR to introduce new governance practices to water managers. Findings present relevant empirical evidence from field work, where the material co-production process revealed nuanced information about consumer hesitancies and led to new understandings of governance possibilities. The discussion section considers what findings reveal about the possibility to develop consensus on difficult sustainability transitions through material co-production. The chapter concludes with a discussion of material co-production's implications for theorizing and applying practice-based interventions in sustainability transitions.

Theoretical Foundation

Centering Practices in Sustainability Transitions

The sustainability transitions literature has increasingly noticed that patterned practices (e.g., eating, bathing, and recreating) can lock-in unsustainable patterns of behavior (Geels, 2020; Shove, 2010b). Through the repeated performance of a practice, perceptions of a "right and wrong way of doing things" emerge and become attached to daily habits (Nicolini, 2017, p. 5). These perceptions can, in turn, limit whether transition pathways are deemed acceptable, or even credible, by practitioners (Raven et al., 2010; T. Schatzki, 2011; Shove, 2010a). Applying a practice-theoretical lens can reveal the technologies, infrastructures, markets, cultural meanings, and social norms that become inextricably linked through practice (Reckwitz, 2002; Shove et al., 2012). For instance, showering practices are reinforced by social norms regarding hygiene as well as embodied experiences with body odors and other sensations that can reinforce wasteful patterns of energy and water use (Hand et al., 2005). Practice-informed studies of hygiene found that embodied experience also affects the physical design of homes and bathrooms, and how time and work-life routines are organized (Browne et al., 2013; Hand et al., 2005). These behaviors and choices often prove difficult to change through policy instruments; nevertheless, they remain open to dramatic reconfiguration (T. Schatzki, 2016; Shove, 2022).

Transitions management builds on theories of socio-technical transitions (Geels, 2002; Kemp, 1994), as well as integrated assessment of long-term societal change (Rotmans et al., 1997), sustainable development (World Commission on Environment and Development, 1987, p. 19), complexity theory (Rotmans et al., 2001), and innovation studies (Dosi, 1982; Rogers, 2003) to accelerate transitions towards sustainability. Informed by these ideas, transition managers initiate cycles of experimentation and learning among diverse stakeholders to iteratively adapt processes and goals to progressively attain sustainability outcomes (Kemp & Loorbach, 2005; Loorbach & Rotmans, 2006). One opportunity identified in transitions management is Strategic Niche

Management (Kemp et al., 1998; Van Der Laak et al., 2007), which seeks to nurture niche innovation with potential to upscale and lead to widespread sustainability transformations.

Nurturing innovation is often done through the design of socio-technical experiments, a collective endeavor where the “goal is to try out innovative approaches for solving larger societal problems of unsustainable technologies and services” (H. S. Brown et al., 2003, p. 292). Reflecting the influence of practice theory in transitions management, researchers have begun exploring practice-based interventions (PBIs), initiatives that explicitly or implicitly aim to introduce and experiment with new or alternative household or organizational practices (Laakso et al., 2021, p. 101861). However, the influence of these PBIs on widespread practice remains uncertain. For example, Laakso et al. (2021, p. 101861) reviewed the processes by which low-carbon PBIs upscale, meaning they are “continually reproduced by those who do them, gain traction outside a limited number of households, and [become] embedded in the wider system of practices.” While they found that the PBIs studied did meet some local success, they concluded that, in general, the spatio-temporal grounding of practices requires they be reformulated when transferred to new sites (Laakso et al., 2021). This leaves in question the ability of site- and temporally-specific PBIs to contribute to large-scale sustainability transitions (Laakso et al., 2021; Naber et al., 2017).

As currently theorized, PBIs may have limited effectiveness as a tool in transitions management. Perhaps due to the disciplinary nexus of socio-technical transitions and practice theory in consumer studies, PBIs have thus far primarily targeted household energy practices and technologies (Hargreaves, 2011; Sahakian & Wilhite, 2014; Warde, 2005). Furthermore, the limited discussion of PBIs in the literature tends to follow the tendency in transitions management to consider the role of certain actors as privileged and knowledgeable “managers” of “the system” that is external to them (Avelino, 2009; Hendriks, 2009; Meadowcroft, 2009; Shove & Walker, 2007). This separation legitimates knowledge of those with authority to act, while delegitimating knowledges and strategies of other groups of people (Klenk & Meehan, 2017; Nightingale et al., 2021). Approaches aligned with transitions management, such as reflexive governance (Voß et al., 2009) and complexity governance (Scoones & Stirling, 2020), see transitions as driven not by a single powerful actor but by many kinds of actors in a distributed governance arrangement (Avelino & Wittmayer, 2016). Recognizing the complexity inherent in such processes, “The general approach is one of nurturing and growing rather than planning and controlling long-term societal change” (Voss et al., 2009, p. 277). This calls for more transdisciplinary approaches to the management of transitions.

The present research therefore identifies a rich opportunity to extend PBIs to what Shove & Walker (2007, p. 476) term “the governance of practice.” As Shove and Walker (2007, p. 476) note, “[I]nnovations in practice do not materialize unless enacted by those who *do*–whether that doing involves showering, visiting friends at the week-end, taking up canyoning, snowboarding or whatever.”[66] The governance of practice stands in sharp contrast with the “heroic” view of transition manager as institutional entrepreneur. According to practice theory, individual leverage to change practices, if any does exist, is

[66] While the practice ontology may be seen to offer an insufficient account of power (T. Schatzki, 2017), the effects of power are certainly present in practice theory insofar as power is effected, and made manifest, in moments of human action and doing (Watson, 2016).

limited to an actors' competent performance of practice, and reaches only as far the meanings and materials linked to these practices (T. Schatzki, 2016; Shove, 2022). Therefore, a better practice-informed approach to accelerate transitions in governance would be to equip governance actors "with the sensitivities, skills, and resources" to understand the role of practices and collaboratively mobilize these towards sustainability goals (Hoolohan & Browne, 2020, p. 112). This insight is applied to the present research, which advances governance PBIs as experiments that attempt to accelerate social learning about new practices of governance.

Learning Our Way to More Sustainable Futures

Transitions management recognizes that learning processes are imperative for sustainable transitions to take effect (Bentley Brymer et al., 2018; Medema et al., 2014; Pahl-Wostl, 2007; Vinke-de Kruijf & Pahl-Wostl, 2016; Wals & Heymann, 2004). In the sustainability literature, social learning is widely applied in studies of natural resources management and collaborative governance. This research generally theorizes that establishing conducive environments that foster relational learning processes can lead to substantive learning outcomes aligned with individual and shared objectives (Bentley Brymer et al., 2018; Medema et al., 2014; Pahl-Wostl, 2007; Vinke-de Kruijf & Pahl-Wostl, 2016; Wals & Heymann, 2004). However, the strength and direction of this relationship has been questioned (Baird et al., 2014; Eriksson et al., 2019; Reed, 2008; Reed et al., 2010; Van Bommel et al., 2009). Sustainability's theories of social learning are primarily based on the organizational learning literature (Reed et al., 2010). That scholarship tends to understand learning as *sensemaking*, taking place through everyday activity such that "learning is an unfolding aspect that cannot be predicted and controlled, but may be supported" (Elkjaer, 2022, p. 584). Sustainability scholars, however, tend to view learning more instrumentally, as "a 'thing' that can be made to 'do' something to somebody (e.g., help motivate persons) or something (e.g., help make organizational strategies come through)" (Elkjaer, 2022, p. 584). As explained below, defining social learning as participatory sensemaking requires three significant departures from how social learning is typically conceptualized and studied in sustainability science, presenting new problems and opportunities for transition management's practical project of facilitating societal learning for sustainability.

To begin, studies taking an instrumental view of social learning tend towards cognitivism, almost always defining learning in terms of declarative knowledge ("knowing that") rather than practical knowledge ("knowing how"). Such theorizing in sustainability draws from an eclectic mix of "dimensions" to characterize learning (e.g., Baird et al., 2014; Bentley Brymer et al., 2018; Ernst, 2019) and typically assesses declarative knowledge using standardized measures (e.g., a survey), mental mapping exercises (e.g., Baird et al., 2018), or content analysis of conversations (Bentley Brymer et al., 2018). While studying declarative knowledge in learning processes is certainly informative, other ways of knowing should also be included in analysis (Reed et al., 2010). In particular, the embodied and affective basis of learning should not be ignored (Nightingale et al., 2021).

As defined in the psychology literature, learning involves sensitization as an organism's cognitive systems becomes more responsive to certain aspects of its environment and habituation as it becomes less so (Olson & Hergenhahn, 2016). For example, learning may involve acquiring sensorimotor abilities to detect and respond to environmental features, or emotional-cognitive abilities to intuitively understand the mental state of others. Thus, learning is a fundamental mechanism that enables an organism to make meaning from, and take effective action in, a coupled socio-material environment (De Jaegher & Di Paolo, 2007; Maturana & Varela, 1980). Using the term established in Chapter 4, *embodied cognitive capacities* describes one's acquired abilities to detect and respond to one's internal and external environment. In orchestrating and assessing social learning, it is important to monitor how embodied cognitive capacities change as declarative and practical knowledge is acquired, transferred, or lost.

An additional challenge to the instrumental view of social learning is that it is methodologically individualistic in that the problem is seen to be the individual, therefore the solution involves adjusting individuals to better achieve organizational goals (Elkjaer, 2022). Although in the sustainability literature it is generally accepted that even theories of learning centered on the individual usually include a social dimension, learning is typically demarcated as individual learning processes with social interactions and collective outcomes (Blackmore, 2007; Wals, 2007). On the other hand, the sensemaking view questions whether it is appropriate to characterize social learning as the aggregate of individual learning even though individual cognition is ever-present in social interactions (De Jaegher & Di Paolo, 2007; Maiese, 2013). Instead, *participatory sensemaking* characterizes learning as involving *functionally coupled* interaction with social or environmental features (Jaeger & Di Paolo, 2007). For instance, paired dancers are "moving each other, making each other move, and being moved by each other" whereas if one partner were to give up autonomy, "it would look more like a doll being carried around the dance floor" (De Jaegher & Di Paolo, 2007, p. 494). These coupled interactions take place within a historical arc, with each interaction affecting the starting point of subsequent interactions (De Jaegher & Di Paolo, 2007; Juarrero, 1999). Yet the autonomy with which each individual anticipates, receives, and responds in coordination with the other introduces indeterminacy to these interactions such that spontaneous change remains a possibility, even in stabilized patterns of interaction (De Jaegher & Di Paolo, 2007; Preiser, 2012). For sustainability scholars and transition managers, adopting participatory sensemaking, which involves expanding the unit of analysis from the individual to the interaction, may provide be a better lens with which to analyze the emergent, adaptive, and ultimately uncontrollable nature of transitions.

Applying participatory sensemaking to the study and management of transitions requires a more expansive approach than typically taken. In research on collaborative governance, social learning is usually bounded to a small group of stakeholders engaged in a somewhat formalized learning process without measuring how such learning becomes situated in broader communities of practice (Reed et al., 2010). It is therefore necessary to expand analysis to include the uptake of learning among a broader set of actors and learning systems (H. S. Brown et al., 2003; Reed et al., 2010). However, there are several challenges to this approach. First, the nonlinearity of socio-technical systems makes it is difficult to detect and attribute more distal results of sustainability interventions (Hampton & Adams, 2018; Shove & Walker, 2007). Second, interventions informed by participatory sensemaking necessitate extended periods of commitment, broad partnerships, and alternative governance approaches, each of which poses challenges for researchers and practitioner operating with defined mandates, constrained financial resources, and limited timeframes (Hoolohan & Browne, 2020). Third, when social learning is understood as inextricably embedded within the larger space of governance, not only do the relevant problems and stakeholders becomes more nebulous to define, but also the strategies, goals, and outcomes of governance processes, raising questions regarding who decides the boundaries of sustainability problems (Van Bommel et al., 2009). These significant challenges notwithstanding, gaining a better understanding of participatory sensemaking in sustainability transitions may enable researchers and practitioners to better adapt to the irreducible complexity and inherent ambivalence of policy goals in collaborative processes seeking long-term change.

Collaborative Design Practices to Support Participatory Sensemaking

Design theory and research methods provide a useful set of frameworks and tools researchers and practitioners can use to incorporate participatory sensemaking into transitions management. Design tackles real-world problems that are ill-structured and complex, meaning complete information is impossible and there is no single correct or preferable solution. Instead, design process follows a human-centered, iterative approach that opens proposed solution to contestation and revision to optimize the fit between user needs and an innovation (Cross, 1982). Towards this end, *collaborative design* emphasizes the direct involvement of end-users, stakeholders, and experts with different knowledge bases in formulating solutions (Kyng, 1991; Sanders & Stappers, 2008; Schuler & Namioka, 1993). Beyond improving the functionality and benefits of designs, co-design processes can foster cooperation and trust between different groups (Blomkamp, 2018; Sanders & Stappers, 2008). A hermeneutic cycle of creativity, rapid prototyping, and user-testing gathers participant feedback throughout the design process to narrow the gap between the intended and actual outcomes of a design (J. Wilson &

Rosenberg, 1988). The collaborative, iterative, and ongoing aspect of design methods has made *design thinking* an appealing approach in the management of sustainability transitions (Hoolohan & Browne, 2020).

Despite the broad uptake of design thinking, few sustainability scholars and practitioners seem to be aware of the availability of design research tools that can enable a diversity of stakeholders to iteratively explore, develop, and test approaches to complex challenges (Heiss & Kokshagina, 2021). One of the first co-design tools, *cultural probes,* uses creative prompts, often involving artifacts such as maps, disposable cameras, and postcards, that ask participants to provide information about their daily routines, emotions, values, and aspirations (Gaver et al., 1999). *Sensory probes* extend this engagement beyond visual and aural modalities to also include taste, smell, interoceptive,[67] and multimodal sensing to facilitate awareness and articulation of embodied and sensorially rich experiences, as well as their social aspects (Gayler et al., 2021). Sensory probes make no effort to remove supposedly biasing elements from the research design, as these are considered essential to situated experience. Instead, to inform research and design, sensory probes typically capture *sensory fragments*—slices of personal experience, often in the form of illustrations, photos, or brief audio recording (Gayler et al., 2021). Creative documentary practices are necessary because sensory experiences cannot be easily or accurately described or transferred to others via language-based forms of discourse (Ingold, 2000). Cultural and sensory probes provide a means to facilitate and document participatory sensemaking practices inherent in collaborative governance.

[67] Interoception is an internal sensory system that provides information about an organisms' physical and emotional states.

Design research methods also provide a means to intervene in participatory sensemaking. *Boundary objects*[68] (Star & Griesemer, 1989) are artifacts that can be named, pointed to, and used to enable people from different knowledge domains to meaningfully participate in discourse (Akama et al., 2007; Clatworthy, 2011, p. 20; Knutz et al., 2019). Using boundary objects, Rojas and Kamp (2022) introduce *Place It!*, a method of facilitating collaborative visioning that asks participants to build models representing future possibilities. Alternatively, designers can make use of disruption by presenting a familiar artifact or practice out of context or in an unfamiliar modality to create estrangement or disorientation and prompt reflexive engagement (Wilde & Underwood, 2018). Voß and Guggenheim (2019) applied tasting probes in public settings by deliberatively altering elements, such as asking participants to eat as if they knew a food was poisonous. Using boundary objects and disruptions to facilitate reflection on participatory sensemaking practices provides an opportunity to enhance traditional collaborative governance approaches.

Studies of anticipatory governance in science and technology studies have applied design research methods to develop new ways to foster public deliberation about emerging technologies. Common forms of anticipatory governance (e.g., citizen juries, deliberative forums) often overlook the practical knowledge publics bring to such deliberations (Chilvers & Kearnes, 2015, 2020). Material deliberation (Davies et al., 2012; Sandercock, 1998) incorporates material, experiential, and affective modes of expression to better reflect how governance practices are embodied, historically situated, relationally shaped, and embedded in power relations. Similarly, *experiential futuring* is a

[68] from the Science and Technology Studies (STS) literature, but widely applied in design research

foresight approach that involves imagining and "pre-experiencing" different futures in order to question assumptions about what futures are possible (Burch et al., 2019; Candy, 2010; Candy & Dunagan, 2017; Garduño García & Gaziulusoy, 2021). At a broader level, understanding such formalized engagements as situated within deliberative ecosystems can better represent how decision-making occurs through the accumulation of informal engagements (e.g., museum exhibits, churches, kitchen tables), rather than in one-off forums as often conceived in the deliberative governance literature (Chilvers & Kearnes, 2020; Davies et al., 2012; Selin et al., 2017; Stenekes et al., 2006). Despite the promise these methods and frameworks show for expanding participatory sensemaking about future innovations, they have rarely been taken up beyond the protected space of academic research (c.f. Fam & Lopes, 2015).[69]

Material Co-production: Co-designing Practice-based Interventions in Sustainability Transitions

The study reported in this chapter sought to develop and test a novel method that researchers and practitioners can apply to facilitate participatory sensemaking in the management of a large-scale sustainability transition. The method, material co-production, assumes that humans possess embodied rationality and that effective governance structures should also, and applies co-learning methods to promote governance transitions. Figure 9 illustrates how, in material co-production, proponents and people likely to resist a sustainability innovation collaboratively design a PBI to

[69] Fam & Lopes (2015) combine practice theory, design research, and experiential futuring methods to inform the design and governance of a sustainability transition. They investigated an alternative urine diversion toilet by eliciting qualitative feedback from toilet users using a "graffiti board" inside bathroom stalls.

promote questioning and reflection on the conditions, technologies, and practices involved in the transition. Involving policymakers in the design cycle builds empathy for consumers' embodied cognitive capacities that may be barriers to transition policies, and transfers skills that governance actors may use to support practice-based learning. The co-design process and resulting PBI makes use of rapid prototyping, boundary objects, cultural probes, sensory probes, and material deliberation methods to enable people with different embodied cognitive capacities to meaningfully participate in design and governance processes. The co-designed PBI is then implemented with the general public at regionally appropriate public events to facilitate participatory sensemaking and collect robust, embodied, situated feedback from a large number of residents on their preferences, concerns, and hopes relevant to the proposal. By iteratively applying cycles of PBI design, implementation, and reflection, researchers, policy makers, and informal actors can investigate practical constraints and iteratively co-produce transition pathways responsive to local context. Although centered on producing a PBI in consumer practice, material co-production is also a governance PBI that seeks to advance a transition in governance by introducing and experimenting with alternative practices of governing.

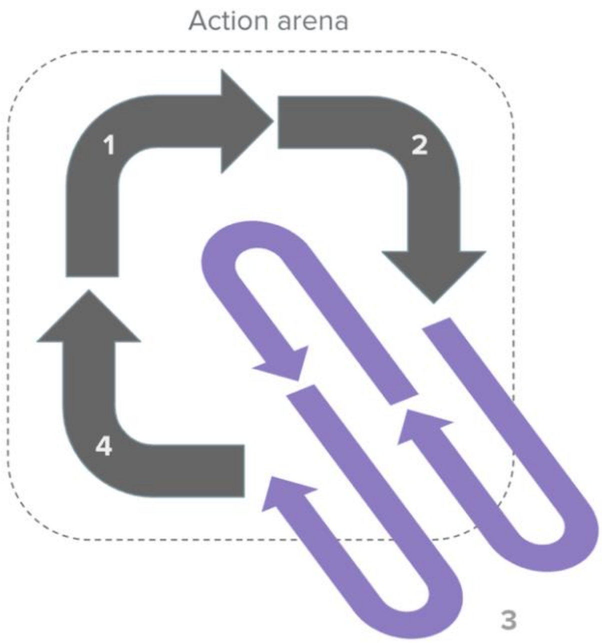

Figure 9, The Material Co-production Process

Figure 9 illustrates the material co-production process, a transitions management experiment to support social learning through participatory sensemaking. Material co-production begins by (1) identifying and engaging relevant stakeholders, including those working to advance a policy and those who may be negatively impacted and therefore resistant to its implementation. In (2), design research methods (e.g., cultural and sensory probes, material artifacts) are applied with these stakeholders to facilitate the co-design of a practice-based intervention (PBI). This PBI is then distributed among the general public (3) to promote material deliberation and gather feedback about the policy proposal, which is then (4) distributed to policymakers to inform their decision-making. The process is then restarted (1) with a revised policy proposal.

Materials and Methods

Participatory Sensemaking About the Direct Potable Reuse of Wastewater

This chapter reports results from a three-year study applying material co-production in Central Arizona, where some utilities will soon begin treating wastewater to potable standards so that it may be incorporated into the drinking water supply (DPR). Impending state regulations for permitting DPR facilities will likely include public outreach requirements (Arizona Department of Environmental Quality, 2023); therefore, utilities planning to implement DPR will soon be undertaking public outreach campaigns, opening new sources of funds for these activities (ARM1). Utilities are eager to understand what makes DPR engagement effective to prioritize their investment of staff and financial resources. These conditions provided a window of opportunity for action research aimed at trialing innovative ways to engage the public about DPR—in the case of this study, with the intent of understanding how embodied deliberative practices can increase social learning in sustainability transitions. This section describes the methods involved in this research.

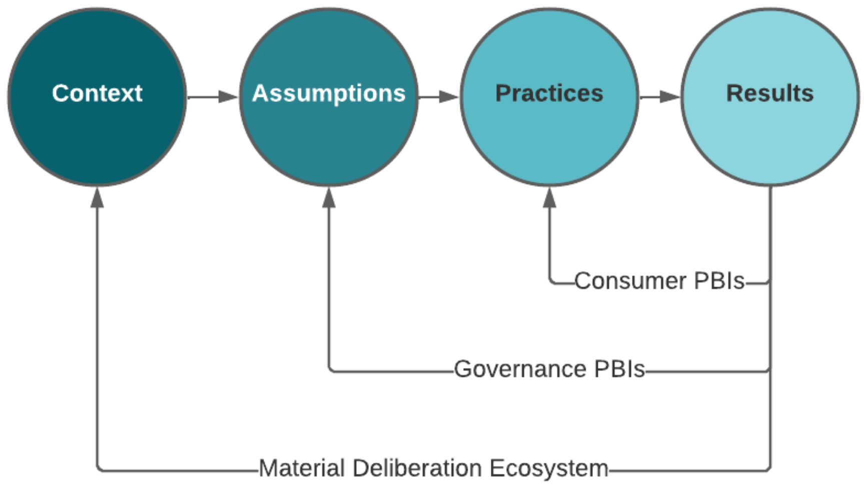

Figure 10, Research Framework

This diagram, adapted from triple loop learning models,[70] illustrates how consumer PBIs target actions to increase sustainability, whereas governance PBIs target the assumptions of rationality that inform these actions. Increasingly applied governance PBIs could increase material deliberation across the socio-technical system, representing a transformative shift in the paradigm of sustainability governance.

Action research investigated an application of material co-production with proponents and skeptics to collaboratively design a PBI in DPR (consumer PBI), and accelerate a transition in governance practices (governance PBI). This research was

[70] The extent and quality of participant learning is frequently evaluated using the triple loop learning framework in which groups of learners progress from an incremental change in problem solving, to a revised set of assumptions, until finally values, beliefs, and worldviews are reconsidered (Argyris & Schön, 1997; Grin & Loeber, 2006; Johannessen & Mostert, 2020; Kolb, 1984; Pahl-Wostl, 2009). Flood and Romm (1996) present triple-loop learning as a sequence of questions: "Are we doing things right? Are we doing the right things? How do we know what the right thing to do is?" (Biggs et al., 2012).

guided by the two-part research question: *How can the process of producing a consumer PBI promote curiosity and reflectivity about a) DPR (consumer PBI) and b) material and collaborative governance practices (governance PBI)?* Although (a) and (b) primarily concerned consumers and producers respectively, as findings will show, it is not so clear-cut to distinguish practices among user groups. Figure 10 illustrates how consumer PBI and governance PBIs are theorized to affect participatory sensemaking about the practices, assumptions, and context of sustainability governance. Research findings were analyzed to assess the impact of material co-production on participatory sensemaking about the practices and assumptions of wastewater governance.

The principal investigator was the author, who was assisted by her advisor, Dr. Christy Spackman, three undergraduate research assistants, Joe Austin, Asha Ramaswamy, and Qyania Jimenez, and a graduate student who is a professional Spanish-English translator, Laura Dicochea.[71] Research activities were granted an exemption by the Arizona State University institutional review board (Appendix D).

The participatory design process to inform the PBI in DPR unfolded during focus groups with consumers (workshops) and producers (meetings).[72] Based on literature discussed in Chapter 2, this study assumed that consumers who distrust conventional tap water will likely be highly skeptical of DPR. Conversely, research reported in Chapter 4 found that drinking water producers involved in implementing DPR projects are among

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[71] The Acknowledgements section includes the complete list individuals and organizations who supported this research in various ways.

[72] Although design research methods were applied in focus groups with both producers and consumers, producer workshops are referred to here as meetings because they employed typical collaborative activities (e.g., virtual sticky notes) employed in professionalized settings whereas consumer workshops made extensive use of material deliberation methods (e.g., cultural and sensory probes, material artifacts).

its most enthusiastic proponents. To recruit 15 tap water hesitant consumers, researchers placed fliers at 58 filtered water refill stations frequented by tap water avoiders throughout the Phoenix area. According to the drinking water literature, bottled water usage is highest among low-income, African-American, and Hispanic residents (Junker & Carpenter, 2021; Teodoro et al., 2022); therefore, additional fliers were distributed through grassroots organizations representing these demographics: Chispa AZ, Unlimited Potential, and The Tiger Mountain Foundation. Individuals who had participated in previous research on drinking water (see Appendix B for a description) were personally invited by the researchers. Recruitment materials were provided in Spanish and English. The 47 respondents were screened for water preference (tap, filtered, bottled), knowledge of DPR, and scheduling availability. Selected participants were compensated $25 an hour for their participation, with additional reimbursement provided for travel expenses. Five water producers were recruited by email to personal contacts at each of the area utilities planning to pursue DPR. The final group included three communications professionals and two operations staff. Collectively, these represented three utilities actively pursuing DPR and one regional NGO involved in coordinating DPR policy. No compensation was provided to producers. Figure 11 provides an overview of the research design.

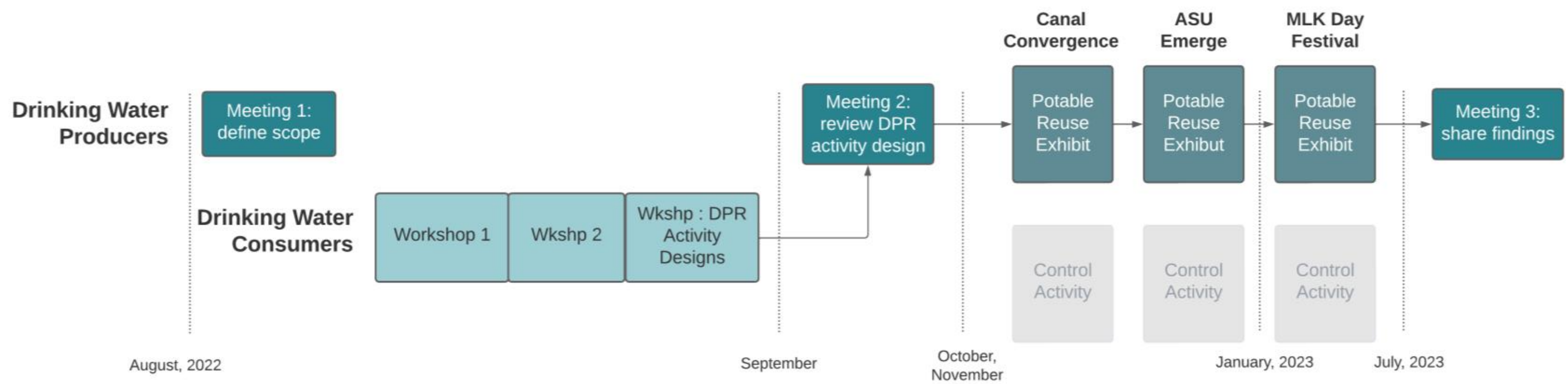

Figure 11, Research Design

This diagram shows the research design for the material co-production process August 2022–January 2023. The process involved three meetings with drinking water producers and two workshops with skeptical consumers to generate design ideas that were assembled to create a DPR exhibit, the *Future Taste of Water* (FToW), which was installed at three public festivals and compared to a control activity. Initial research findings were then presented to a subset of drinking water producers.

Prior to the start of consumer workshops, a producer meeting gathered feedback on their DRP outreach needs and limitations. Consumers attended three focus groups (workshops). Live Spanish translation was provided, and all written materials were presented in Spanish and English. In the first and third workshops, which were hosted at Arizona State University's downtown campus, researchers adapted the Place It! method (Rojas & Kamp, 2022) by providing participants with a table of found objects and sensorially evocative items (e.g., chalk, cardboard, herbal tea, taffy, cotton balls) and asking them to respond to prompts by creating models out of these objects. By way of introduction, participants were invited to build a model of their favorite childhood water memory. After receiving some background information about the project, participants worked in groups to construct a representation of a drinking water system that reflects their values In the second workshop, which took place at a Scottsdale Water facility, a representative of Scottsdale Water gave a PowerPoint presentation about their advanced water treatment process, while attendees took structured notes on their feelings, memories and questions.[73] This second workshop ended with a blind tasting of Scottsdale's tap water, bottled water, and their DPR water and concluded by revealing the sequence of samples. The third workshop involved a futuring activity in which participants were facilitated to imaginatively travel to the future to take a drink of water and bring back artifacts as if they were making a scrapbook of that experience. They then used the found materials to make something to allow others to experience what it was like to drink water in the future. In the final activity, participants were asked to draw on

[73] This workshop was planned as a tour of Scottsdale Water's reclamation plant with a photo journaling project. However, the facility experienced a flood the week before and the tour was canceled forcing researchers to improvise an alternative activity.

the previous workshop activities and, working in groups, create an approach to promote curiosity about potable reuse among people they know who might be skeptical.[74]

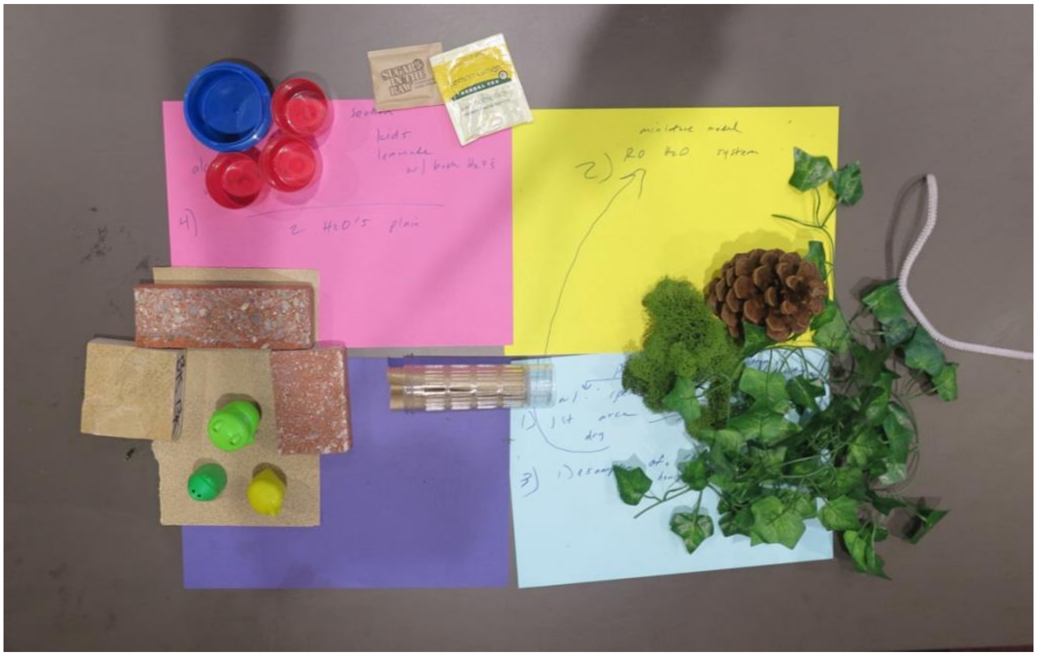

Figure 12, Modeling a Strategy to Promote Curiosity and Discovery About DPR

This model, created by a group of workshop participants, shows an experience where attendees move from a hot, dry, barren landscape into a wet, lush, abundant landscape where they could taste DPR water. This transition became the layout for the Future Taste of Water exhibit.

[74] The actual prompt was to generate “two approaches to promote curiosity and discovery about potable reuse” to which the researchers added, “It might help to think about someone you know who is likely to be highly skeptical of DPR… How can you help these people get curious?”

Consumer workshops elicited over thirty unique design ideas that were adapted, based on the constraints and ongoing feedback of producers, into an exhibit about DPR, entitled *The Future Taste of Water* (FToW). For instance, one group's model, shown in Figure 12, envisioned taking attendees from a hot, dry, barren landscape into a wet, lush, abundant landscape where they could taste DPR water. Based on this suggestion, the FToW exhibit used lighting, sequence, and soundscapes to move visitors from a chaotic and bright experience to a spacious arrangement of live plants and rushing water sounds with an upbeat soundtrack. The activities were prototyped and piloted[75] to refine the exhibit design before launch. The FToW was presented at the Canal Convergence Festival ("Canal Convergence," Scottsdale, AZ) in November 2022, where it was set up for three nights, followed by a second presentation at ASU's Emerge: A Festival of Futures ("ASU Emerge," Mesa, AZ) later that month, and lastly, the MLK Day Celebration ("MLK Day," Phoenix, AZ) in January 2023. More than 1,l00 attendees visited the exhibit across the three festivals.[76]

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[75] Over fifty individuals participated in a pilot of the exhibit and data collection instruments while t was installed at the Arizona State University School of Sustainability.

[76] Attendance at these exhibits was estimated based on participation in activities, so these numbers are likely an undercount of the total number of attendees:

- Experiencing Waters: Canal Convergence, Scottsdale, AZ, November 2021, 1,016 people; Arizona Water Conference, April 2022, 95 people.
- The Future Taste of Water: Canal Convergence, Scottsdale, AZ, November 2022, 722 people; Emerge: A Festival of Food Futures, Mesa, AZ, November 2022, 254 people; Phoenix MLK Day Festival, Phoenix, AZ, January 2023, 64 people.

The exit survey response rate for EW was 32% (n=328 of 1,016 attendees) and 20% for TFTW (n=145 of 722 attendees). This response rate is far below the typical 68% average survey response rate in published social science research (Holtom et al., 2022); however, it was expected given the festival format.

Figure 13, The Future Taste of Water Exhibit

These photos show the various components of the FToW exhibit. The entryway (a) featured an explanation of the research purpose of the exhibit, a voting station, and posters with basic water resource information. Inside an inflatable tunnel, (b) an animation about DPR ran on a loop, and sitting adjacent, (c) a treatment display and illustration explaining how wastewater may be treated and returned to the potable supply. The tunnel exited into an open area that included various activities: (d) a water bar featuring three samples; (e) an interactive activity where people could note feelings, memories, and concerns associated with each sample; and, (f) a selfie station--the caption, "In space, all drinking water is recycled," was later added. At the exit, attendees were asked to vote again (g), and respond to a web-based survey.

Figure 13 includes photo documentation of exhibit activities. The entryway to TFTW exhibit (Fig. 13a), included a poster explaining that the exhibit is a research site and participants' rights, including the right to not participate, which participants could exercise by wearing a sticker. At this station, participants were asked to cast their vote for how they felt wastewater should be re-used by placing a marble resembling a water drop into plastic water jugs labeled with the following choices: "only for non-drinking water uses;" "for drinking water uses and non-drinking water uses;" "not at all;" or, "don't know." Just past this, posters provided basic information about the region's water supply and water scarcity problems, and the opportunity to increase the supply by recycling wastewater. Then, attendees entered an inflatable tunnel housing a flatscreen display (Fig. 13b) with a playful animation explaining DPR created by two undergraduate animation students, Joe Austin and Qyania Jimenez (2022). Adjacent to this was a 3-D display (Fig. 13c) that included a backdrop illustration providing information about how wastewater is currently used and how it might be treated and returned to the potable supply. Two technical DPR experts (one private industry and one academic researcher) reviewed and improved the provided language for clarity, accuracy, and avoidance of bias. This backdrop was integrated with a simple advanced water filtration demonstration that took purple water with glitter in it through successive stages of treatment until it came out clear. Participants exited the tunnel into a circular area enclosed with interactive activities. The focal point of this area was the water bar (Fig. 13d) featuring three samples labeled "River Water (a.k.a. Surface Water);" "Groundwater (a.k.a. Well Water);" and, "Purified Reclaimed Water (Simulated with highly filtered tap water)."[77]

[77] The FToW exhibit sought to fill a gap in extant literature on public perceptions of DPR by

While sampling the waters, people were invited to record sensations, emotions, memories, and questions pertaining to each sample on sticky notes, which were then placed on a grid (Fig. 13e). Another activity was a selfie station (Fig. 13f) that showed three astronauts inside the International Space Station smiling and drinking water, with the caption, “In space, all drinking water is recycled.” Before leaving (Fig. 13g), participants were asked to vote again and respond to a web-based exit survey. Based on space allowances and weather considerations, the configuration of the exhibit changed with each presentation. In particular, the exhibit was downsized for MLK Day because inclement weather necessitated the use of tents. Only elements included in all three exhibit presentations were analyzed for findings reported in this chapter.

Data Collection and Analysis

Data collection relating to the research process included field notes, facilitation protocols, and meeting recordings as researchers planned and reflected on the material co-production and design research methods applied in the research. Data collection also surrounded the research involving water professionals and consumers. Meetings with water professionals were conducted over zoom and recorded. Data collected at consumer workshops and public exhibit presentations included video and audio recordings, researcher observations, and user-generated artifacts (e.g., annotated models). Consumer

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providing participants the opportunity to taste it. One reason for this gap is that few facilities are permitted to produce DPR water for public consumption. Therefore, this DPR water offered to participants was explained and labeled as “Purified Reclaimed Water: Simulated with highly filtered tap water.” However, very few of the 1,100 exhibit attendees noted the simulated nature of the DPR sample on survey responses, sticky notes, or exit interviews, instead referring it to “purified reclaimed water,” or similar terms. Researchers observed many people who were hesitant to try it. This evidence leads the researchers to conclude that almost all participants responded to the simulated DPR water as if it was the real thing.

workshop participants were administered a semi-structured interview protocol (Bernard, 2011) via zoom four weeks after the final workshop. Data collected at exhibit presentations included video and audio recordings, researcher observations, and user-generated artifacts (e.g., sticky notes generated for water samples). In addition, all exiting participants were requested to participate in an exit survey that included standardized (Likert) questions and write-in responses distributed by QR code to exhibit attendees and administered in QualtricsXM, and paper versions of the survey were made available. A subset of participants were invited to participate in an exit interviews that followed a semi-structured interview protocol. Researcher field notes followed a standardized protocol to ensure the consistency of observations across workshops and exhibit events (Creswell, 2018). Appendix A details the annotation rubric for these various data types.

Researchers also administered a control activity to a subset of festival attendees. One researcher used intercept sampling by approaching the first person or group of people who were not engaged in conversation and requesting their participation. If they assented, they were asked to review an 11x17 inch printed version of the 3-D display and DPR demo used in the TFTW exhibit and respond to the same exit survey used in TFTW. All participants in the control activity and exhibit were offered a free pen, whether or not they completed the research activities.

Quantitative survey data were subjected to statistical analysis in R software. Audio recordings of interviews and snippets extracted from video data were transcribed by a professional transcriptionist experienced in this type of research. User-generated artifacts were photographed and discrete comments typed into a computer. Transcribed interviews and videos snippets, user responses to interactive activities, and researcher field notes were entered into MAXQDA coding software to enable the systematic organization of qualitative data. Analysis of qualitative data utilized a codebook created using protocols for content analysis to generate themes (Joffe & Yardley, 2004).

Findings: Participatory Sensemaking about DPR Practices

Water Professionals' Hesitancies

The initial meeting with water producers provided insight into their experiences with and concerns about DPR engagement. During this meeting, it was surprising for researchers to learn the prevalence of bottled water use among the relatives of these water professionals. One water utility collaborator noted, "My husband will not drink tap water…. He trusts that it's clean. It's not the quality that bothers him, it's the taste" (ARM1). Whereas another utility employee explained:

> [M]y family is Latinos, and my parents grew up in very poor countries and you did not drink the water… And so, even though they live here, and they live in a place where the water is safe… every week they spend a lot of money buying these plastic bottled water. (ARM1)

This employee agreed with the researchers' speculation that tap water skepticism may increase with the inclusion of DPR: "[For] somebody who is already drinking bottled water all the time and then you add another layer of, 'This is also coming into your water, but being treated for it,' I think it's going to be a hard sell" (ARM1). For water professionals, the diversity of dispositions towards municipal water can be overwhelming. One remarked, "[Y]ou're trying to educate people who have different perspectives on tap water and bottled water and DPR, and it's like, how do you sway all of them to understand? Because the approach has to be different for all of them"

(ARM1). Several utility employees reported feeling frustrated that, despite extant efforts to educate about water supplies, as one put it “[P]eople aren't hearing anything we're saying. So how are we supposed to educate them on something so touchy like DPR?” (ARM2). However, in the second producer meeting, after the researchers presented initial findings, water professionals expressed hope the exhibit could help them understand the “level of engagement that's going to be needed to educate people on this” (ARM2). The next section summarizes some of the most effective strategies identified in this research to promote curiosity and discovery about DPR.

Consumers’ Hesitancies

The majority of workshop and exhibit attendees had little familiarity with drinking water treatment, or DPR, and were initially reluctant about DPR but became supporters due to their participation. Comparing pre- and posttest votes regarding participant support for various forms of reuse, presented in Figure 14, reveals some trends. Although 1,040 participants voted at the entrance, only 745 voted at the exit, introducing some uncertainty as to how individual participants changed their votes. Nevertheless, the total number of votes demonstrates a 28 percent increase in support for DPR at the group level. Analysis of quantitative and qualitative data collected at workshops and exhibits adds more detail to how individual attendees’ curiosity about DPR, and their support for its use, changed because of their participation.

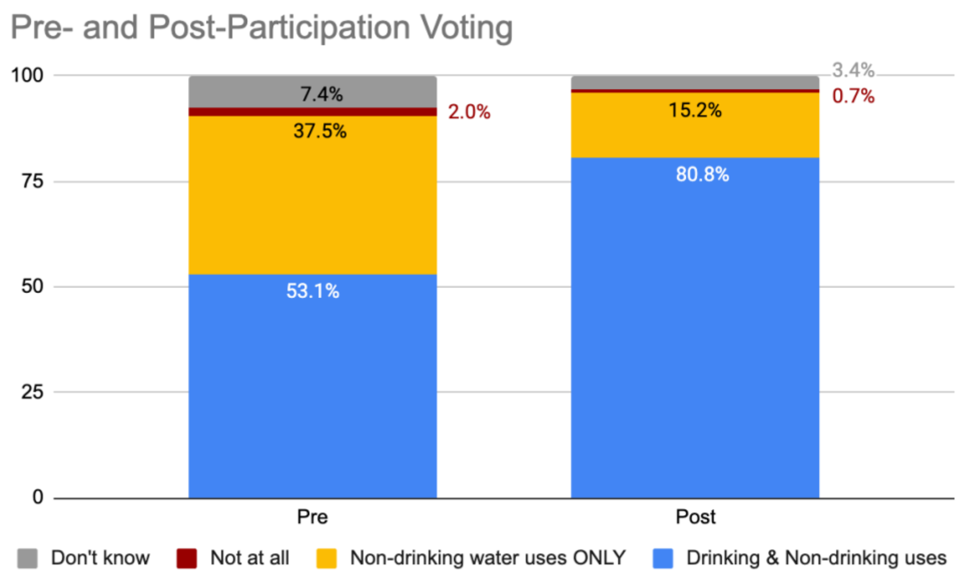

Figure 14, Support for Reuse at The Future Taste of Water

The treatment group was asked at the entrance and exit to the exhibit to vote on how they thought reclaimed water should be used: "for non-drinking water uses only," "for drinking and non-drinking water uses," "not at all," or "don't know." The chart shows a 28% increase in support for drinking water use between pre- and posttest responses.

The exhibit exit survey asked, "How willing, or unwilling, would you be to drink reclaimed water if it matched or exceeded your current tap water quality?" 110 of survey respondents answered either "Extremely," "Somewhat," "A little," "Not at all," or "Prefer not to say." Of the 83 respondents (75%) who were extremely willing to drink reclaimed water, 58 wrote a response to the question, "What is the main reason for your willingness, or unwillingness, to drink reclaimed water?" 24 of these responses (41%) mentioned taste in their explanation. Among these respondents, some thought DPR “tastes great!” whereas for others, the flavor improvement was relative to the current supply, “It tastes better than Arizona’s current tap water.” In some cases, the taste of DPR was enough to overcome disgust. One respondent expressed it this way, “If it tast[es] better than tap, I will definitely drink it. I will just try not to think about where it came from.” Several participants couched their support with the sentiment, “That's probably what we're already drinking in the water from the faucet” (ARWI08). For these individuals, adding advanced water purification represents a significant improvement to the flavor, quality, and safety of tap water.

On the other hand, exit voting suggests that, after visiting the exhibit, 5 of 745 participants (0.007%) did not support the reuse of wastewater as a drinking water supply. This is likely an undercount of the actual prevalence of non-supporters among festival attendees. Because highly skeptical consumers are less likely to participate in an exhibit about DPR in the first place, and if they do, they may be less likely to give feedback through the informal and formal assessments, researchers made extra efforts to document non-participation. Participant observers posted at the entrance reported that, after reviewing the purpose of the exhibit, at least ten people walked away. One of these said, “That’s scary” (AREPOCC3), whereas others commented, “I don’t drink tap water” (AREPOCC3; AREPOMLK). Inside the exhibit, some attendees were observed selectively participating in exhibit activities, often by watching others in their group sampling waters but not sampling themselves. In exit surveys, 26 respondents (24%) indicated they were somewhat, a little, or not at all willing to drink reclaimed water if incorporated into the water supply, and 12 of 17 write-in explanations mentioned concerns about quality. Data collected at consumer workshops and public exhibits confirmed that those who continue to be reluctant after participating have unresolved questions regarding the quality of DPR water. As one workshop participant explained, “[T]he technology is there, but at the same time, there’s still a lot of, like, unanswered questions” (ARWI07). Some questioned the limitations of testing, and what may be left in water after it has undergone purification. Others expressed concern about the priorities of decision-makers. For example, “I would be concerned at when there's urgency sometimes, then things are done very quickly, and will it be done in a way that is healthy for people and that will last and it's safe? (ARWI03). Generally speaking, concerns about quality are linked to ongoing hesitancy, whereas appreciation of taste is linked to support.

However, many participants who expressed hesitancy about DPR quality still supported utilities including it in their water supply. Exhibit participants repeatedly noted the topic, DPR, is “important” and “timely” and cited the hydrological crisis affecting the study region. This concern was at a high point during the study period because, in August 2022, the Bureau of Reclamation declared the Colorado River to be in Stage 1 and Stage 2 drought. The perceived urgency of securing the water supply seemed to override many participant concerns, as evidenced by comments such as “AZ is out of water so I'm willing regardless” (ARES). A sense of personal responsibility motivated some participants to accept DPR, despite their reservations. For instance, one participant raised concerns about DPR’s safety, but also stated she understands we have water shortages. After sampling the water, she explained her feelings about DPR this way, “I want to. I think we should, but I'm not there yet” (AREPOMLK).

Others expressed resignation about the inevitability of DPR, with comments such as, “[W]e’re going to have to do this [DPR] anyway” (ARWI02). The belief that consumers (or water authorities) have no choice in whether to accept DPR sets up a false dichotomy between continued scarcity and DPR acceptance. Furthermore, the conditionality of some support for DPR should be concerning to water utilities. Research conducted elsewhere has found that even widespread support gained during climatological crisis may diminish when crisis abates (Dolnicar & Schäfer, 2009; Garcia-Cuerva et al., 2016; Gilbertson et al., 2011; C. West et al., 2019). Therefore, DPR support motivated by its association with superior quality water may be more durable than support associated with water scarcity and climatological risk.

A small proportion of workshop and exhibit attendees were already enthusiastic about DPR. These people tended to have water policy, engineering, or conservation backgrounds and pre-existing familiarity with water reuse. Among these individuals, the good taste of water provided confirmation of the appropriateness of their pro-DPR stance. One workshop participant, a recent immigrant from Mexico with a background in irrigation management, observed:

> I didn't feel any distrust for all the information they [Scottsdale Water] provided me. [But still,] we only trust the word of the official person. [B]ut when the water [DPR] also tastes good, appearing the right way, with no color, aroma, or flavor, well, that gives me a lot of confidence. (ARWI11)

However, even among water professionals, comfort with DPR is not universal. This research documented several cases where water professionals, especially those with regular contact with wastewater, refused to sample DPR. For example, one exhibit participant expressed support for DPR but could not get herself to sample it, explaining that, after 10 years spent cleaning portable toilets, "I just can't get it out of my head"

(AREPOCC3). As a result of their daily practices, the irrigation manager and the portable toilet maintenance worker developed different embodied cognitive capacities to associate meanings with DPR's materiality, despite both professing trust in DPR and water authorities.

Providing DPR samples (actual or not) was a critical part of revealing the nuanced feelings of workshop and exhibit participants. In comparing treatment and control responses to the post intervention survey, the research team found statistically significant differences between those exposed to interactive activities and those who viewed a two-dimensional version of the exhibit. The treatment group was less willing to try DPR (3.49 as compared to 3.94 for the control), but also much less disgusted by it (1.84 as compared to 2.37 for the control). Sampling DPR water, or just being exposed to other people sampling it, appears to make it less disgusting, while also providing an opportunity for people to evaluate their actual (rather than hypothetical) willingness to try it. If this conclusion is correct, then the exhibit revealed a more accurate representation of consumers' actual attitudes towards DPR than the control did.

Increasing Curiosity Among Hesitant Consumers

Tastings. The workshops and exhibits helped identify strategies that increase curiosity about DPR that utilities can draw from in their promotional efforts. First and foremost is the value of providing tastings of DPR water. Many consumers strongly prefer its flavor, or at least find unobjectionable. Given this, it would be easy for utilities to market DPR as superior to conventional water, or as an affordable alternative to bottled water. However, DPR will likely be blended with conventional supplies, which means, as one utility communications professional explained, we're "trying to balance the, ‘it's going to be better than what we have’ but ‘[our] other water is still great quality’” (ARM3). By presenting DPR alongside the other two main sources of water (surface water and groundwater), consumers could compare these supplies and speculate on the reasons water acquires various flavors. Participants captured these experiences on sticky notes, which were posted for all to see. Many participants mentioned perusing these notes and noticing how individual experiences aligned or contrasted. For instance, analysis of sticky notes posted for each sample finds that groundwater was strongly associated with minerals, surface water was strongly associated with naturalness, and both water supplies were associated with earthy tastes. Reclaimed water, on the other hand, was most frequently likened to bottled water. Terms like “Clean,” “Pure,” and “Clear” were used for all three samples. Therefore, this tasting format appears to have not only increased awareness of DPR but also increased general knowledge about the diversity of water supplies. As one participant remarked, "Thank you for providing the tasting samples—that really brought it home" (ARES).

To assess how feelings about DPR may change over time, follow-up interviews with workshop participants were timed for four weeks after the last workshop. During these interviews, four participants indicated they had not realized they had sampled DPR, providing an opportunity to reveal this information and monitor their responses in real-time. Here is an exchange with one of these participants:

> Participant: Oh. So, the one they said was from the filter was the recycled one?
>
> Interviewer: Yes, that’s true.
>
> Participant: Well, I didn't die. So now I have more trust in it.
>
> Interviewer: Why is that so?

> Participant: Because my tummy didn't hurt… Nothing happened to me… It wasn't good, but I was able to drink it. In other words, not bad, but different. Because if it had been bad, I wouldn't [have done it]. (ARWI10)

Several other workshop participants reported monitoring their body for negative or positive health effects in the hours and weeks after sampling DPR. Thus, determining DPR's safety or continued concern involved assessing one's reaction to both the momentary *and* sustained experience of sampling DPR.

Social Learning. Providing the opportunity to sample DPR in a social setting provided still further evidence consumers could draw from in determining its acceptability. One highly reluctant workshop participant explained why she decided to sample DPR, "Well, everybody was trying it. So I didn't want to be the only one that didn't" (ARWI08). After seeing others' pleasant responses, she continued, "I was just curious…To see it, to smell it, to taste it, to see if it was really clean" (ARWI08). Another participant, after seeing the face of her friend tasting the water, exclaimed, "Oh gosh, I will taste the water!" (AREEMG). These encounters indicate the importance of participatory sensemaking, which emphasizes experiential learning through action, rather than discourse.

Proponents also promoted the merits of DPR's taste to others in their social networks. For instance, according to an observation recorded at the exhibit, "A couple went into this very against drinking reclaimed water. After tasting it, she changed her mind but was unable to convince the man to change his opinion" (AREEMG). One workshop participated suggested harnessing this evangelical energy to spread the word about DPR: "Maybe one thing you could do in these sort of workshops is ask them to, as homework, talk to three people that they know about it" (ARWI01). Another workshop participant suggested a "train-the-trainer" model utilizing the network of Hispanic public health workers (*promotoras*) to conduct workshops with parents about DPR's role in the drinking water supply. This grassroots approach inverts the "grass-tips" strategy popular among utilities to enlist respected public figures to sample DPR to demonstrate their support. A grassroots approach may be more effective for those suspicious of authority figures.

Indeed, the sentiment "[W]e're going to have to do this [DPR] anyway" indicates that many believe utilities will adopt DPR with or without public support. For this reason, one-on-one interactions with utility representatives, or third-party actors like university researchers, is particularly important for establishing DPR's social legitimacy. As a workshop participant explained, "It's really helpful, I think, when there's people going like, 'Hey, come here, look at this thing'" (ARWI03). For example, one participant visited the exhibit while the water bar was untended. After walking around the exhibit but not sampling any waters, he started to leave, but a researcher intercepted him. Asked why he elected not to sample DPR, he responded he was hesitant because it's new. However, after one of the exhibit facilitators gently invited him, he agreed to try DPR and, while sampling it, his face visibly relaxed. He said, "I'm really surprised. This tastes great. Not at all like chemicals." The only difference in his decision whether to sample DPR appears to have been the personal invitation (AREPOEMG). Personal invitations and individual encounters can demonstrate a level of attention to consumer's feelings and concerns rarely experienced in utility interactions.

For many workshop attendees, the quality of interaction they had with the Scottsdale Water representatives was as important as the quality of information he shared. As one participant recounted,

> The presentation… Wow. He was really good. How thorough he was, how he's confident, he was so knowledgeable, and he answered every single—and people were asking, like, a lot of questions[78] and very specific things, and he basically had the answer to everything. And so, I think that gave me a lot of confidence. (ARWI02)

After this encounter, all workshop participants sampled DPR, sometimes to their own surprise.[79] When brainstorming strategies to promote curiosity about DPR, several workshop participants suggested providing similar interactions, "Something that's not just information relayed to us, but perhaps interactive where we can ask them [water authorities] questions—a Q&A panel or something of the sort" (ARWI06). Providing two-dimensional engagement opportunities, rather than one-directional outreach, demonstrates that utilities are willing to listen to consumers' feelings and concerns and work to ensure their education is understood.

Technical Information. Notwithstanding the importance of personal engagement, the content of technical information conveyed about DPR was also key, especially for those whose reluctance is motivated by quality concerns. In follow-up interviews, many workshop participants recalled that Scottsdale Water had "to get specific permission and test it for a week before" offering them samples of DPR water (ARWI01). Scottsdale's established record was also meaningful: "[I]t wasn't just one year of testing.

[78] Participants asked more than 43 questions!

[79] And, as mentioned above, four of them lacked clear recognition at the time that they were sampling DPR.

[Scottsdale's] been doing this for like, two decades" (ARW3). Treatment information was also important among many exhibit survey respondents. Comments included, "If it is clean and safe to drink, then I'll drink it," and, "Regular quality control and reporting needed" (ARES). Information about pre-treatment requirements for certain dischargers, such as hospitals and industrial facilities, was reassuring to workshop and exhibit participants alike.

In discussing DPR among themselves, participants typically used language related to processing, such as "treated" "purified" and "reverse osmosis" water. When workshop participants brainstormed how technical information could build curiosity about DPR, it tended to be high-level and interactive. One group imagined, "There could be like a model that they… actually see it happen… But without going on the entire tour of the entire plant… Maybe start with dirty water on one end and watch it come clean out the other" (ARW3). Rather than providing detailed technical information about treatment, it is enough to demonstrate at a very high level that filtration processes are effective and that the appropriate controls are in place to maintain DPR's quality.

Hope and Agency. Amidst the water scarcity concern expressed by many participants, DPR represented hope for the future. According to one survey respondent, DPR offers, "Hopeful relief," while another wrote, "We have a future, good." In sticky notes, DPR was frequently associated with "the future," and the positive depiction of recycled water on the International Space Station was mentioned many times. The future orientation of DPR also prompted reflection about potential pathways generated by choices in the present. Several workshop participants mentioned how they feel more empowered by the knowledge that utilities can reclaim water, and that by drinking it they can contribute to water conservation. Learning about DPR also highlighted cycles of pollution, prompting care for what ends up in wastewater streams. After learning about water recycling, one workshop participants speculated, “I think when I'm showering and stuff, it's [going to be] hard to not think about [what’s going down the drain]” (ARW2). This concern extends to the treatment works. A workshop participant asked the Scottsdale Water representative, “What is safe to put in the water to keep from damaging [the treatment facility]?” (ARW2). Once aware of the possibility of recycling of wastewater into drinking water, some participants became more attentive to these circular flows.

In addition, some participants expressed hope that DPR can focus attention on the consequences of unsustainable resource consumption patterns. One workshop participant explained, “[T]he best is reclaiming the water. And for two reasons: one, because we would drink that water again; and the other, if people don't like it, they are disgusted. They will take care of the water” (ARWI10). As this participant noted, DPR can also focus attention on the core causes of un-sustainability. Asking consumers to adopt DPR signals urgency and need that utilities are unaccustomed to disclosing. Utilities can channel the resulting consumer agency towards protecting water, and wastewater, supplies with potential for system-wide benefits. This idea was attractive to one utility communications strategist, who pointed out that municipal demand has very little impact on Colorado River shortage, so their utility avoids strategies involving restricted household usage; instead, “To hook in on DPR as a way for people to want to be engaged in the process and take action and have an impact… that could be a really, I think, valuable way to handle that DPR outreach and education” (ARM2). The material co-production process generated new understandings of consumers that producers can apply to pursue the transition to DPR.

Equity and Voice in Drinking Water Governance

Social tastings, technical demonstrations of DPR, and one-on-one time with drinking water authorities are useful individually, but most powerful when provided together. One exhibit attendee explained:

> …[F]or a lot of people, water is very abstract and it's something that we do take for granted. So I think seeing firsthand, being able to taste the difference, being able to interact with it in this way, helps kind of make you feel a little bit more aware of the issues and understand like, yes, it is really serious to be handling this. But also this exhibition was really interactive and fun. And all the people that were running it were really nice, really friendly, and really willing to chat about like, so what are your thoughts on this? I don't think there is a lot of platforms to be able to talk about this. (AREIEMG04)

This sentiment that the gravity of the water situation and the proposal to use DPR demanded a different approach to public participation was echoed by one workshop participant, who observed, "[T]he process now, I don't think that's adequate for something as important as this" (ARWI02). A water professional agreed that "a formal public meetings" is fundamentally different from "a workshop-type of setting where the expectation is that they're coming to learn" (ARM2). However, formal meetings would benefit from more incorporate workshop-type activities. Whereas workshop participants mentioned that many barriers, such as immigration status, language, shyness, or insufficient knowledge, prevent them from participating in traditional meeting formats, these were not significant barriers in the activities used in the workshops or exhibit. Well-designed activities, by nature of their interactivity, can increase procedural equity by increasing participation and inclusivity of water governance.

Whether interactive activities increase voice in utility decisions is less clear. Many participants expressed gratitude for being informed about DPR and noted that, because of attending the workshops or exhibit they feel more prepared to participate in public conversations about DPR. One workshop participant explained, “I have more information to know what questions might be helpful for myself and my family…Where is the water going to come from? Who's going to process it? What kind of processes will be used to get this water ready for us?” (ARWI03). While not all participants wanted more voice in utility decisions about DPR, all expressed a desire for some level of engagement, “not just that they're going to start using it” (ARWI06). Furthermore, this engagement should not be one-off and limited to DPR. For workshop participants, “already being in conversations” with utilities can help establish trust in sound utility management decisions (ARWI03). As these comments indicate, utilities should approach public engagement as an ongoing dynamic that is responsive to changing knowledge and socio-environmental conditions.

Workshop participants were highly sensitive to distributional inequity of who gets “good” water. At the root of this suspicion was observed socioeconomic disparities between municipalities. One participant expressed skepticism that her municipality would be able to produce the same quality DPR as more affluent Scottsdale, explaining, “I would need to see the process here” (ARWI09b). Water professionals were aware of the perception that lower income communities systematically receive lower-quality water and considered it in their DPR planning. As one commented, "[Y]ou don't want people to think…we're targeting the poorer neighborhoods or those sectors first, like, 'Hey, we're going to test this on you'" (ARM1). Although water professionals were preoccupied that people may feel victimized by receiving DPR, this research found that many people already feel victimized by conventional tap water. One participant, who repeatedly referred to her tap water as "nasty," said, "I would like it [DPR water] to be for everyone because our system is selfish" (ARWI12). Whereas water utilities had previously dismissed the idea that DPR could be seen as an "upsell" on conventional water,[80] others have already suggested that the water quality improvements of DPR may be compelling (CDM Smith, 2017). This research finds, however, that the success of this strategy may depend on whether consumer concern about the low quality of conventional drinking water supplies is due to taste or to mistrust in authority; for the latter group "upselling" DPR may be less effective.

One water provider predicted, "So it seems to me that the likely outcome of DPR would be… more people will go to bottled water" (ARM1). This is certainly a possibility given that many area consumers believe the present system delivers low-quality water and perceive bottled water as safer or higher quality, as evidenced by the high prevalence of water filtration and bottled water use among area consumers (Gartin et al., 2010; Teodoro et al., 2022). Learning more about conventional treatment process could help consumers understand the value of tap water. As one workshop participant explained:

> I used to just never drink [tap water], but now I'll use it to cook… I have had a couple of cups of [tap] water since the workshop and I'm not afraid of it… Now, if I have a

[80] At one point a water utility collaborator joked, "That could be our motto: if it's good enough for Scottsdale, it's good enough for the rest of the valley" (ARM1).

> choice between tap water or bottle of water at the gas station, I'll take tap water (ARWI02)

Heightened public interest in DPR may thus present utilities opportunities to build baseline understanding of the water system, how drinking water is treated, and the role of environmental stewardship in reducing water supply challenges and treatment costs.

Findings: Participatory Sensemaking about Experiential and Collaborative Governance Practices

Benefits of Experiential Engagement

To the surprise of some water professionals involved in this research, the low-fidelity FToW exhibit proved very effective at building curiosity among skeptical consumers. Although other factors, such as heightened awareness of drought during the study period, may have played a role, findings indicate that the human-centered design methods and practice-based interventions employed during the design process and the exhibit itself contributed to its success.

The material artifacts utilized in workshops were particularly effective for engaging diverse consumers who often feel excluded by formal public meeting formats. One workshop participant expressed a desire for workshops on other topics to express her opinions, “Do you know how good that feels? A lot of times people—or I myself—you don't get to let things out” (ARWI05). Another speculated, “This could be applicable to very many different areas where we need to have collaboration happen” (ARWI03). One utility employee also saw this possibility: “I would be really intrigued to see how this would work in some of our more contentious areas in the city where we have had some tough public meetings" (ARM2). Material methods proved highly effective at expanding the kinds of knowledge included and the quality of deliberation in governance.

A different mode of experiential engagement, tastings, enabled consumers to build from what they know—the experience of drinking water—to explore their fears and concerns about water issues. By leaving sensory fragments, or traces of experience, through votes and sticky notes, these individual experiences were made meaningful within the exhibit format, and through the work of researchers, in larger discourses about DPR. At first, the water professionals engaged in this research were concerned that centering engagement on tasting was not going to be effective. According to one, "You can't just say, here's the water you normally drink, here's DPR water, they both look clear, they both taste the same. So, everything is good, go about your life, right? It just doesn't work that way, right?" (ARM2). However, after reviewing workshop and exhibit findings, this same person noted, "I think it's so helpful to hear and kind of see what you did to foster that engagement" (ARM3). Another commented that, in ongoing planning for their utility's DPR demonstration facility, "I don't recall in all the conversations when that has come up that anyone has thought about two-way communication or how we let people share their feelings or their experience. And so I think that that would be really valuable" (ARM3). In addition to generating findings that water professionals can apply to increase support for DPR, by demonstrating that design research methods can increase participation and provide valuable information about a policy proposal this research also generated social learning about new practices of governance.

Discussion

By applying a participatory design process with tap water skeptics and proponents, this research found that it is possible to promote curiosity about DPR among even the most hesitant consumers. Furthermore, water professionals engaged in the co-design process witnessed how utilities may benefit by engaging consumers feelings early in planning. The implications of these findings for theorizing and intervening in sustainability transitions are discussed in more detail in the following sections.

Participatory Sensemaking to Attune Embodied Cognitive Capacities

The workshops adopted a design research approach in which *extreme users*, a small, niche group sharing an uncommon interest, became collaborators (Bixler, 2011; Palinkas et al., 2015). Cultural probes, such as building water system imaginaries with found objects, and sensory probes, such as tasting DPR alongside other water supplies, prompted reflexivity about drinking water practices and the meanings of wastewater. Participants then applied this altered understanding to design activities that would increase others' curiosity about DPR. From these design ideas, the researchers produced the FToW exhibit. The most successful activities in the workshop and exhibit promoted participatory sensemaking through enjoyable, social, experiential engagements. Through these activities, consumers could attune their embodied cognitive capacities, long conditioned to react with disgust, to the possibility that wastewater may be a benign, or even desirable, part of the drinking water supply.

The workshops with tap water skeptics illustrate how drinking water practices, reinforced through everyday routines of securing acceptable drinking water, have made some meanings, such as "clean" and "pure," particularly durable. The finding that many water industry actors have close family members who do not drink unfiltered tap water underscores the stability of these practices. When consumers sample tap water, they may encounter flavors due to minerals or disinfection (e.g., chlorine). Depending on a person's embodied cognitive capacities to detect and make meaning from these flavor experiences, they may go unnoticed, provoke like or dislike, or be interpreted as a sign that tap water is unsafe, or safe. Through repeated practice, these embodied cognitive capacities may become habitual reactions. Consumers' embodied cognitive capacities are part of a broader skillset that may include specific competencies developed to secure safer water. This skill is performed multiple times a day whenever one decides to draw drinking water from a jug, fridge, or in house filtration system rather than the tap. Consumers also cultivate preferences for certain bottled water suppliers, learn technical concepts, such as "reverse osmosis," and invest money, time, and physical labor hauling water to their homes. Even those with in-house filtration must maintain and replace system components regularly. Through practices such as these, embodied cognitive capacities are acquired, reinforced, and changed.

Although participatory sensemaking can describe the functional coupling between water's materiality and sensory experience, it is particularly useful in understanding how embodied cognitive capacities are transferred between consumers' bodies. Participatory sensemaking processes attune embodied cognitive capacities to "correctly" detect and attach meaning to water's properties. These competencies become markers of identity as one learns to participate appropriately in culturally shared practices of care for water and, by extension, one's own body. Through shared cultural identities, practitioners' embodied cognitive capacities might be attuned across space and time even when the particulars of drinking water practices differ. As Teodoro et al. (2022) have documented, experiences with public drinking water failure in places such as Flint, Michigan and Jackson, Mississippi have increased tap water distrust among residents who identify with the racial, ethnic, socioeconomic, or other social identities of these victims, even if they themselves reside in service territories of well-functioning water utilities.

As consumers strive to make sense of these situations, they may acquire new embodied cognitive capacities to detect and make meaning from the flow of experiences involved in drinking water practices. The continual updating of embodied cognitive capacities introduces an indeterminacy into participatory sensemaking activities that preserves the possibility of change even in highly regularized patterns of interaction. DPR tastings, and practice-based interventions more generally, make use of the space of possibility provided by every encounter between a human and its surrounding environment. Offering a sample of DPR disrupts regularized ways of experiencing drinking water and prompts reflexive engagement with the convergence of materiality and sensory experience involved in the activity of drinking. As indicated by the profound relief many expressed when they found, to their surprise, that DPR “tastes great,” these experiences can also be emotional. Experiences of pleasure, or disgust, travel across bodies through exclamations, facial expressions, and body language. Sensory fragments recorded on sticky notes provide a way for participants to record their feelings, as well as any lingering questions, and leave traces of the participatory sensemaking inherent in tasting DPR (Fig. 13e). Similarly, by making the pre- and post-participation vote tallies visible in clear bottles (Fig. 13g), participants can reflect on how embodied cognitive capacities can change in an instant.

However, the continual updating of embodied cognitive capacities also introduces some uncertainty about their durability. Practitioners and researchers should not assume that an individual who expresses support for DPR in the exhibit will feel the same in the future, at other locations, or in different social settings. In particular, the data suggests that for some participants DPR acceptance is driven by a fear of running out of water. Comments such as, “I want to… but I’m not there yet,” and the water producer’s prediction, “Eventually, it's going to just exist, and people won't even think about it,” indicates that participants expect Arizonans’ embodied cognitive capacities to evolve in response to changing social and physical conditions. The finding that participants’ monitor their own bodies after sampling DPR indicates that changing conditions may even be internally generated (interoception). This suggests that as DPR becomes more familiar through increased applications in Texas, Colorado, California, and locally in Central Arizona, residents’ embodied cognitive capacities will gradually attune to the legitimacy of wastewater as a source of drinking water. Research in psychology confirms that humans often underestimate their capacity to adapt to future situations considered unacceptable in the present (Nemeroff et al., 2020). This might seem an argument for the decide-inform-defend approach to water governance, especially given DPR facility planning takes place on 3-10 year horizon.

However, these lengthy planning timelines also suggest the risks involved in losing public support for DPR. As utilities apply experiential DPR practices to surmount the “yuck factor,” new obstacles may arise, such as concerns over how DPR may exacerbate perceived or actual disparities in drinking water given the costs to install and operate DPR facilities. Material co-production provides a way to reinforce newly acquired embodied cognitive capacities and adaptively attune these to the evolving socio-material context and policy opportunities.

Material Co-production as Transitions Management Experiment

The effectiveness of the PBI in DPR demonstrates the potential for steering consumers' embodied cognitive capacities towards managers' desired outcomes. Similar approaches, such as nudging, have been charged with *neurogovernance*, a form of "governmentality" in which bioscientific knowledge is applied to make subjects more legible, and controllable, by government (Foucault, 1980; Papadopoulos, 2018; Whitehead et al., 2017). Like "green nudges" (DesRoches et al., 2023), applying consumer PBIs to produce a "constricted and enrolled individual of the future" (Neidich, 2014, p. 268) may achieve some sustainability gains, but is unlikely to lead to the widespread societal transformations some argue are necessary for sustainability (K. O'Brien & Selboe, 2015). Instead, material co-production is a transitions management method that utilizes consumer PBIs as a format to experiment with new governance practices. Material co-production is therefore guided by different goals than previous governance approaches and this provides several backstops against neoliberal tendencies towards neurogovernance. The important elements of material co-production are reported here, as well as lessons learned from this instance that may be applied in subsequent iterations as researchers, managers, and consumers continue exploring societal transitions towards sustainable water management.

First, transitions management emphasizes diverse participation in governance on the assumption that increasing the amount and type of knowledge included in learning processes can enhance decision-making. In material co-production, extreme users, both proponents and opponents of a policy proposal, co-design a consumer PBI to promote curiosity and gather input among the general public. In this case, the PBI about DPR was highly effective, resulting in tangible learning about DPR among consumers and generating knowledge about consumer concerns and preferences to inform policy. However, in order to achieve the secondary goal of material co-production, the knowledge generated in the consumer PBI must increase reflexive learning among governance actors as well, and ultimately alter their governance practices. In this case, the governance PBI drew attention to the embodied cognitive capacities that inform bodily practices of drinking water, bringing the cycle of contestation and retrenchment or revision of drinking water practices out of homes and into the public sphere where drinking water meanings could be problematized in participatory sensemaking. By revealing some of the breadth and nuances of DPR hesitancy, the researchers increased policy actor receptivity to hesitancy as a natural condition of embodied rationality, rather than evidence of irrationality. Furthermore, the collaboration introduced governance actors to new ways of engaging consumers' embodied cognitive capacities, and some expressed interest in applying these practices in their own outreach. Material co-production therefore introduced new ways of conceptualizing and engaging with the consumer that may lead to earlier and deeper participation in regional water governance. Should this come to pass, these innovations would bring the water governance practices of local utilities into closer alignment with their aspirations to apply integrative water management frameworks, such as One Water management, that emphasize public participation in water governance.

Second, a primary objective in transitions management is to increase the pace and quality of learning. Thus, in material co-production, the goal is to apply activities that enable reflexivity and engagement in order to enhance deliberations. This is intended to increase participatory sensemaking, not to increase support for certain policy outcomes. Of course, this may be easier said than done. In this implementation, given many participants' quality concerns, it was necessary to provide value-neutral technical information to support their explanatory learning (knowing that) alongside their somatosensory explorations (knowing how). However, given the evocative topic, politicized policy landscape, and the tendency for uncertainty in risk communication to provoke anxiety, it proved difficult to develop information-based messages that were accessible and reassuring without seeming to promote DPR.[81] It was clear from the comments of participants that many believed the researchers were utility representatives, and that the purpose of the exhibit was to build DPR acceptance. This ran counter to the researcher goals and may have affected the authenticity of participant responses, which were already vulnerable to response bias given the informed consent processes involved. Such compromises are an inevitable part of balancing stakeholder interests in action research and necessary to build the positive relationships for successful research implementation and continuance (Turnhout et al., 2020). Through their participation in this research, water professionals gained comfort with the deliberative possibilities of experiential engagements. Building on this, subsequent iterations of material co-production with these individuals could provide opportunities to position DPR not as an

[81] This is a common difficulty in risk communication (Renn et al., 2011).

inevitability, or even as normatively desirable, but instead present it as a neutral object to encourage consumer reflection rather than performance.

Third, following on the prior point, transitions management is a processional approach: through cycles of experimentation, monitoring, and learning it seeks to strategically adapt pathways to sustainability (Kemp & Loorbach, 2005; Loorbach & Rotmans, 2006). The transitions management experiment reported here achieved some gains but should be situated within the long arc of what are ultimately un-steerable socio-technical transitions. In this transition, DPR can be seen as one instance of an adaptive cycle, in which a technical innovation, the use of wastewater as a drinking water supply, necessitated a societal innovation, the legitimation of this practice, to increase water supply sustainability. The transitions management experiment reported here investigated the potential for a novel method, material co-production, to accelerate learning about wastewater as a potential drinking water supply *and* increase the capacities of local water governance actors to manage such transitions. Limitations required the research team to put aside the technical question about *whether* DPR is an adaptive strategy to achieve societal sustainability goals. A subsequent iteration in the management of this sustainability transition could include collaborators from technology, regulatory, and environmental sectors, in addition to consumers and producers, to expand the scope of material co-production and tackle broader research questions pertaining to DPR or other sustainability transitions.

Conclusion

Due to strong public resistance, utilities that wish to implement DPR have been reluctant to engage consumers about their plans, but will soon need to do so, making it an opportune setting to experiment with new practices of deliberative governance. This chapter described an action research experiment involving a novel method, material co-production, to increase learning in the management of sustainability transitions. The experiment produced new information for policymakers, including the potential of DPR adoption to reverse the trend towards declining acceptance of tap water. The experiment also demonstrated the benefit of providing consumers opportunities to directly experience DPR water, advanced water treatment technologies, and the human operators involved in their operation; rather than simply serving as unidirectional education or promotion, these activities can be valuable in gathering consumer feedback to inform policy. Material co-production thus demonstrated its ability to draw participants' embodied cognitive capacities into policy deliberations to better reflect the participatory sensemaking processes through which institutions and practices are formed and transformed. As an example of applying embodied rationality to policymaking, this experiment further demonstrated its value as a normative universal rationality, opening the door to applying this standard to the management of other sustainability transitions.

Material co-production offers several contributions to theorizing social learning, practice theory, and transitions management. First, although social learning is a popular construct in studies of sustainability governance, its utility has been limited by a superficial understanding of learning. According to participatory sensemaking, learning arises from the continuous and involuntary interaction between a body and its socio-material environment and results in the acquisition or adjustment of embodied cognitive capacities to detect and respond to environmental signals. Examining the embodied cognitive capacities associated with learning, and how these are acquired and transferred in participatory sensemaking, makes clear the deficiency of sustainability research methods that understand learning as individual or involving primarily declarative knowledge. For example, whereas participants who visited FToW exhibit were offered the opportunity to experience DPR water as well as see how others experienced it, participants in the control activity were only exposed to information about DPR; as a result, FToW exhibit attendees gained a more accurate understanding of their actual willingness to try DPR water. By making extensive use of design research methods, such as sensory probes involving tasting, this research was better able to surface participants' embodied cognitive capacities and make these legible for collaborative governance research and practice.

Practice theorists have argued that sustainability transitions are made manifest through the widespread conversion of practices, not attitudes (T. Schatzki, 2016; Shove, 2010a, 2022); however, policymakers have found it difficult to apply this insight to increase sustainability (Hampton & Adams, 2018). This chapter finds that continual updating of embodied cognitive capacities presents an ever-unfolding opportunity to attune them in new ways through practice. PBIs are therefore well suited to facilitate targeted acquisition or attunement of embodied cognitive capacities. The FToW exhibit explores this possibility by facilitating participatory sensemaking to encourage reflection on patterned drinking water practices, accelerating the acquisition embodied cognitive capacities to make meanings of "yum" instead of "yuck" when encountering purified wastewater in drinking water. As this research demonstrates, targeted interventions in participatory sensemaking can be an effective strategy to promote the widespread adoption of sustainability practices. But more importantly, material co-production supports the practical capabilities of policymakers to integrate PBIs into the governance ecosystem. Policymakers' acquisition of the practical skills and political willingness to undertake deliberations to enhance participatory sensemaking about contentious sustainability proposals has the potential to enable the pursuit of planned transitions, instead of delaying until crisis prompts traumatic revision of practices and norms.

This research therefore represents several improvements in how PBIs are theorized and applied to advance the adoption of sustainability practices. First, incorporating design theory into the development of PBI's brings them into better alignment with the design thinking that informs transitions management. Second, the use of collaborative design with extreme users increases the likelihood the resulting intervention will resonate with the embodied cognitive capacities of similar stakeholders, as well as less extreme users. Third, whereas PBIs have until now focused on household practices, this research expands the scope to governance practices and, fourth, adds a focus on embodied cognitive capacities. Material co-production is therefore a two-fold practice-informed transitions management strategy: the PBI in DPR facilitates participatory sensemaking to attune consumers' embodied cognitive capacities to the possibilities of DPR; and, the PBI in governance attunes producers' embodied cognitive capacities to the importance of participatory sensemaking in sustainability transitions. In this application, PBIs are no longer rationalized attempts to "steer" societal transitions to sustainability, but a means to better reflect the embodied rationality of governance actors and governance processes in the management of transitions.

Practically, the success of the PBI in DPR indicates that material co-production has potential to benefit other difficult sustainability transitions. Iterating the method across cases will enable refinement, and possibly the emergence of a toolkit of bespoke design research methods. Research-wise, there are outstanding questions about the practicability and scalability of the governance transition instigated in material co-production that should be addressed in subsequent research. Theoretically, the overlap and intersections of practice theory, embodied cognitive capacities, and participatory sensemaking should be teased out to critically examine the need for separate theories. Additionally, material co-production is just one means of applying these theories in the management of transitions; other interventions are certainly possible and may already be reported in disconnected literature. Therefore, efforts should be made to identify and compare material co-production to other methods to identify any patterns or best practices and determine what methods are best suited to which applications.

CHAPTER 7

CONCLUSION

"…theorizing practice is itself a practice, one that produces particular kinds of consequences in the world, for which we as theoretical producers are responsible. Academia plays an important role in training scholars and practitioners to see and value the complexity and dynamics of the sociomaterial world. Theories that rely on linearity and independence of discrete entities are ill-equipped to deal with such contemporary realities as multiplicity, transience, and dispersion (Law and Urry, 2004)."

— Feldman & Orlikowski (2011, p. 19)

This dissertation seeks to equip sustainability scholars and practitioners with theoretical foundations and practical tools to recognize and grapple with real-world complexity. It applies insights from embodied and enacted cognition, practice theory, design research, and socio-technical systems theories to answer the questions: *What guides human action (descriptive)? Given this, how should we evaluate cognition and action (normative)? And, in what ways can applying this descriptive and normative understanding of human action improve sustainability science (prescriptive)?* Answers come from an empirical investigation into the practices of consumers and water industry professionals as they navigate a contested transition to incorporate treated wastewater into the drinking water supply. This conclusion chapter begins by reviewing the empirical findings and then discusses their theoretical, ontological, and practical implications for sustainability science. It closes by anticipating and responding to possible challenges against this dissertation's proposals.

Chapter review

Following the background on direct potable reuse (DPR) and drinking water perceptions provided in Chapter 2, Chapter 3 presented a theory of human action based on a review of the historical and conceptual throughlines connecting functionalist psychology and philosophical phenomenology to contemporary theories of enactivism, embodied cognition, and practice theory. These theories and frameworks were selected for this research not because they are "true" in a realist sense. In fact, the chapter's historical overview unsettled notions of finality in how consciousness and cognition are conceptualized in psychology and philosophy. Instead, this dissertation pragmatically drew attention to embodied and enactive theories of cognition (EEC) because, it argued, they provide a "story" of cognition that better explains human action in a complex world. For example, according to JJ Gibson's (1979/2014) theory of affordances, our experience of the world is a product of the dynamical coupling between our perceptual capacities and the socio-material environment. By combining embodied and enactive theories of cognition with practice theory, this chapter characterized cognition as environmentally and socially situated sensemaking. This theoretical foundation informed the *embodied practice* approach[82] applied in the dissertation.

Chapter 4 presented an empirical investigation of wastewater governance

[82] The term "embodied practice" appears widely in the literature but its use here is unique in referring to a research orientation, theoretically rooted in EEC. Furthermore, although the more established strand of practice theory has made a strong impact on the study of sustainability transitions, this research represents a novel application of biologically informed practice theory (e.g., Rouse, 2023).

institutions in Central Arizona. It drew on ethnographic interviews with 34 regional stakeholders and observations at 56 water industry meetings to answer the research question, *How have feelings influenced DPR decision-making?* By tracking the institutional work of various actors, this chapter identified the specific *embodied cognitive capacities* involved in competent performance of drinking water practices. This chapter found that policymakers adapted DPR policies in anticipation the embodied cognitive capacities of a range of actors, complicating simplified narratives of public perceptions as barriers to acceptance. Furthermore, the chapter reported on the experiential practices reuse proponents innovated to facilitate participatory sensemaking. These experiential engagements adapted drinking water practices to include the competent performance of new wastewater meanings. Building on these findings, this chapter theorized institutionalization as the attunement of embodied cognitive capacities to appropriately sense and respond to socio-material surroundings, while participatory sensemaking provides the means of attunement. Legitimacy describes the feeling when embodied cognitive capacities align with experienced social-material reality. This research contributed an embodied practice-informed account to an active strand of theorizing in the organizations and socio-technical transitions literatures about the micro-foundation of institutions (Geels, 2020; Haack et al., 2020; Powell & Rerup, 2017; Zucker & Schilke, 2019).

Chapter 5 investigated the support that normative theories of rationality provide for various utility strategies to legitimate DPR. Policy design requires an understanding of how an actor ought to act, or what constitutes right action. However, many sustainability scholars lament that prevailing theories of rationality insufficiently explain sustainability problems, confounding solution-finding efforts (Constantino et al., 2021; Schill et al., 2019; Schlüter et al., 2017, 2019). Furthermore, sustainability scholars seem to have little awareness of embodied alternatives (cf. Bercht & Wijermans, 2019). This chapter addressed these gaps by introducing a normative standard rationality adapted from previous work in embodied and enacted cognition (Gallagher, 2018b; Mastrogiorgio & Petracca, 2016; Petracca, 2021; Rolla, 2021; Spellman & Schnall, 2009). *Embodied rationality* characterizes rational judgements as those reflecting adaptive attunement of one's embodied cognitive capacities in response to one's socio-material environment so as to maintain the competent performance of actions. A review of various utility efforts to promote DPR revealed these strategies to be informed by assumptions of probabilistic rationality (e.g., rational choice theory), bounded rationality, and the heuristics and biases approach; however, utilities' most successful engagement practice, DPR tastings, is rather informed by embodied rationality. This chapter concluded that normative assumptions of embodied rationality are well suited to formulate interventions in the contemporary sociopolitical context of drinking water governance, and potentially other sustainability transitions. The study represents the second empirical application embodied rationality in the scientific literature (see also, Lerique, 2022) and the first discussion of embodied rationality in sustainability science literature.

Chapter 6 described the action research portion of this dissertation, which applied embodied rationality to guide strategic interventions in drinking water and governance practices. This chapter introduced a novel approach to the management of sustainability transitions: *material co-production* applies design research methods to collaboratively design practice-based interventions (PBIs) with policy proponents and opponents.

Material co-production is therefore a *governance PBI* that supports the water policymakers' adoption of participatory sensemaking in collaborative governance. This chapter described how material co-production was applied with water policymakers and hesitant consumers to iteratively co-design a PBI in DPR, an exhibit entitled *The Future Taste of Water* that engaged more than 1,100 attendees at festivals. Although the exhibit clearly supported participatory sensemaking about DPR, findings also indicated that the governance PBI aided policymakers' recognition of embodied rationality in consumer decision-making. The chapter concluded that material co-production provides a way for the design of PBIs to itself be a transition management experiment, expanding the applications of PBIs considered in the literature to include governance PBIs. More generally, the chapter drew attention to the benefits of applying design research methods to the co-design of transitions experiments. Furthermore, it demonstrated that embodied rationality can be useful in conceptualizing the behavior of not only individuals but also collectives, which is explored more in the next section.

Implications for Sustainability Science

In the absolute sense, Carlos Gershenson (2003) writes, "*Things do not depend on the models we have of them*" (p. 3, emphasis in original). Nevertheless, how we represent our reality does shape what we see. Foundational theorizing about socio-ecological systems (SES) contends that "social and ecological systems are in fact linked, and that the delineation between social and natural systems is artificial and arbitrary" (Berkes & Folke, 1998, p. 4). Nevertheless, SES theories struggle to conceptualize humans and nature in non-dualistic terms, and this failure has potential to limit adaptive capacity

(Cooke et al., 2016). Furthermore, despite the importance SES theories place on feedbacks between human actions and the environment, assumptions of human decision-making are rarely made explicit in relational SES theorizing (Bercht & Wijermans, 2019; Constantino et al., 2021). This dissertation argues that core assumptions about human cognition and definitions of correct reasoning influence how we describe and intervene in sustainability problems, with consequences for societal transformation. As a work of interdisciplinary scholarship, this dissertation draws from several disciplines, including practice theory, design research, embodied and enactive cognition to develop an embodied practice view of human cognition. It generates frameworks of embodied cognitive capacities and participatory sensemaking which serve as analytical devices for sustainability scientists' efforts to understand this coupling, while embodied rationality and material co-production provide the means to formulate policies that foster normatively desirable SES dynamics. This section explains in more detail the potential of this work to advance sustainability science's practical understanding of coupled human action in social and environmental surroundings.

Practice Ontology

Practice theorists have praised the socio-technical transitions literature for shifting focus away from individual choice or grand theories of institutional change and onto practices and their arrangements, contexts, and histories, but they have criticized the ontological premise of dominant theories of socio-technical transitions (Raven et al., 2010; T. Schatzki, 2011; Shove & Walker, 2007, 2010). For example, Schatzki (2011, p. 16-17) writes about the Multi-level Perspective (Geels & Schot, 2007), "[W]hat the MLP distinguishes as the micro and the meso 'levels' are really just different components or sectors of a single plenum embracing spaces of innovation and spaces that perpetuate the past and present." Instead, practice theorists argue that practice theory is a relational ontology that describes how the fundamental features of life, such as knowledge, meaning, human activity, and social institutions must be understood as rooted in and transpiring through practices and their connections to other practices (Nicolini, 2013). As Nicolini (2016, p. 100) puts it, "when it comes to the social, it is practices all the way down." Practice theory is therefore a "flat ontology," meaning that all elements of practice exist at the same level (Reckwitz, 2002; T. Schatzki, 2016; Shove, 2022). Such theorizing is not arbitrary: conceptualizing socio-technical systems as hierarchical arrangements may lead landscape-level drivers of unsustainability to be seen as outside the system, which risks reifying power structures that may, in fact, be contributing to the problem (Shove & Walker, 2007, 2010).

Applying the practice ontology in this research revealed how consumers, as everyday drinking water practitioners, are carriers of practice and therefore as consequential as water technicians. Thus, this research analyzed the practices of consumers as well as those of drinking water professionals (and their families by proxy) to find that individuals across these groups perform similar water filtration activities and attach similar meanings to drinking water flavors. This finding illustrates the constellation of linked drinking water practices that connect across space and time (see Schatzki, 2016; Shove et al., 2012; see also, Marston et al., 2005).[83] Schatzki emphasizes that practices don't themselves create interdependencies between individuals but rather

[83] According to the practice ontology, "embodied, materially mediated arrays of human activity centrally organized around shared practical understanding" (T. R. Schatzki, 2001, p. 11) comprise "practice-arrangement bundles" that are interconnected with other practice-arrangement bundles to form a constellation of human practices (T. Schatzki, 2016; T. R. Schatzki, 2002).

“their lives *hang together* through these and other connections, regardless of whether and how interdependent these lives are” (T. Schatzki, 2016, p. 31, emphasis added). By centering analysis on a variety of different actors’ competent performance of practices, and their connections, this research begins to dissolve the distinctions between levels and scales of governance assumed in much sustainability theorizing.

Moreover, socio-technical systems theories theorists tend to assume stability and continuity in what are continually evolving socio-technical regimes (T. Schatzki, 2016). Practice ontology emphasizes the spontaneity and unpredictability of practice formation and dissolution. Elements are potentially reconfigured in the moments of doing; meanwhile, through the complex interdependence of bundles of practice, altering one practice may have potentially significant consequence for subsequent practice formulations within the same social space (Shove et al., 2012; Smets et al., 2017). However, the normativity of praxis both enables and limits the possibility of meaningful and competent action by practitioners (Watson, 2016). DPR tastings, as discrete practice-based experiments, work on the possibility that they can result in spontaneous reconfigurations of meaning and matter and the further possibility that the normativity of praxis can spread these reconfigurations to new practitioners. For instance, the offer to sample DPR prompted many The Future Taste of Water exhibit attendees to completely re-evaluate wastewater and develop new competencies to appreciate its potential role in drinking water. As these altered practices diffuse through increased reproduction in communities of practice, their linkages to other practices become denser and slower to change resulting in sedimentation (Shove et al., 2012). This research illustrated how this may take place not only through the spread of new competencies of DPR tasting, but also through utilities' uptake of tastings as a mechanism of collaborative governance.

However, as practice theorist Joseph Rouse (2023) points out, practice ontology may seem to separate social practices from their embedded geophysical environments. Rouse (2023, p. 286) draws from evolutionary biology and related fields to offer a naturecultural account of practices as "a continuing realignment of skills and behavior with changing patterns of resource availability and behavior." Other practice-theoretical accounts emerging from organizational institutionalism emphasize the bodily basis of practice, arguing competent performance involves emotional and aesthetic engagement with the material world (Greenwood et al., 2017; Harquail & Wilcox King, 2010; Scheer, 2012; Voronov & Vince, 2012). This dissertation's embodied practice approach builds on these to mobilize embodied cognitive capacities as a means discuss the naturecultural dynamics involved in detecting and responding to the socio-material environment. This contribution begins to align practice theory, and its application in socio-technical transitions, with the EEC view that human culture emerges, and changes, through coupled bodily interaction with environmental affordances.

Relational Ontologies

Practice ontology is a relational ontology, in which everything "becomes" through relations, implying that relations between components are more fundamental than the components themselves (Smets et al., 2017; Walsh et al., 2021). It is becoming clear to many sustainability scientists that relational ontologies aid understanding of how complex interactions across geographic and temporal scales shape sustainability problems (Cooke et al., 2016; Escobar, 2018; Fritz & Binder, 2018; Himes & Muraca, 2018; Klain et al., 2017; Spies & Alff, 2020; Walsh et al., 2021; S. West et al., 2018, 2020; Wyborn, 2015). Meanwhile, dualistic ontologies that conceptualize the human and non-human as independent, contained domains can be counterproductive to the goals of sustainability. As Cooke and et al. (2016, p. 837) point out, SES theorizing tends to frame "the environment as an independent biophysical reality that humans act upon," which "ontologically separate[s] mind from matter and, consequently, people from their surrounding environment." Relational ontologies "eschew the divisions between nature and culture, individual and community, and between us and them" (Escobar, 2018, p. 139). Some of the more discussed relational ontologies are Ecuadorian *been vivir* (Gudynas, 2011; Merino, 2016), Buddhist philosophy, and the norms of reciprocity among Indigenous traditions in the Great Lakes region of North America (Awāsis, 2021; Kimmerer, 2013). However, efforts to advance relational perspectives in Western-dominant academic theorizing have met limited success (Himes & Muraca, 2018; S. West et al., 2018), and some proposals have been accused of appropriating Indigenous worldviews (Z. Todd, 2016).

Recently there have been calls in sustainability science "to develop distinct normative, methodological and ontological roots for relational values" (S. West et al., 2018, p. 36). In natural resources management, Himes & Muraca (2018, p. 5) describe "relational values" as a "framework for the articulation of human-nature relationships that challenges the Western dichotomic model of either conserving nature for its own sake (wilderness) or securing the utility flow of natural capital (instrumentality, eco-efficiency)." West et al. (2018, p. 36) puts the relational approaches taken in human geography and anthropology in conversation "with more positivistic approaches in, for example economics and psychology" to re-theorize nature stewardship. Such efforts endeavor to make relational thinking "less illusory and more tangible" within sustainability science (Escobar, 2011, p. 137). Applications of EEC to sustainability theorizing offers support rooted in Western-dominant scientific knowledge systems for relational, nondualistic ontologies. EEC provides a naturalistic view of human consciousness that underscores (as von Uexküll earlier intimated) how the difference between humans and even the simplest organisms is one of degree, not kind (Bateson, 1979; Colombetti, 2014; A. Damasio & Carvalho, 2013). Moreover, EEC provides support for the humanature view by providing an account of cognition as co-constituted with the environment. However, few sustainability theorists have explicitly drawn from EEC to advance relational ontologies.

Extant applications of EEC in the sustainability literature have thus far proven generative. In their analysis of urban foraging, Cooke et al. (2016) apply the "dwelling perspective" advanced by Tim Ingold (2000, pp. 186–187) "to take the animal-in-its-environment rather than the self-contained individual as our point of departure." Ingold's theory of environmental perception was inspired, in part, by Gibson's affordance theory, studies in ecological psychology, and evolutionary biology. Raymond, Giusti, and Barthel (2018) apply theories by Gibson, as well as Lakoff and Johnson (1999) and Maturana and Varela (1980), to propose "embodied ecosystem services."[84] As Raymond

[84] Raymond, Giusti and Barthel (2018) illustrate this with an example of a mountain biker:

> In this example, the web of relations between environment, culture, body, and mind defines the range of possible riding speeds upon which the mountain biker can enjoy riding, i.e., when the embodied ecosystem value exists. One rider sitting on his bicycle could say: 'this trail is too difficult for me today.' The issues for the rider could be that he/she is unfamiliar with the terrain (environment), does not have an appropriate bicycle (culture), is in poor physical shape (body), is in a bad mood (mind), or all of the above. It is also important to notice that none of these relations are independent from each other, indeed the same web of relations could still provide embodied ecosystem value in a race situation. (p. 788)

et al. (2018) explain:

> [T]he environment provides something that the individual perceives as offering the potential for activity, but actualization of the activity only emerges when the different characteristics of the individual, such as his or her physical abilities, social needs and personal intentions, are matched in meaningful relations with the environmental features. (p. 783)

This dissertation's framework of embodied cognitive capacities describes the individual characteristics, while participatory sensemaking provides the means to explain how an individual constantly attunes, through action, their embodied cognitive capacities to detect and respond to ecosystem services. As previous and present applications of EEC in the sustainability literature make clear, EEC provides fertile ground for theories that view humans as both actants and actors in a co-constituted reality.

Because sustainability science seeks to guide society towards sustainability outcomes, how scholars and practitioners understanding humanature relations influences how they conceive real-world solutions. Ecosystem services, for example, was developed by natural resource economists to quantify the benefits and disbenefits humans receive from nature so they can be represented in economic terms. This approach has been criticized as reductive (Lele et al., 2014; Schröter et al., 2014), but such criticisms are pedantic given the logical consistency between ecosystem services and economics' rational choice theory's zero-sum model of decision-making. As Raymond et al. illustrate, EEC provides an altogether different starting point to understand how humans co-produce natural benefits and disbenefits. However, such theorizing has not yet

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Their framework, however, makes no explanation of how these values are acquired or changed, which is what embodied cognitive capacities provides.

articulated the normative model aligned with relational values (or pro-environmental relationality more broadly). This dissertation is the first attempt to name and apply embodied rationality as a normative assumption in assessing and intervening in humanature dynamics.

Complex Adaptive Systems

Static models are of little use in characterizing the complex temporal and spatial dynamics of SES; dynamical models are necessary to account for how humans' action-perception cycles shape and are shaped by individual and collective behaviors, in addition to environmental feedbacks (Anderies, 2015; Preiser et al., 2018; Schill et al., 2019). Early theories of resilience emphasized instability and unexpected shifts in ecological regimes (Holling, 1973; Prigogine & Stengers, 1984). This work built on prior biological scientists' theories of homeostasis and self-regulation in living organisms (Cannon, 1932; Hammond, 2005) and the characterization of living systems as open systems, meaning they are able to exchange information with elements traditionally deemed outside spatial and temporal system boundaries (Von Bertalanffy, 1968). Resilience studies also sought to understand the human influence on system dynamics, ushering in studies of SES that drew from complexity theory to incorporate the influence of adaptation in ecosystem dynamics (Berkes & Folke, 1998; Gunderson & Holling, 2002; Hartvigsen et al., 1998).

Theorizing SES as complex adaptive systems (CAS) provides the conceptual, modeling and governance tools to envision humans and environments as intertwined (humanature) rather than separate systems as was the tendency in previous SES theorizing (Preiser et al., 2018). However, few have applied CAS to investigate how “inner processes” shape “outer processes” in SES (cf. O’Brien & Hochachka, 2010; Wamsler et al., 2021), and still fewer theorize this co-production in ways that challenge the binary of inside-outside altogether (cf. Wyborn, 2015). The lack of attention given to human cognition is surprising because it is frequently considered an important driver in unsustainable resource dynamics. In one of the only examples of extant theorizing about inside-out CAS, Schill et al. (2019) suggest that, through socio-ecological co-evolution, humans are “enculturated” in broader cultural contexts and “enearthed” in their biophysical environment in ways that reinforce SES patterns. These efforts highlight the enormous potential of EEC to aid conceptualizing the complex interconnectivity of individual-collective-environment in humanature.

EEC, as a CAS theory of human cognition, can provide important details to elaborate on the embeddedness of humans in CAS, and vice versa[85] (Gallagher, 2017, p. 20; Hutchins, 2014; Kyttä, 2004; Sterelny, 2010). As Giovanna Colombetti (2014, p. xvi) writes, “Mind shares the organizational properties of life, and to understand the organizational properties of life is thus to make considerable progress toward understanding the mind as well.” EEC theorizes cognition as the emergent property of a perception-action system that is non-decomposable, meaning that one cannot understand its workings by solely examining body or environment. For example, sustainability scholar Hukkinen (2012) drew from Lakoff and Johnson’s theory of primary metaphors (1980/2003)[86] to propose an alternative to variable-based, input-output SES systems

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[85] This is discussed as “doubly-embedded institutions” in institutional theory (Hallett & Ventresca, 2006), which is the language used in Chapter 4.

[86] The theory of primary metaphor describes how basic concepts derive from direct physical experience and provide the building blocks for abstract concepts (Lakoff & Johnson). According to the theory of primary metaphor, basic concepts, like “up,” originate in the relationship between our

models. Hukkinen (2012, p. 102) argued that resource users "observe and distinguish SES limits with universally shared concepts that make use of a sensorimotor system that has co-evolved with the ecosystem being observed." Primary metaphors are one manifestation of how the co-constitutive relationship between body and mind shapes how we perceive and communicate about the world. Hukkinen (2012) also applied the theory of autopoietic systems[87] to propose that SES are continuously generated through a network of relational processes. Applications of EEC by Hukkinen (2012, 2014), Raymond et al. (2018), and Cooke et al. (2016) demonstrate that EEC provides rich theoretical terrain to elaborate on the bi-directionality of human cognition and the emergence of (mal)adaptive humanature patterns.

EEC, which originates primarily from scholarship in psychology and philosophy, offers to remedy the lack of socially informed theorizing in CAS. Cosens et al. (2021, p. 3) charge, "Complexity science, with its roots in mathematics, and resilience with its roots in ecology, do not fully account for social attributes such as agency, power, and empathy." This dissertation's frameworks of embodied cognitive capacities and participatory sensemaking, as well as the normative model of embodied rationality, consider social relationships to be of primary importance in theorizing humanature. These frameworks enable what Preiser et al. (2018, p. 48) call "doing research into the nature of CAS," meaning developing theories and methods that describe the CAS attributes, which they distinguish from "doing research from a CAS perspective," meaning applying

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bodies and our environment, such that simply by nature of our embodiment we can understand more abstract concepts, like the desirability of "feeling up" and the undesirability of "feeling down" (L. Shapiro, 2019).

[87] As explained in Chapter 3, autopoeisis describes the characteristic of living systems to regulate and renew themselves so as to maintain the integrity of their structure (Maturana & Varela, 1980)

systemic theories or approaches in order to observe and intervene in specific areas of interest.[88] Material co-production provides an example of the latter, as the next section explains in more detail.

Methods of Adaptive Governance

Humanature challenges the one-way causality assumed in “the Anthropocene” without reducing human responsibility to remedy it (Tsing, 2021). As Ezequiel Di Paolo (2020, p. 255) writes, assuming harmony in humanature relations “makes us think of degrading and conflictive conditions as anomalous simply because they challenge the apparent norms of harmony… [and] blinds us to the way these ‘negative’ trends are as much the means as the test of life.” A fundamental implication of relational ontologies is that, if a humanature system can only be understood through relations, then human and environment become meaningless constructs. Furthermore, the coupling inherent in humanature makes it difficult to ascribe blame solely to actions or individuals who contribute to environmental degradation. EEC provides a framing that de-centers the individual within a complex web of social and environmental affordances without losing track of personal, and collective human, agency. Applying embodied rationality to sustainability problems involves seeking to understand how cycles of degradation emerge and are reinforced through humanature relationships.

By providing a normative psychological framework, embodied rationality can

[88] This insight is central to what Preiser and Cilliers (2010) term “critical complexity,” which follows the logic of reductionism while simultaneously maintaining awareness of the choices made in reducing the system. Critical complexity reminds us that, although CAS may be useful to examine how complex phenomena are constituted relationally through emergent patterns of behavior, such studies are observer-dependent because framing system boundaries in open systems is a subjective endeavor (Preiser, 2012).

help mainstream new modes of analyzing and intervening in maladaptive system dynamics without reinforcing dualistic separations of human-nature, self-other, or body-mind, or reductive causal logics. Embodied rationality further undermines assumptions of methodological individualism, linear causality, and human rationality that guide many sustainability interventions already destabilized by researchers' increased understanding of complex system dynamics (Armitage et al., 2012; Cosens et al., 2021; Folke et al., 2005; Preiser et al., 2018; Westley et al., 2013). Embodied rationality lends support for iterative, pluralistic, adaptive sustainability interventions to foster learning and experimentation, approaches but demands new methods of engagement. For instance, characterizing humanness as embodied rather than enbrained leads to partial solutions that target mental representations (e.g., mental models, attitudes, values and beliefs, Cooke et al., 2016). In one alternative, Kaaronen and Rietveld apply affordance theory to investigate how a landscape of "pro-environmental affordances" may lead to tipping points in the collective behavioral patterns of a social system.[89] As this example illustrates, adopting embodied rationality to guide interventions towards normative humanature relations opens new methodological territory in sustainability science.

Arguably, adaptive management approaches that emphasize social learning already assume embodied rationality as the normative standard rationality. However, these approaches do not generally acknowledge the role of feelings or the social situatedness of participatory sensemaking. The research findings reported here suggest

[89] Kaaronen and Strelkovskii's (2020) concept of landscape-level pro-environmental affordances is meant to provide an alternative to the methodological individualism informing libertarian paternalism and covert interventions such as "nudging" that are discussed in more detail in Chapter 5. However, adopting material co-production to development of pro-environmental affordances could increase the legitimacy of such interventions, and likely improve their effectiveness in other ways.

that appropriate practices of participatory sensemaking can support the attunement of embodied cognitive competencies—including emotional competencies and environmental awareness—so that individuals and groups may respond to changing socioenvironmental conditions more adaptively. In deliberations over DPR in Central Arizona, material methods, such as model building (cultural probes, (Gaver et al., 1999) and tastings (sensory probes, Gayler et al., 2021), increased curiosity about DPR as a possible resilience strategy, but also increased policymakers' recognition that material deliberation methods can be a useful tool in governance. Adopting embodied rationality as a normative foundation centers feelings and relations in policy processes.

Material co-production has potential relevance in the management of difficult sustainability transitions beyond drinking water. For instance, scholars have sought to explain how "sense of place" emerges from situated humanature relationships to make place attachment a powerful stabilizing force in sustainable development (Masterson et al., 2017; Raymond et al., 2017; Stedman, 2002). The reluctance to abandon a place made precarious by climate change may be seen unreasonable when one assumes that rational choice involves maximizing personal utility. Embodied rationality, on the other hand, accepts place attachment as rational and provides opportunities to formulate interventions. Sense of place is produced through embodied interactions with the landscape of material and socio-cultural affordances (Rietveld & Kiverstein, 2014). Applying material co-production with residents and policymakers could identify place-specific embodied cognitive capacities that make some possibilities for action-perception automatic and habitual (e.g., stepping into a ground-level house), whereas others create estrangement (e.g., climbing up to a stilted house). These capacities to detect and respond to environmental affordances could inform the design of practice-based interventions that foster exploration of transition alternatives. Importantly, the participatory sensemaking involved in exploring affordances and co-designing alternatives is as important as the resulting policies. Such practices promote substantive deliberation while attuning more and more peoples' embodied cognitive capacities to detect and adaptively respond to pro-environmental affordances. In this way, material co-production provides a generalizable strategy for co-developing interventions that works with residents' embodied rationality to foster emergence of more adaptive humanature dynamics.

Beware of Panaceas

Although this dissertation is premised on EEC, there are many other epistemologies of humanature. For instance, Karen O'Brien (2021; 2016) extends Karen Barad's (2003, 2007) concept of intra-action[90] to argue that sustainability transformation cannot be achieved through isolated actions or individual interventions; instead, it requires recognizing and engaging with the complex web of entanglements and relationships that shape social, economic, and environmental systems. Other examples might be actor network theory (Callon & Latour, 2015), vital materiality (J. Bennett, 2010), and affect theory (Hemmings, 2005). Although these propositions emerge from distinct disciplinary lineages, they arrive at similar fundamental conclusions as this dissertation about relationality, complex dynamics, and the need for disperse and emergent, rather than targeted, interventions in humanature. This recalls Gershenson's

[90] Karen Barad's (2003, 2007) intra-active theory of agential-realism draws from quantum mechanics, post-structuralism and feminist theory to argue that the fundamental units of reality are entangled phenomena. Barad's theory of intra-action proposes that entities come into being through their entanglement with one another, and their properties emerge in relation to the specific context of observation.

(2013, p. 2) caution about the fiction of statements about how things "really are," and instead "opens the door for different descriptions of the world to co-exist without contradictions: they will be more useful for different contexts." This dissertation allows for ontological pluralism while arguing for the broader application of EEC in sustainability because of its demonstrated utility, in this research and elsewhere, to describe and analyze humanature dynamics and prescribe solutions that are responsive to real-world dynamics.

The dynamics of sustainability transitions include the socio-politics of sustainability scientists and policymakers, for whom adopting a normative framework of embodied rationality is arguably easier than other epistemological proposals. The naturalistic hypotheses of human experience advanced within EEC are part of the epistemological project of psychology, but provide a bridge to other ontologies, such as relationality, without compromising core disciplinary commitments. Furthermore, the EEC theories offered in this dissertation are in direct response to sustainability scientists' and others' calls for more attention to human cognition and emotions in SES and sustainability policymaking more generally. This dissertation therefore argues that EEC provides a naturalistic way to conceptualize non-dualistic humanature while clarifying, through embodied rationality, why humans are uniquely response-able among our nonhuman relations.

In advancing the adoption of embodied rationality as possible pathway to sustainability transformation, this dissertation opens itself to several challenges. The conclusion to Chapter 6 discussed how material co-production avoids perpetuating neurogovernmental impulses to apply bioscientific knowledge of cognition to control the populace. However, Papadopolous (2018, p. 120) singles out embodiment as a concept that "appears to exercise an almost therapeutic function" because of its resonance with relational ontologies and its naturalist foundation. These same attributes motivate this dissertation to recommend EEC to sustainability scientists; therefore, it is necessary to proactively respond to such challenges.

Whitehead et al. (2017) define "neuroliberalism" as applying insights from the behavioral sciences to develop policy initiatives that both react to and recreate neoliberal approaches to government. In their book, *Neuroliberalism: Behavioural Government in the Twenty-First Century*, Whitehead et al. locate neuroliberalism's origin in the fusion of economics and psychology that began in the 1940s and came to fruition in the 1970s and 80s. In Chapter 5, this dissertation argued that the field of behavioral sciences emerging from this fusion is premised on assumptions of probabilistic rationality (e.g., rational choice) and bounded rationality, themselves premised on assumptions of methodological individualism and disembodied, linear processing models of cognition. The model of governance that follows these underlying assumptions is top-down, linear planning that seeks to steer individual behaviors towards normatively desirable societal outcomes. As Chapter 3 explained, the historical lineage that led to the embodied and enactive theories of cognition emerged in direct reaction against atomistic theories of experience. Functionalist theories of consciousness led to the various theories and frameworks of EEC that inform the normative universal rationalities synthesized in Chapter 5 to embodied rationality, this dissertation's proposal. Models of governance informed by embodied rationality conceptualize societal outcomes as emergent and ultimately un-steerable, which is demonstrated in the material co-production method presented in

Chapter 6. By applying EEC to governance practices rather than specific policies, this dissertation avoids contributing to neurocapitalist capture of a "turn" in scientific understanding of cognition.

Despite Papadopolous's (2018) suspicion that embodiment is particularly vulnerable to appropriation in cognitive capitalism, he agrees that it also offers liberatory possibilities. In his book, *Experimental Practice: Technoscience, Alterontologies, and More-Than-Social Movements*, Papadopolous argues that cognitivist notions of the brain as the center of knowledge production laid the groundwork for the "cerebral value proposition" (p. 120) of cognitive capitalism, while greater awareness of "the immune body" embodiment and emergence" (p. 122) motivated interest in the discarnate body. Papadopolous cautions that although embodiment may appear to be a rejection of mentalism in favor of the material body, its support for "technologies of the self," such as yoga and meditation, demonstrate how embodiment can be mobilized towards neuroliberal goals. Instead, Papadopoulos suggests an alternative path, alterontologies, defined as "all ontologically transformative practices that are simultaneously the effect and the precondition for the continuation of existence of marginalized actors that redraw politics as we know it by creating alternative conditions of existence that make just forms of life emerge" (p. 159). His goal, which this dissertation shares, is "not to distinguish between good versus bad governance, but to explore" what distinguishes neuroliberal applications of embodiment from those that seek to foster conditions for emergence of just relations (p. 150). The difference between the situated politics of alterontologies and the politics of neurogovernance hinges on practices and the specific assemblages of matter, materiality, and competencies they mobilize and reify in a never-ending process of becoming. As this dissertation makes clear, the proposal to adopt EEC as a foundation for theorizing in sustainability science is not about formulating better policies, but rather about *doing* sustainability governance differently in practice. By backgrounding outcome and foregrounding process, more transformative possibilities can emerge.

Conclusion

The practice perspective taken in this dissertation takes situated knowledge co-production seriously in policymaking (Turnhout et al., 2020; Wyborn, 2015) by attending to how knowledge is co-produced through sensorial and emotional engagement within a landscape of biophysical and sociocultural affordances. Humans' embodied cognitive capacities, and the routinized practices of drinking water that create, reinforce, and change them, become an window to investigate how new notions of rationality increasingly inform sustainability governance practices. When policy involves participatory sensemaking to co-attune embodied cognitive capacities, lines between maker and receiver of policy, and even the boundary of problem domains, blurs in ways instructive for sustainability science. Governance approaches supported by embodied rationality foster participatory sense-making by engaging actors from across society, including policymakers and those directly affected by policies, in practices that attune embodied cognitive capacities to adaptively respond to changing socio-environmental conditions. These governance practices reflect the inextricable co-production between self-other, human-nature, mind-body, and emotions-cognition. By calling attention to these governance practices and their underlying assumptions, this dissertation seeks to develop the "perceptual and social infrastructures that nurture the ability to see self and other as emergent from and dependent on the supra-individual matrix that supports both life and individual” (Reid & Taylor, 2003, p. 2). The embodied practice approach described here provide a descriptive, normative and prescriptive means to navigate a web of entangled interdependence to sustainability.

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APPENDIX A

DATA NOTATION SYSTEM

Annotation	Meaning
WWGPO	Wastewater governance public meeting observation notes
WWGPOP	Wastewater governance private meeting observation notes
WWGI	Wastewater governance interview transcript
ARW	Action research workshop transcript
ARWPO	Action research workshop participant observation notes
ARWI	Action research workshop exit interview
ARWS2	Action research workshop exit survey
ARWA	Action research workshop artifact
ARM	Action research meeting transcript
ARMPO	Action research meeting participant observation
ARE	Action research exhibit transcript
AREPO	Action research exhibit participant observation notes
AREI	Action research exhibit exit interview
ARES	Action research exhibit exit survey
AREA	Action research exhibit artifact (sticky notes)

Annotation	Meaning
CC	Canal Convergence Festival
EMG	ASU’s Emerge: A Festival of Futures
MLK	the MLK Day Celebration

APPENDIX B

PILOTING MATERIAL CO-PRODUCTION: THE EXPERIENCING WATERS EXHIBIT

Prior to applying the material co-production to design a practice-based intervention (PBI) in direct potable reuse (DPR), the research team, Manheim and Christy Spackman, undertook a pilot with fellow graduate student Shomit Barua. Initially, this pilot was intended to focus on DPR. An early partnership was formed with Scottsdale Water, the only utility in the region equipped to produce DPR. Scottsdale Water had already organized a successful reuse beer fest, which they hosted at their annual Canal Convergence Art Festival, and they were receptive to the idea of partnering to create a new exhibit about DPR at this festival; however, the agency contact left her position before firm plans were in place and the collaboration stalled. As a result, the team shifted focus of the PBI to conventional drinking water tasting practices, producing an exhibit entitled *Experiencing Waters* (EW) that was presented at Canal Convergence in 2021, where it engaged more than 1,000 visitors.

To develop EW, researchers hosted a two-part virtual workshop[91] that was first trialed with a group of colleagues and then run with two groups of hesitant consumers for a total of 14 participants. Consumers were recruited from filtered water refill stations and with the help of grassroots community partners and compensated as described in Chapter 6. All participants were mailed a small box containing necessary materials, including a small bottle of water and instructions on how to prepare a sample of tap water from their kitchen sink. During the first workshop, participants were guided in sipping and sniffing the water samples similar to the practices of wine tasting (R. S. Jackson, 2023). In online platform Miro, they collaboratively developed a sensory wheel for water based off the taste and odor wheel for raw and treated drinking waters (Suffet et al., 1999) and the

[91] The workshop was conducted virtually to comply with Arizona State University's Covid-19 policies.

concept of Polarized Sensory Positioning (Teillet, 2015) in which participants place water samples between two polarized descriptors. The sensory wheel included categories for odor, flavor, and texture, as well as other embodied experiences, memories, desires, fears, and associations. In between workshops, participants were incentivized with cash rewards to gather and post to online platform Padlet any images and sounds that resonated with their memories or experiences with water. The second workshop involved a futuring activity where participants were asked to imagine it was 20 years in the future and humans have found a balance with their environment and they were in their kitchen sipping water. They then populated a sensory wheel representing what water in the future might be like.

The tasting activity was adapted for a one-session workshop with water professionals that took place in-person outdoors on ASU's Tempe campus. Meeting in-person afforded more physical engagement with movement and materiality, so the researchers trialed a version of the sensory wheel that used artifacts rather than words. Building on work that found consumers can readily detect differences between products, but find it much more challenging to describe these differences (Dietrich & Burlingame, 2020), the researchers translated the consensus descriptors from the focus group sensory wheels into artifacts (e.g., "chalky" became a box of chalk) and distributed these around the meeting space. After a facilitated tasting exercise, participants were asked to gather artifacts that represented their water experiences. In a second meeting with water professionals hosted virtually, researchers shared findings from the focus groups and requested feedback on the initial concept for the EW exhibit.

The material artifacts and 3-D water wheel became the foundation of the EW exhibit. The exhibit was trialed with 39 undergraduate ASU students and refined based on participant feedback and researcher observations before being presented over six nights at Canal Convergence in November 2021. In this exhibit, participants were invited to sample three unlabeled waters, which they were told represented the diversity of tap water found in the region. The samples were: West Valley tap (only groundwater), East Valley tap (mostly surface water with some groundwater), and East Valley tap filtered using reverse osmosis (RO). The samples were color coded, and participants received one token corresponding to each sample. Participants were invited to sample each water and place a token on the table that best matched their experience. Researchers used words like "experience" and "sample" instead of "taste" to help participants expand their reflexive awareness beyond tasting and hedonic like/dislike. Tables were arrayed in a circle inside a dome that used projected images and audio of aquatic sounds, such as drops of water, natural streams, and water in metal containers and pipes, to create an immersive experience that was both calming and defamiliarizing (Spackman et al., 2022). The tables were populated with artifacts corresponding to the consensus descriptors of water discovered during the focus groups. Dynamic tableaus projected above each table reinforced the categories: chlorine = swimming pools; earthy/musty/moldy = dirt and vegetation; mineral = rocks; infrastructure = pipes. Recognizing that the cues provided would not adequately describe all experiences, space was left open for participants to identify and add in additional or missing cues. In essence, the participants co-created a flavor wheel for each water sample.

In addition to Canal Convergence, the exhibit was displayed at the AZ Water Conference (April 2023), which offered an opportunity to compare how water experts engaged with it. This pilot achieved several goals,[92] which were applied to improve the subsequent application of material co-production to produce the consumer PBI in DPR, *Future Taste of Water* (FToW) exhibit, as well as to more intentionally implement the PBI in governance with water professionals.

[92] See Spackman et al. (2022) for a detailed account of findings.

APPENDIX C

IRB FOR WASTEWATER GOVERNANCE

EXEMPTION GRANTED

[Dave White](#)
[GFL: Sustainability and Innovation, Global Institute of (GIOSI)](#)
480/727-9234
Dave.White@asu.edu

Dear Dave White:

On 8/13/2021 the ASU IRB reviewed the following protocol:

Type of Review:	Initial Study
Title:	Wastewater Governance: Managing Wastewater in AZ Under a Changing Climate
Investigator:	Dave White
IRB ID:	STUDY00014128
Funding:	None
Grant Title:	None
Grant ID:	None
Documents Reviewed:	• Interview Consent Form, Category: Consent Form; • Interview Protocol, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • Interview Recruitment Message, Category: Recruitment Materials; • Participant Observation Consent Form, Category: Consent Form; • Participant Observation Protocol, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • Wastewater Governance_Research Protocol.docx, Category: IRB Protocol;

The IRB determined that the protocol is considered exempt pursuant to Federal Regulations 45CFR46 (2) Tests, surveys, interviews, or observation on 8/13/2021.

APPENDIX D

IRB FOR PERCEPTIONS IN SUSTAINABILITY TRANSITIONS

ASU Knowledge Enterprise Development

EXEMPTION GRANTED

Dave White
GFL: Sustainability and Innovation, Global Institute of (GIOSI)
480/727-9234
Dave.White@asu.edu

Dear Dave White:

On 7/19/2022 the ASU IRB reviewed the following protocol:

Type of Review:	Initial Study
Title:	Perceptions in sustainability transitions: planning for the potable reuse of wastewater in Arizona
Investigator:	Dave White
IRB ID:	STUDY00016153
Funding:	Name: NSF: Directorate for Social, Behavioral & Economic Science (SBE), Grant Office ID: FP00031748
Grant Title:	FP00031748;
Grant ID:	FP00031748;
Documents Reviewed:	• consent_festival control-7-18-2022.pdf, Category: Consent Form; • consent_festival treatment_7-18-2022.pdf, Category: Consent Form; • consent_workshop_consumers_7-18-2022.pdf, Category: Consent Form; • consent_workshop_utiltiies_7-11-2022.pdf, Category: Consent Form; • Letter of Support_Chispa_54102.pdf, Category: Other; • Letter of Support_Tiger Mountain.pdf, Category: Other; • Manheim_2022_Submitted DDRIG.pdf, Category: Sponsor Attachment; • recruitment_methods_email_workshop_consumers_7-11-2022.pdf, Category: Recruitment Materials;

	• recruitment_methods_email_workshop_consumers_7-18-2022.pdf, Category: Recruitment Materials; • recruitment_methods_flyer_workshop_consumers_7-18-2022.pdf, Category: Recruitment Materials; • recruitment_methods_script_festival_control_7-11-2022.pdf, Category: Recruitment Materials; • recruitment_methods_twitter_workshop_consumers_7-11-2022.pdf, Category: Recruitment Materials; • Research Protocol_Perceptions in sustainability transitions planning for the potable reuse of wastewater in Arizona.docx, Category: IRB Protocol; • supporting_documents_festival control survey_6-14-2022.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • supporting_documents_festival post-treatment interview protocol_7-11-2022.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • supporting_documents_participant observation protocol_6-14-2022.pdf, Category: Other; • supporting_documents_workshop evaluation_6-14-2022.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • supporting_documents_workshop exit interview protocol_7-11-2022.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • supporting_documents_workshop post-questionnaire_6-14-2023.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • supporting_documents_workshop pre-questionnaire_6-22-2022.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • supporting_documents_workshop protocol_6-14-2022.pdf, Category: Other; • supporting_documents_workshop sign-up_7-11-2022.pdf, Category: Screening forms;

The IRB determined that the protocol is considered exempt pursuant to Federal Regulations 45CFR46 (2) Tests, surveys, interviews, or observation on 7/19/2022.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

If any changes are made to the study, the IRB must be notified at research.integrity@asu.edu to determine if additional reviews/approvals are required. Changes may include but not limited to revisions to data collection, survey and/or interview questions, and vulnerable populations, etc.

REMINDER - Effective January 12, 2022, in-person interactions with human subjects require adherence to all current policies for ASU faculty, staff, students, and visitors. Up-to-date information regarding ASU's COVID-19 Management Strategy can be found here. IRB approval is related to the research activity involving human subjects, all other protocols related to COVID-19 management including face coverings, health checks, facility access, etc. are governed by current ASU policy.

Sincerely,

IRB Administrator

cc: Marisa Manheim
Marisa Manheim
Christy Spackman