

Contents lists available at [ScienceDirect](https://www.sciencedirect.com)

Environmental Innovation and Societal Transitions

journal homepage: www.elsevier.com/locate/eist

The role of psychology in sociotechnical transitions literature: A review and discussion in relation to consumption and technology acceptance

Paula Maria Bögel*, Paul Upham

Institute for Environmental and Sustainability Communication (INFU), Leuphana University Luneburg, Universitätsallee 1, D-21335 Luneburg, Germany

ARTICLE INFO

Keywords:

Agency
Psychology
Consumption
Technology acceptance
Socio-technical transitions

ABSTRACT

In the sustainability transitions literature, social phenomena have mostly been examined in relation to – and at the level of – collective forms of action. Here our focus is on psychological, primarily individualistic approaches to understanding action as behaviour, with particular attention to consumption and technology acceptance. We document and discuss the ways in which the psychology of agents or actors has been described and theorised in these contexts within the sociotechnical transitions literature to date, both implicitly and explicitly. A review of the latter literature shows that while actor motivation and behaviour are often implicitly referred to, these are rarely theorised explicitly using psychological concepts. Reasons for the limited use of individual-level, psychological constructs are discussed and suggestions for how these may be more closely connected to structural and collective processes are made.

1. Introduction

The *social* is inherent to sociotechnical perspectives. The key assumption of the concept of socio-technical transitions is the co-evolution of society and technology, building upon the more specific interaction of social and technological design choices identified in the social construction of technology (SCOT) tradition (Bijker et al., 1987; Pinch and Bijker, 1984). Technological developments lead to social and broader societal responses, which then affect the further development of technology (Adil and Ko, 2016). This duality is also reflected in frameworks such as the multi-level perspective (MLP; Geels, 2002), where it is argued that transitions come about through different types of interaction between processes at the three levels, via: niche-protected innovations gradually becoming more powerful; landscape-level change that pressures the socio-technical regime; and/or destabilisation of the regime enabling niche-innovations to gain their own momentum (Rip et al., 1995).

From sociological perspectives, transition researchers highlight the role of subjective human experience when, for example, the roles of meanings, interpretation, discourses and symbols are referred to (Stedman, 2016). Yet human experience in transitions processes can also be examined from psychological (particularly social psychological) perspectives (Gazheli et al., 2015). For example, Sarrica et al. (2016) argue for the importance of a ‘human perspective’, using psychological concepts, in understanding energy-related transitions. Again with regard to energy system transition processes in Japan, (McLellan et al., 2016) likewise refer to the role of psychological dimensions, while Adil and Ko (2016) refer to the need to better understand consumption psychology as informing the diffusion of decentralized energy technology technologies.

* Corresponding author.

E-mail addresses: boegel@leuphana.de (P.M. Bögel), paul.upham@leuphana.de (P. Upham).<https://doi.org/10.1016/j.eist.2018.01.002>

Received 17 May 2017; Received in revised form 10 January 2018; Accepted 13 January 2018

2210-4224/ © 2018 Elsevier B.V. All rights reserved.

To date, though, while research on energy demand reduction is informed by several different disciplines, with economics and sociology being of particular relevance, social psychological approaches have been, despite their potential to complement the dominant approaches, less influential in informing policy interventions (Sorrell, 2015). Moreover, as we discuss here, they have been little used in earnest in the sociotechnical transitions literature.

We would suggest that it is the emphasis on various forms of collective agency that has led to the socio-technical transitions literature giving less attention to psycho-social processes (see Smith et al., 2005; Hynes 2016). Collective agency expressed through institutions and organisations lends itself to explanatory accounts that involve shared, social processes. Yet accounts of individual-level processes arguably also have much to offer in terms of understanding the behaviour of individuals. We show below that while there are a small number of studies referring to psychological perspectives in the sociotechnical transitions literature, these use a rather limited number of psychological theories and mostly from a functional perspective (i.e. in terms of outcomes), without examining psychological processes themselves in depth (Gazheli et al., 2015; Nye et al., 2010; Stephenson et al., 2015; Whitmarsh 2012).

Our premise is that psychological explanations of various aspects of individual agency have their own intrinsic value – that while there may be sociological analogues or equivalents for understanding particular processes, “ignoring insights from psychological research can handicap progress towards a low-carbon, sustainable future” (Clayton et al., 2015). While sociological or cultural accounts of subjectively-experienced phenomena place their focus external to the individual in terms of processes and emphases, psychology emphasises the characteristics and processes of individuals (micro-level) or group of individuals (meso-level): “sociology generally devote their efforts to identifying *which* social phenomena have effects on individuals while psychologists generally specialize in identifying *the mechanisms or processes through which* social phenomena have their effect on individuals” (Thoits, 1995, p. 1231)?.

Hence while sociological accounts engage with processes experienced by individuals, the origins and nature of those accounts are (by definition) posited as social. Psychology as a discipline offers complementary insights in terms of focus. There are of course deep ontological differences (e.g. regarding the nature of agency: for a more detailed discussion on ontological differences and also points of connection, see e.g. Rivers 1916; Thoits 1995; Shove 2010). Overall, though, we take the view that disciplinary interchange is likely to provide an expanded view of complementary accounts for the understanding of human behaviour in sociotechnical transitions.

With these observations in mind, we firstly conduct a systematic literature review to document and discuss the ways in which the psychology of agents or actors is described and theorized in the socio-technical transitions literature, both implicitly and explicitly. Pre-empting the findings, the literature review shows that the primary use of psychology in the sociotechnical transitions literature has been in relation to consumption and technology acceptance. Of the large variety of perspectives and theories available to psychology, only six main theoretical perspectives have been deployed, of which one, social practice theory, is sociological in origin, albeit with a psychological component relating to habitus and dispositions (Bourdieu, 1986). We show how more use could be made of these six, notwithstanding the greater number of options available.

Secondly, reasons for the lack of integration of psychological theories in other areas of socio-technical transition research are discussed. Of particular importance here is the way in which the systems view of socio-technical research contrasts with the tendency of psychology to focus on the isolated effects of single factors, which in turn relate to the field’s dominant methodological approach, namely forms of experiment (including exploratory attitudinal surveys) that aim at causality testing. Indeed, a justifiable critique of psychological approaches is that by nature they are typically based within individualistic and cognitive paradigms (Keller et al., 2016) and that these fail to adequately take: (a) the influence of the environment into account (Sorrell, 2015); and (b) the influence that individuals may have on that environment (co-construction). Despite these features of dominant psychological approaches, we nonetheless take the view that subjective experience matters for socio-technical accounts and processes; and, therefore, that there is merit in considering how such processes may be better and more closely integrated into structural and collective accounts, including through the use of a broader range of psychological theories than those used so far.

Thus, thirdly, research directions are presented regarding how the use of psychology in transitions might be further developed further, including beyond the sub-fields of consumption and technology acceptance. Based on the findings of the literature review, further theoretical strands for research are elaborated that aim at overcoming the limitations of current dominant psychological approaches. This relates particularly to theories that go beyond the focus on the micro-level of the individual and address the meso-level of social groups, being this e.g. family, community or organizations. For example, identity- and value-related approaches are discussed in detail, as these offer a way to analyze social influences in relation to individual-level factors (e.g. Fielding et al., 2008). Moreover we argue that there is also merit in understanding the psychology of actors other than the public as consumers and citizens, “[t]he elements in socio-technical systems ... [being] maintained, reproduced and changed by various actor groups (e.g. firms and industries, policy makers and politicians, consumers, civil society, engineers and researchers)” Geels’ (2012, p. 417). Although Geels’ comment above refers to different social groups rather than to the individuals of which those groups are comprised, we would nonetheless argue that individual-level psychological processes are no less important.

Finally, in terms of the scope of the paper, it should be noted that here we do not address the equally important matter of exactly how micro-, individual-level processes, whether these are conceived of in psychological or sociological terms, (a) come to be expressed in the systems level, multi-actor processes that sociotechnical transitions theorists posit; or (b) may be studied. For this purpose, one might consider, for example, extended approaches to structuration that include psychological processes through methodological bracketing (Upham et al., 2018). Here, though, we focus on highlighting how psychological processes have implications for transitions processes per se, without elaborating on their translation or conversion to larger scales.

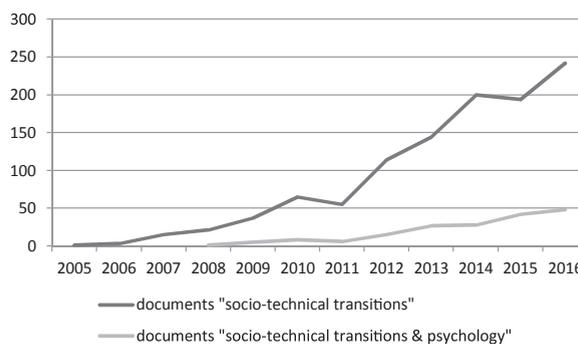


Fig. 1. Number of publications on socio-technical transitions, from 2005 to 2016.

2. Methods and data

A literature search was undertaken in the Scopus database (Date: 08.03.2017), using the following search terms: ‘Socio-technical transitions’ and ‘psych*’ as an indicator of explicit use of psychological theory in the transitions literature. In a first step, we applied these search terms to ‘abstract, title and keywords’. This led to only two results; lending some initial support for the hypothesis that psychological theories are rarely explicitly referred to in socio-technical transitions research. To capture all documents with an implicit use of psychological theories; the search string was then applied to ‘all fields’. In order to refine the research topic; the search was limited to journal articles. The time period was left open and is limited only by the parameters of the database. It has to be noted; however; that the socio-technical transitions literature in its current form appeared only in the early 2000s; despite the phrase sociotechnical having been coined much earlier (Emery and Trist, 1960); in the context of coal-mining.

The specific search terms and parameters of any literature review are usually debatable for their consequences in terms of items returned. For example, the Scopus database does not reflect the arts and humanities, nor the social sciences, as comprehensively as google scholar. Moreover there is also likely to be a large body of papers focusing on aspects of sociotechnical transitions without using the term ‘sociotechnical’ explicitly. Similarly there will be a large body of papers addressing human behaviour or practice, including those using e.g. behavioural economics as a perspective, that do not use the ‘psych’ term. The search conducted here is thus conservative in scope, and deliberately so, primarily for pragmatic reasons, i.e. to generate a manageable, focused corpus for review.

While the above search method thus omits papers that could still be considered relevant, it nonetheless returned 191 results. Most publications appeared in *Energy Policy* (12) and *Technological Forecasting and Social Change* (12), followed by the *Journal of Cleaner Production* (10) and also *Energy Research and Social Science* (8), despite the latter being only recently founded. Overall, the literature review shows an emerging body of research over the last 10 years, with a maximum of nearly 50 publications in 2016 (see Figs. 1 and 2). Most publications originated in the UK (74), followed by the United States (28), the Netherlands (20), Australia (18) and Germany (18).

3. Results

In the following section, we first provide an overview of the results of the literature review. Second, illustrative examples of different categories of manuscripts are presented.

3.1. Overview

To analyze the results from the literature review, the manuscripts were clustered based on their use of psychological constructs and theories, resulting in three different categories:

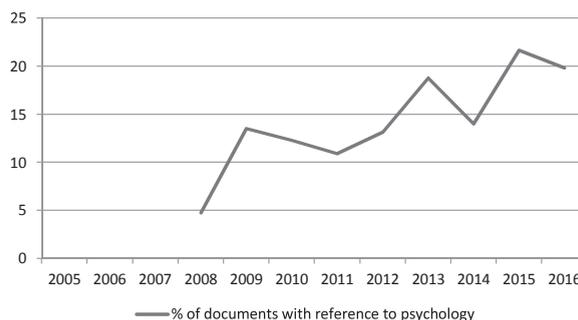


Fig. 2. Percentage of socio-technical transitions publication referencing psychological concepts, theory or empirics, from 2005 to 2016.

1. *Manuscripts of limited relevance to the topic* (87 manuscripts): to obtain an overview not only of the explicit use of psychological theories in socio-technical transition research (with the literature defined as above), but also the implicit use of psychology – e.g. reference to of psychological concepts such as attitudes or well-being – the search strings were applied to all parts of the full-texts of the articles and the reference list. The resulting overview of explicit and implicit use, including understanding the barriers mentioned with regard to further integration of psychological theories, laid the basis for the next stage of the review. The disadvantage of this approach, however, is that Scopus search returns include every document using both terms; even if, e.g. only one methodological paper from a psychological journal was cited in a work on socio-technical transitions. To account for this, the first step of the review included reading all abstracts and checking via search function the use of the terms “psych*” and “socio-technical transitions” in the text. As a result, 87 manuscripts were excluded because they either are not explicitly situated within a socio-technical transitions frame, despite using the phrase, or they do not use psychological concepts or theories.

2. *Implicit use of psychological theories* (81 manuscripts): this category refers to manuscripts that refer to constructs addressed in the psychological literature (acknowledging that these are not *only* addressed in the psychological literature), e.g. attitudes or values, but where this reference is mostly either without reference to specific psychological theories and/or findings from this discipline regarding the relevant construct, or if psychological approaches are applied, where this consists of only a brief reference. The fact that most manuscripts (beside the irrelevant ones) can be classified as examples of implicit use of psychological theories supports our starting hypothesis that the sociotechnical transitions literature refers implicitly to psychological constructs but does not use these in detail.

3. *Explicit use of psychological theories* (23 manuscripts): this category refers to manuscripts that explicitly use psychological theories within a sociotechnical transitions frame. In these conceptual and/or empirical papers, psychological constructs and theories are treated as a central component. However, regarding the integration of theories, and especially the integration of theories across different disciplines, these manuscripts can, overall, be classified as only lightly theorized (the nature of this becomes more evident below).

Reasons for this lack of integration of psychological theories in socio-technical transition research are discussed subsequently. An overview of the manuscripts included in this category as well as some illustrative examples are given below to illustrate the situation and the challenges for further use of psychological theory in the sociotechnical, sustainability transitions literature. Articles that explicitly use psychological theories to discuss the use of different disciplinary theoretical approaches in more general terms (e.g. Batel et al., 2016; Sorrell, 2015) are of particular interest in this regard. The rationale for using the review as a basis for discussion is that this simultaneously evidences the status quo in terms of current usage, while also allowing in-depth discussion of options and issues raised.

3.2. *Implicit use of psychological constructs and theories*

Within this category, two different ways of using psychological insights can be differentiated, whereby the major difference lies in the intensity of the application of psychological theory and empirics. Firstly – and this characterizes the majority of the manuscripts – attitudes and behaviours are referred to as being of high relevance for transition research, including several psychological references (e.g. from the field of environmental psychology) but, even if the relevance of psychology for socio-technical transitions research is acknowledged, neither psychological theories nor findings from this research field are connected to the scientific work. For example, in their analysis of the further development of battery-electric vehicles, (Nilsson and Nykvist, 2016) discuss barriers and drivers of the diffusion of battery-electric vehicles and – among others – several psychologically-relevant constructs such as knowledge, norms, and cognitive barriers. They particularly refer to the importance of knowledge development to support the diffusion of battery-electric vehicles and mention different ways to increase this kind of knowledge, e.g. via information campaigns. However psychological theories that use these constructs are not drawn upon, nor are relevant psychological empirical findings.

In a second sub-category, psychological constructs are mentioned in more detail but still without involving relevant psychological theories and/or findings from psychological research. Usually, these papers refer to the following psychological constructs: motives (e.g. Chatterton, 2016; Ruppert-Winkel et al., 2016), values (e.g. Audet and Guyonnaud, 2013; Lilliestam et al., 2016; Miller et al., 2014), trust (e.g. Büscher and Sumpf, 2015; Goedkoop and Devine-Wright, 2016; Missimer et al., 2017), attitudes (Bowerman, 2014; Hassink et al., 2013; Ma et al., 2013; Puhe and Schippl, 2014; Scott et al., 2014) and well-being (Brown and Vergragt, 2016; Dawson and Martin, 2015; Folke, 2016; Macmillan et al., 2016). The constructs are used in different fields of application which underlines the broad application context of psychology in interdisciplinary research. For example, well-being is discussed with regard to changes in consumer behaviour (Brown and Vergragt, 2016), housing (Macmillan et al., 2016), and as a (desired) outcome of ecosystem service in developing countries (Dawson and Martin, 2015), sustainable water management (e.g. Walsh et al. (2016) highlight the psychological importance of biodiversity benefits of green stormwater infrastructure for city dwellers, especially the positive effects on urban life quality), and sustainable development in general (Folke, 2016).

Concerning fields of application, as implied above, researchers from the field of energy research in particular have called for the application of psychological approaches in order to better understand actor behaviour. For example, Adil and Ko (2016) mention the need for using socio-psychological theories regarding the diffusion of decentralized energy systems, e.g. consumer psychology with regard to new technologies such as MicroSmartGrids, which require heightened consumer participation. The authors conclude: “As more smart devices become ‘proven technologies’ their commercialization is affected by end user perceptions, suggesting a deeper study of socio-psychological and philosophical aspects of energy consumption behaviors” (Adil and Ko 2016, p. 1030).” Likewise, McLellan et al. (2016) highlight the importance of the influence of psychological factors on energy systems. Regarding differences between historical changes of the energy system in Japan and the future of transitions, they conclude that: “The driver in this case is

the combined physical infrastructure damage and psychological impact of a natural and manmade disaster).”

Studies from energy research, however, also provide insight into why psychological theories, even if their use is acknowledged, are not applied in more detail in this research field. The work by [Dijk et al. \(2016\)](#) is a good example in this regard. The authors analyze the potential of the, so far, niche technology of full-electric vehicles for further market expansion. In their work, they explicitly refer to social psychological research on drivers and barriers to sustainable behaviour, namely a well-cited review paper by [Steg and Vlek \(2009\)](#). Attitudes, behaviours and social pressures are mentioned as influencing factors for the diffusion of full-electric vehicles, yet these factors are not further examined. The authors criticize the mechanistic assumptions of psychological approaches and the isolation of single factors in psychological analysis: “(...) the social context tends to be treated in a somewhat mechanistic way (identify obstacle, delete obstacle, subject will adopt innovation), which overlooks the multiplicity of concerns.” ([Dijk et al., 2016](#), p. 85).

[Shove \(2010, p. 1274\)](#) has described this as the so-called ABC-model of behaviour change, with change dependent “upon values and attitudes (the A), which are believed to drive the kinds of behaviours (the B) that individuals choose (the C) to adopt”. [Shove \(ibid\)](#) is critical of the assumption and focus on individual responsibility and of the capacity to choose, arguing that this neglects the complexity of societal systems, including the role of social practices and infrastructures that shape behaviour, preventing or at least limiting individual choices. She also observes that where policy-oriented reports on human behaviour and sustainability acknowledge the importance of context, the processes that lead to this context – particularly those economic and political – are elided. While we concur with this critique and with the implicit politics of ascribing responsibility for system change to individual consumers rather than to the wider range of actors who also play a role in maintaining unsustainable systems of provision, we do not see this as an argument for ignoring the insights that attitude-behaviour models offer. While these barely deal with individuals’ contexts (though typically social norms are considered), this is also clearly not their purpose, which is to elaborate intra-individual psychological structures relating to environmentally-relevant behaviour. Below we selectively discuss the additional dimensions that psychological approaches bring, while acknowledging the existence of sociological approaches.

Interdisciplinary frameworks, e.g. the Energy Cultures Framework ([Stephenson et al., 2015](#)), tend to lightly integrate different perspectives. While some authors have argued that the ontologies of the sociological perspective and the individual psychological approach are incommensurate and, thus, should not or cannot be integrated (cf. e.g. [Shove, 2010](#)), studies conducted based on these interdisciplinary frameworks (e.g. [Stephenson et al., 2015](#)) as well as other studies integrating an individual-based micro-level perspective with meso and macro perspectives ([Upham et al., 2018](#)), however, strengthen the case for interdisciplinary research enlightening our understanding and conception of human behaviour within socio-technical transitions frames, even if some irreconcilable differences between the approaches remain. Moreover frameworks that aim at some degree of neutrality in normative and theoretical terms, e.g. the cross-paradigmatic framework of the social-acceptance of energy systems ([Upham et al., 2015b](#)), at least seek to account for ontological differences, offering a basis for further integrative research, even if, again, full commensurability is rarely possible.

Moreover, while we acknowledge that the somewhat reductionist perspective of dominant psychological theories often neglects societal and narrower social contexts, we would still argue that, firstly, there are psychological theories and approaches that do explicitly refer to at least social context; and second, the isolated analysis of factors, while undeniably having disadvantages, nonetheless offers interesting potential for lines of research on particular aspects of socio-technical transition processes. The first aspect is highlighted in the following section in relation to the explicit use of psychological theories in socio-technical transition research and the second aspect is discussed further below in relation to a research agenda.

3.3. Explicit use of psychological theories

Although the body of socio-technical transitions literature that refers at least lightly to socio-psychological theory has increased over the last ten years, such papers remain few in number and only a very small number explicitly refer to psychological theory. Possibilities for this have been referred to above. In the following sub-sections, those studies that do nevertheless explicitly use psychological theories are presented, with discussion of how these previous findings can be used to develop a research agenda that bridges societal and individual perspectives, thus allowing for further integration of psychological approaches in socio-technical transitions research.

The studies are presented according to their theoretical foundation. Six theoretical perspectives, with different possibilities and abilities for the integration in socio-technical transitions research, are differentiated:

1. Rational and mindful decision making
2. The matter of habit
3. The role of norms
4. The societal level
5. Place attachment
6. Information & persuasion

The classification of theories used here is based, on the one hand, on the classic categories of psychological theories and on the other hand, more importantly, on their different application fields in the context of sustainability studies, being this sustainable consumption (e.g. [Jackson, 2005](#)) or socio-technical transition research ([Batel et al., 2016](#); [Nye et al., 2010](#)). This allows for further discussion of the context-dependency of the application of theories instead of the (often prevalent) general critique of theories (e.g. re

the justifiability of theories relying on rational choice models). The studies in the first sub-section below rely on the assumption of deliberate behaviour, defined by rational, deliberate and mindful decisions and actions, driven by tangible and social outcomes. The second sub-section presents theories that, in contrast to the assumption of mindful decision making, view behaviour as habitual. A psychological norm-based lens is described in Section 3. Norm-based approaches assume that action is not motivated by tangible or social outcomes but rather by internal drivers associated with personal norms. While the theories discussed in the first three sub-sections focus on the individual level, the fourth sub-section presents theories that addresses theories on social interactions. The fifth and six sub-sections show additional, specific perspectives of psychology: place psychology, as part of the geography of transitions, and theories from social psychology on communication processing, as part of research on social acceptance studies.

As stated, the overview of theories below is not exhaustive but reflects the psychological theories most often used so far in socio-technical transition research, with search parameters narrowly defined. The list could be extended significantly, considering the broad range of psychological research (e.g. see Jackson's (2005) overview on psychological theories and their application to research on sustainable consumption). Moreover a disciplinary review in an interdisciplinary context (sociotechnical transitions for sustainability) is inevitably debatable as to its parameters, the boundaries between disciplines being 'fuzzy' (cf. Zehr, 2015).

(1) Rational and mindful decision making

Studies in this category rely on the characterization of people as *homo oeconomicus*, defined by rational, deliberate and mindful decisions and actions. Most often these studies use the Theory of Planned Behaviour (TpB) by Ajzen (Ajzen, 1991, 2011) as a central theoretical approach, which is probably the most popular psychological theory for (rational and mindful) behaviour change. Meta studies also suggest that it is the most successful approach in this regard, i.e. in terms of statistically predicting behaviour (Webb et al., 2010). The TpB relies on the assumption that how one evaluates the outcomes in terms of behaviour will determine ones' behavioural intention and one's behaviour itself, the so-called expectancy-value approach. It assumes that human behaviour is guided by three factors: attitude towards the behaviour (beliefs about outcomes x outcome likelihood), social norms (beliefs about what others think) and perceived behavioural control (beliefs about how easy or difficult it will be to carry out the behaviour in question).

Regarding fields of application, studies using TpB focus on individual behavior, often in form of consumption behaviour. The TpB was one of the most influential approaches in the early stage of sustainable consumption research (Liu et al., 2017) and is still being used in this regard in socio-technical transition research, e.g. regarding renewable energy system adoption by consumers. For example, Yun and Lee (2015) coupled the socio-technical perspective with the TpB to analyze consumers' adaption of renewable energy systems. This study confirmed the influence of attitude, subjective norm and perceived behavioural control on consumers' intentions to use renewable energy systems (ibid). In addition, the authors identify variables that have an impact on attitude (social trust, social support) and behavioural control (facilitating technical conditions). These additional findings are of particular relevance for guiding interventions that aim at increasing behavioural intention through one of the three factors.

While the focus of the TpB is usually on the micro- (individual)-level, Brones et al. (2017) address the use of the theory to examine changes at the organizational level. In their study, the authors analyze sustainability change, namely the integration of eco-design, at an organizational level from a transitions perspective. The authors suggest that individual behaviour change theories should be combined with organizational change theories for this purpose. They develop an eco-design transition framework including these different theoretical approaches and apply it to a case study.¹ Their framework is a good example of how theories from transition research can be combined with individual behaviour change approaches. It is, however, still arguably lightly theorized in terms of the degree of integration of the concepts.

Despite these attempts to integrate the individual in a broader framework that addresses the organizational and/or societal level, some of the critiques of the TpB arguably remain valid and hence limit its application in socio-technical transition research without qualification. First, the basic assumption of the theory is still the rational and mindful decision making of individuals. Yet, as several commentators have argued in this context, mindful decision making, requiring awareness and close attention, cannot always be assumed (Gazheli et al., 2015; Sorrell, 2015). For example, consumption behaviour is assumed to be often habitual (Audet and Guyonnaud, 2013). The next section, therefore, discusses theoretical approaches that take these limitations into account.

Second, although social norms are reflected in the current version of the theory and, thus, considered in socio-technical transition research using TpB (see for example Sopha et al., 2013), such use is in a rather light way (Axsen and Kurani, 2014; Jackson, 2005). Recent research aims at overcoming this limitation by focusing on the social influence in the adoption of new environmental technologies such as alternative fuel vehicles or solar panels. Hence Axsen and Kurani (2014) propose reflexive layers of influence: three different layers and respective kinds of intrapersonal influence are distinguished in their framework. The first layer is the awareness of the new technology which depends on its (societal) diffusion. In the second step, the assessment takes place, which depends on the negotiation and interpretation of meaning of the new technology. In the third and last layer, the self-concept, the process of reflexivity happens: "the actors links his or her (diffused) awareness and (translated) assessment of the artifact to their self-concept or identity" (ibid, p. 851). While the framework is a valuable further step towards the integration of social influence into individual behaviour models, it still focuses on micro level processes and further research is needed to take the broader societal influence, e.g. cultural values, into account. We refer to this in the research agenda and we also deal with sociological perspectives on norms subsequently.

(2) Habitualized behaviour

¹ A further approach to individual behaviour change used by Brones et al., 2017, as well as many other researchers, is nudging. Nudging as a theoretical concept is not further discussed in this review because it stems rather from behavioural economics than from psychological research. This is not to belie the value of nudging or behavioural economics, but rather reflects the search parameters used here.

The question of pro-environmental behaviour as deliberate behaviour versus habitualized behaviour has gained attention in socio-technical transition research and energy research in particular. Nye et al. (2010) suggest distinguishing between different forms of energy behaviour: deliberate energy conservation behaviour and ongoing energy-use behaviour in everyday life. Based on their assumption that ongoing energy-use behaviour can be characterized as habituated behaviour (see also Sorrell 2015), it can be assumed that theories that presume mindful, reflective decisions such as the TpB do not seem not applicable for this kind of behaviour. Nye et al. (2010) suggest that a new stream of psychological research that focuses on the social construction of identity and consumption may be a promising way to research habitualized behaviour. The basic assumption is that identity and lifestyle aspects are key drivers of energy behaviour. Nye et al. (2010) mention the example of air conditioning as a symbol of modern life. Likewise, lighting can be interpreted as a symbol for prosperity. Similarly, Koutiva et al. (2017) show the influence of identity processes in water use, being this conscious or habitual. Given the potential of identity-based theories as a means of enriching understanding of processes relevant to transitions, in the research agenda below we present different identity-based models and discuss their potential application.

One perspective that has much in common with this kind of psychological research is social practice theory. Although sociological in its origins and intentions – Bourdieu (1986) as the prime advocate sought to explain social structure – in applications of social practice theory, it is individuals who are nonetheless considered the carriers of both practices and of their social inheritance (their habitus). Social practice theory has been increasingly widely used in sustainability research to explain habitualized behaviour (Kent, 2015). In SPT, “routine human action is understood as a product of collective social practices influenced as much by the environment as it is by personal preferences or processes of deliberation (Kent 2015, p. 729)”. Practices are thus a key unit of analysis. However, this also underpins one of the main critiques of Bourdieusian practice theory, namely that individual agency in the sense of self-determination is conceived of as highly constrained: changes come from ‘above’ (Batel et al., 2016).² In their study on automobilty, Kent (2015) attempt to overcome this limitation by combining social practice theory with psychological theories. The authors examine how feelings, defined as bodily sensations, are an essential part of the practice of private car use, e.g. feelings of comfort and, thus, relevant for the resilience this system. In more general terms, this seems to be a promising approach to combining sociological approaches such as social practice theory with psychological approaches that “point to the importance of identity, lifestyles, and ‘subjective norms’ in driving everyday, ‘unthinking’ energy use (Nye et al., 2010, p. 702). The approach illustrates how a combination of psychological and sociological theories can enlighten our understanding of energy behaviour, supporting the premise that both psychological and sociological perspective have validity, explanatory utility and are irreducible to each other.

(3) The role of norms

In contrast to the expectancy-value approach, norm-based approaches assume that action is not motivated by tangible or social outcomes but instead by more internal drivers associated with personal norms. Note that personal norms differ from social norms defined in the TpB. While social norms are characterized as beliefs about what others think one should do, personal norms are an expression of ones’ internal values. Some integrative frameworks, such as the Energy Cultures Framework, also mix personal and social norms. With reference to the Energy Culture Framework Stephenson et al. (Stephenson et al., 2015, p. 357) provide an example: ‘Norms are personal and social expectations about how life should be lived, including (in relation to transport) such things as expectations about speed of travel and aspirations for car ownership.’

There are several psychological theories that focus on the normative dimension of pro-environmental behaviour, such as Ecological Value Theory, Schwartz’s Norm Activation Theory and Stern’s Value Belief Norm Theory (for an overview see Jackson, 2005). The latter explicitly refers to the influence of values on personal norms. While theories relating to norms and values have been widely used in research on pro-environmental behaviour they are, however, less present in socio-technical transition research. As mentioned above, values are often implicitly referred to but only very few studies in socio-technical transition research explicitly address value theories from psychological perspectives (Martin and Upham, 2016).

In terms of sustainability transitions research, Martin and Upham (2016) examine how citizens’ values are related to the diffusion of grassroots social innovations, here in form of product reuse groups, based on psychological value theories, namely Schwartz’s value theory, and also sociological value theory, in particular the theory of the collective enactment of values. This norm- and-value approach also seems promising for the integration of psychological theories in socio-technical transition research, bridging as it does the individual-level and the societal level perspective: values are examined from both perspectives for complementary purposes. It might also be noted that values, in so far as they are slow-changing, are generally conceptually located at the ‘landscape’ level (cf. Zehr (2015) on the sociological perspective on values); however, their expression is through individuals and their organizing practices are at the regime level.

(4) The societal level: Social Representations Theory

We have already distinguished the above mentioned TpB which focuses on deliberate behaviour, driven by tangible and social outcomes, from those theories focusing on habitualized behaviour and the strand of theories that assume that behaviour is instead internally driven by personal norms. Another differentiation can be made between individual- and societal- level theories (Evensen and Stedman, 2016). While the TpB is an individual-level psychological theory, social representation theory is a societal level social-psychological theory. According to Evensen and Stedman (2016, p. 15) social representations can be described as “complex ideas, processes and objects translated into common sense that is accessible and applicable in everyday life.” Two main processes are relevant in social representations theory: anchoring – the linkage of new concepts, such as shale gas (Upham et al., 2015a), to existing concepts – and objectification (the use of associated imagery and descriptive language). Both processes occur as part of

² Giddens, 1984 Giddens’ structuration theory, which includes an emphasis on practice, affords individuals more conscious, deliberative agency.

communication and discourse.³

There have also been several suggestions on how social representation theory could be combined with individual-level psychological theories. For example, social representation theory has also been discussed as an extension to the cultural approach, namely the Energy Culture (EC) Framework (Sarrica et al., 2016). The EC framework is an interdisciplinary approach that already aims at bridging the individual and the societal level (Stephenson et al., 2015). The interaction between norms (e.g. shared beliefs, habits), material culture (availability of technologies relevant to energy use, e.g. public transport system) and energy practices is examined in the model. Despite the integrative nature of the framework, as referred to above, some commentators still take the view that practice theory views individuals passively: "(...) a further step is needed to achieve a more effective comprehension of the individual – society link; the cultural factors should not be seen and studied only as external data embedded in the organization of material and social life that influences individual feelings, judgment and behaviours but also a constitutive part of the individual mind" (Sarrica et al., 2016, p. 3). In our view, social representations theory could be applied to achieve this integration. In social representations theory, representations are defined as culturally and contextually situated but the theory also accounts for transformations based on communication processes and negotiations between individuals and groups and, thus, leaves room for individual agents to act.

Another example of the combination of social representations theory with individual psychological theories is the work by Evensen and Stedman (2016). The authors combine social representations theory with construal level theory to examine public perceptions of shale gas development. Construal level theory implies that objects physically closer a person or nearer in time are described in more detail and specificity. Likewise, socially-relevant activities (e.g. self-experienced) are described and thought about in more detail than socially-distant experiences. The theory has, for example, been used to explain peoples' perceptions of climate change. Based on conceptual level theory and social representations theory, Evensen and Stedman (2016) show that close proximity strengthens the relationship between perceptions of shale gas development and support for/opposition to development. This should not be seen as offering support for a simplistic 'NIMBY' thesis of public objection, but is to illustrate the bringing together of individual and social level analyses as a means of understanding public responses to energy technology.

Other socio-psychological approaches have been applied to study the role of citizen and consumer expectations and beliefs in socio-technical transition research. Phillips and Dickie (2015) compare the narratives of people with different levels of actions aiming at carbon reduction – e.g. use of public transport, or building or moving to an eco-house – in order to understand attitude-behaviour gaps. The authors found that people use different narratives to deal with the dissonance aroused by differences between environmental concern and action. Dissonances are also a relevant psychological construct regarding processing and evaluation of new information, and are addressed in more detail in the section on "Information & persuasion".

(5) Place attachment

The concept of place plays an important role in socio-technical transitions (cf. e.g. Feola and Nunes, 2014; Murphy and Smith, 2013; Süsser et al., 2017; Whitmarsh et al., 2015). Outside of a sociotechnical transitions frame, Devine-Wright (e.g. 2009) has conducted an extended programme of place-related research in relation to public perceptions of new energy infrastructure. Place identity and attachment approaches in socio-technical transition research deal with the question of how proximity to energy development and perceived identity of places influence public's perceptions of sustainability projects, e.g. renewable energy projects. For example, in their study on shale gas hydraulic fracking Whitmarsh et al. (2015) find that place-based factors (location, rurality, employment in energy industry, length of residence in area, and place attachment) have a strong influence on social acceptance of shale gas. Feola and Nunes (2014) show the influence of place on the success of grassroots innovations, showing for example that less successful or completely inactive transitions initiatives are more likely to be in urban areas. The authors assume that is caused in part by the weaker local attachments in urban areas, which cannot be compensated for by global attachment. Likewise, a study by Süsser et al. (2017) confirms the influence of place meaning on the emergence of grassroots innovations in the context of renewable energies.

Place approaches often combine geographical and psychological factors (Devine-Wright, 2009; Whitmarsh et al., 2015) and it is this interdisciplinary perspective that has probably favored their application in socio-technical transitions research. Another advantage of these approaches is that besides individualistic perspectives, place attachment can also be studied from societal perspectives (see for example Süsser et al., 2017). Devine-Wright (2009, p. 430) point out how place approaches and social representations theory could be used to this end: "Research informed by social representations theory can investigate how proposed place changes are interpreted (via anchoring and objectification), evaluated (as threat or opportunity) and contested among individuals and between individuals and organizations (...)." Thus place approaches have been suggested by other researchers, too, as a promising way to foster agency-related research in research on socio-technical systems (cf. Stedman, 2016). Indeed, if agency at the individual level comes to be accounted for more often in socio-technical transition research, then the role of place and context will probably by itself become even more important as a topic of research (cf. Bristow and Healy (2014) on the integration of the human factor in resilience thinking).

(6) Information & persuasion

Several studies in socio-technical transition research examine how the public reacts to information on new technologies, information that often aims at increasing social acceptance (e.g. Whitmarsh et al., 2015). In social psychology, there has been intense study of the influence of prior-held beliefs on the processing and evaluation of new information – so-called confirmation bias: „

³ On social representations, there is relevant place- and energy-related work by Batel et al. (e.g. Batel et al., 2013), but this either did not refer to sociotechnical transitions specifically, or is classed by Scopus as a review (Batel et al., 2016) and hence not returned in the literature search. We have taken account of these methodological limitations in our thinking and discussion in the paper, but to relax the search terms would have resulted in an overly-large filtering task.

Confirmation Bias' means that information is searched for, interpreted and remembered in such a way that it systematically impedes the possibility that the hypothesis is rejected – that is, it fosters the immunity of the hypothesis (Oswald and Grosjean, 2004, p. 79)." Based on cognitive dissonance theory, research on confirmation bias in social psychology research has shown that prior-held beliefs influence information-seeking (Schulz-Hardt et al., 2000), the evaluation of information (Edwards and Smith, 1996; Fischer et al., 2011; Lord et al., 1979) as well as the memory of information (Stangor and McMillan, 1992) in such a way that initial beliefs are preserved.

In this connection, several studies from research on socio-technical transitions have found a gap between (high) environmental awareness and concern and levels of action to mitigate climate change and have referred to dissonance processes in this regard (cf. Phillips and Dickie, 2015). The discrepancies between beliefs or beliefs and behaviour are likely to cause dissonances and evoke different strategies to reduce them, with denial of climate change being one of these. While social psychologists have studied cognitive dissonance as an individual phenomenon, Cohen (2013, p. 43) suggest further examination of dissonance at the societal level, so called "collective dissonance". Cohen identifies collective dissonances as one factor that will lead to change processes within socio-technical systems, as "pronounced levels of collective dissonance cannot be maintained indefinitely." (Cohen 2013, p. 43).

More generally, Leviston et al. (2013) point to the need to account for biased processing of information due to further psychological mechanisms, e.g. the influence of risk frames or in-group/out-group differences such as the fundamental attribution error (where consequences are attributed to individuals' internal characteristics, without considering their circumstances (Jones and Harris, 1967)).⁴ Findings from Whitmarsh et al. (2015) support this call: their experimental study confirmed not only the influence of prior attitudes on processing and evaluation of information on sustainability topics but in addition the influence of several other psychological factors, e.g. environmental values.

4. Discussion: current state of research and future directions

Findings from the literature review show that psychological concepts are often only implicitly referred to and few manuscripts explicitly refer to psychological theories. Those studies that explicitly use psychological theories reveal six different psychological perspectives on agency in transitions and related theories: 1. The assumption of rational and mindful decision making, driven mainly by attitudes, with the Theory of Planned Behaviour most often used; 2. Habitualized behaviour, in contrast to rational and mindful decision making, mainly analyzed via the sociological social practice theory; 3. Norm-based theories such as Schwartz's Norm Activation Theory assuming that behaviour is driven by personal and social norms (in contrasts to the focus on attitudes); 4. Societal level psychological theories (in contrast to the individual-level theories mentioned above), especially social representations theory has been proven useful in transition research; 5. Theories focusing on the importance of place and place attachment; and 6. Communication and social psychological approaches examining information processing & persuasion.

The above theories have different fields of application and are thus applicable to different kinds of research questions. For example, the examples presented in Section 3 show that despite the limitations of the ABC-model (Shove 2010), the Theory of Planned Behaviour can be useful if the required preconditions are met in an analytical context, namely active and deliberate decision making. What is problematic, however, is a mismatch of theory to context. For example, despite much of energy behaviour being arguably habitualized, rather than driven by rational and mindful decisions, variants of the Theory of Planned Behaviour continue to dominate in this context. One of our purposes above is to highlight that there are other psychological theories that are conceptually closer to the systems-level concepts of transitions thinking.

Besides the arguably narrow theoretical focus of the current use of psychology in transitions contexts, another shortcoming that the literature review reveals is the narrow empirical focus on consumer psychology and technology acceptance to date. As described in the section on *Methods and Data*, the search terms *psychology* and *socio-technical transitions* were used for the literature review. Nevertheless, the examples given for the explicit use of psychological theories in transition studies mainly refer to the topics of consumption and technology acceptance. There are some exceptions, e.g. (Gössling et al., 2017) re EU policy officers and Brones' (2017) re the integration of eco-design at the organizational level, overall the psychology of transitions to date appears to be the psychology of consumption and technology acceptance.

There are reasons for this, other than perhaps disciplinary preferences. In the following section, methodological and conceptual challenges for the integration of psychological approaches in transition research are discussed and research directions posed. Rather than seeking to be comprehensive, we illustrate the further possibilities by highlighting two additional theoretical approaches, namely those relating to identity and values. In addition, we illustrate how a psychology of sociotechnical transitions need not be limited to consumption and technology acceptance.

4.1. Methodological challenges: limitations to experimental designs

Psychological approaches to drivers and barriers of relevance to transition processes tend to be rather mechanistic, based on the analysis of a separate factor or even several factors, such as attitudes, norms and control beliefs in the TpB, but without fully taking into account broader, societal contexts. One reason for this approach in psychology, which contrasts with the aim of socio-technical transition research to analyze complex systems, are the methodologies dominant psychological research, namely experimental

⁴ This sums up the key limitation of psychological approaches to agency; the inverse applies to sociological approaches. Our premise is that use of both, sequentially or simultaneously, should provide greater insight.

approaches (Aronson et al., 2014). It should be noted that the experimental approach does not necessarily involve a laboratory: it is a paradigm in which the objective is to test for causal relationships among factors. Thus a randomized experiment is defined as: “An experiment in which units are assigned to receive the treatment or an alternative condition by a random process such as the toss of a coin or a table of random numbers (Shadish et al., 2002, p. 12).” This approach is commonplace in psychology and is even referred to as the “true experiment” (Shadish et al., 2002, p. 13).

The typical experimental approach in psychology differs significantly from experimental definitions used in the sociotechnical transitions literature, notably the transition experiment (e.g. Gazheli et al., 2015; Seyfang and Haxeltine, 2012). While psychologists highlight the advantages of their type of experiments, especially the ability to test causality by isolating psychological factors (cf. Shadish et al., 2002), the focus on one factor limits the ability of the methodology to take into consideration the wide variety of contextual factors in which individuals are embedded in real-life settings. Some psychologists do remark upon the implications of this for the generalizability of results gained under such constraints. For example, concerning findings on the confirmation bias, social psychologists (Jonas et al., 2001, p. 558) note: “However, it is not yet clear whether these results can be generalized to and thus have implications for real-world decision making, for example, in politics or business.” In general, though, such limitations are acknowledged tacitly rather than formally.

4.2. Ontological differences: the individualistic focus in mainstream psychology

Psychological approaches by nature – and especially ‘mainstream’ psychological theories such as the Theory of Planned Behaviour – tend to deploy individualistic and cognitive paradigms (Keller et al., 2016). As stated, these tend to neglect: (a) the influence of the environment (Sorrell, 2015); and (b) the influence of individuals on their environment (co-construction). The same holds true for the use of other theoretical approaches that focus on the individual level, notably behavioural economics (Gazheli et al., 2015). This is arguably one of the main reasons that individual agency has been given rather little theoretical attention in the transitions literature: “Finally and most importantly, the focus on autonomous decision-making by individuals neglects how preferences, attitudes, expectations and behaviours are embedded in and shaped by broader physical and social systems that both enable and constrain individual choice (Sorrell, 2015, p. 79)”. In fact, most psychological theories applied to sustainability research rely on the workable concept of *individual agency* (Jackson, 2005).

This problem of not considering in depth the social systems that embed individual actions is found in other areas of related research. Even with regard to the study of sustainable consumption, where psychological theories have been used most in transitions contexts, Liu et al. (2017) conclude: “At the same time, some studies have tended to understand and predict sustainable consumption at the individual level, overlooking the social and situational factors influencing consumers’ decision to act sustainably.”

In contrast, sociological approaches consider in depth the social system and are, thus, often presented as an alternative to psychological approaches. The following section discusses the two disciplines in relation to socio-technical transition research and outlines possibilities for a joint research agenda. This research agenda is further elaborated in Section 4.4, namely with regard to theoretical perspectives that aim at bridging psychological and sociological approaches.

4.3. Sociology and psychology in socio-technical transitions: challenges and a research agenda

Sociological perspectives do of course offer accounts of human behaviour or practice. Sociological perspectives of practice, particularly those that decline to view practice and behaviour as synonymous (Shove, 2010), take practice as the key analytic unit of practice and view this as socio(technically) embedded and emergent. People carry practice and individuals do not exist in the sense of independent, isolated entities. There are no contexts or external drivers impinging on people: all are viewed as endogenous to social or sociotechnical systems (ibid). Learning is seen as a part of and in relation to the accumulation of various forms of capital and habitus (Bourdieu, 1986). Various sociological theories – e.g. symbolic interactionism (Blumer, 1969); social construction of technology (e.g. Bijker, 2009); Habermasian discourse theory (Habermas, 1996); and institutional theories (e.g. Amenta and Ramsey, 2010) – variously address meanings, norms and cognitive frames from sociological perspectives.⁵ Finally, despite a vast literature on attitudes, the evidence on attitude-behaviour correlation and consistency is mixed,⁶ has been so for decades and this has implications for the psychological premise that behavioural change requires attitudinal change (Chaiklin, 2011).

Clearly, psychologists neither have a disciplinary monopoly on the phenomena that they study, nor are their perspectives and constructs uncontested or unproblematic. Moreover, not infrequently, particularly in consumption contexts, these perspectives are appealed to and applied in ways that blur psychological and sociological frames of reference. Noppers et al. (2014), for example, mix sociological and psychological rationales for the importance of symbolism in consumption, particularly conspicuous consumption, and then investigate this within a psychological frame. Practice theory is sociological in origin, but in so far as practices are what people do, then even if practice theory does not recognise individuals as autonomous agents, from outside of its frame of reference it appears to be dealing with what psychologists would describe as behaviour.

In general, psychological perspectives provide detail on individual-level processes that typically privilege internal (intra-individual) processes. If in doing so they unduly neglect, black-box or poorly explain context, then they are no more ‘guilty’ than are

⁵ We thank a reviewer for their contribution here.

⁶ Chaiklin (2011, p. 48) states: „The one thing that methodological advances have clarified is that attitudes have some utility in predicting behavior when it is not a problem to the person and there is social acceptance of its expression in action.”

accounts that privilege inter-individual processes. The more important question here is the extent to which psychological perspectives can contribute to the study of processes that are important for sociotechnical transitions.

In this respect, what we have sought to do above is to illustrate the further relevance of even the few approaches found in the sociotechnical sustainability transitions literature to date. The theme that links the examples is that of the detail afforded to intra-individual processes. A counter-case would require the argument either that intra-individual processes are irrelevant to transitions processes, or that those processes are conceptualised at such an aggregated scale, and over such extended time periods, that again they have little relevance. Yet the widespread use of detailed case studies and the general attendance to micro-level phenomena and activity (e.g. by entrepreneurs, innovators and users; by agencies such as intermediaries; involving political contestation in specific contexts; or concerning the effects of specific regulation and policy on the progress of specific technologies) make it clear that the sociotechnical, sustainability transitions literature is concerned with multi-scalar activity and also with the connections between scales. Our purpose is to remind that individual-level processes merit closer attention as part of this, particularly, but not only, in consumption and technology acceptance contexts.

4.4. Directions for further research: rethinking (social) psychology

Taking into account the aim of social psychology, namely to: “examine psychological processes that can be observed in all human beings and that allow for social influences on individuals” (Aronson et al., 2014, p. 9, own translation; see also Spreng, 2017), it becomes clear that social psychological research, at least, does offer the potential for going beyond a focus on the individual. Moreover, this need not deploy statistical, experimental methodologies. Work on social representations (Batel et al., 2016; Upham et al., 2015a) illustrates the potential for the application of those social psychological theories with a focus on social influences to socio-technical transition research. This includes both where the psychology of publics as citizens and consumers is involved (Upham et al., 2015a; Whitmarsh et al., 2015), as well as the psychology of other actors in innovation systems, such as procurers in local government (Levidow and Upham, 2016, 2017).

We have argued that these kind of psychological theories may be particularly useful through their explanation of individual agency within broader societal systems. To date, though, of such theories, only social representations theory has been used in research on socio-technical transitions. In addition to the discussion above, we suggest some further options for further research below.

First, a stream of theories identified in the literature review and that seems particularly promising for further research are those focusing on identity; not least, because previous studies have highlighted its potential to narrow the well-known attitude-behaviour gap (Hibbert et al., 2013). The importance of identity has already been established as part of place approaches to energy transitions. For example, “place identity refers to ways in which physical and symbolic attributes of certain locations are contribute to an individual’s sense of self or identity (Devine-Wright, 2009, p. 428).’ Further research might also analyze the role of identity processes in relation to the symbolic meaning of goods and practices and also the role of changing (evolving) identities. In this regard Mead (1956) was one of the first to point to the socially-constructed nature of the self. Mead’s approach focuses on the role that communication inherits for the construction of the social self. He argues that: “A self can arise only where there is a social process within which this self has its initiation. It [the sense of self] arises within this process (Mead 1956, p. 42).’ Connected to Mead’s approach is the idea that every material artefact has a symbolic meaning, meaning that has been derived through negotiation in social interactions. The symbolic meaning of things is of particular relevance of consumption processes (see for example McCracken’s (1986) meaning transfer model. From this perspective, material goods become an important part of ones’ self (Jackson, 2005) and the self-concept, in turn motivates, behaviour.

In other contexts, previous studies confirm a strong influence of identity processes on the development of grassroots innovations (Seyfang and Haxeltine, 2012). For example, regarding the complex relation of identity, lifestyles, symbolic meaning, air conditioning can be interpreted as a symbol of modern life and domestic heating can be interpreted as a symbol of prosperity (Nye et al., 2010). Likewise, cars have been shown to be status symbol in many different ways, closely connected to one’s self-concept (Axsen and Kurani, 2014; Gazheli et al., 2015; Stephenson et al., 2015). Further research is, however, needed in this regard as there is only a limited range of research that examines the symbolic meanings of new technologies from a psychological perspective, e.g. the symbolic dimension of renewable energies and how this influences our energy behaviour (Nye et al., 2010); or the interrelation with identity (re-)building and behaviour. Analyzing these meanings from a psychological perspective could enlighten our understanding of interconnections between individual and collective (social) processes. Such research can be built upon the large body of research from other approaches, e.g. STS, to derive at a comprehensive understanding of symbolic meanings.

To analyze the influence of stakeholders’ identity and identity construction on both the individual and social and societal level, the approach of Elliott and Wattanasuwan, 1998 on identity and social-symbolic consumption seems promising. The framework allows examination of two kinds of resources (materials and symbolic) and two kinds of processes (individual and social) in the construction of meaning and identity and, thus, allows for combining the individual (micro), social-(meso), and societal(macro)-level, also including references to structural factors. Underpinning such analysis is the self-concept of a person, including broad life history and current situation. This includes current self-symbolism, e.g. car ownership as a status symbol, and personal norms. The meaning and construction of meaning of these material goods is posited by Elliott and Wattanasuwan, 1998 as shaped by three processes: lived experience, mediated experience and discursive elaboration. Lived experience means for example the experiences that stakeholders have with cars with alternative propulsion technologies, e.g. limited range or a search for refueling stations. Mediated experience relates to the presentation of symbolic resources, such as different car types, in the media. The third process, discursive elaboration, describes the negotiating of symbolic meaning and self with relevant others, e.g. friends, family and colleagues, which results in a

concretized meaning in relation to the self-symbolism. Discursive elaboration is influenced by and itself influences social norms and values.

The combination of social practice theory and identity-related processes would be another way for further research in this regard (cf. Kent, 2015). Indeed Bourdieu's concept of habitus as a set of inherited and acquired individual competences and traits is both individual and social, being carried by the individual but thoroughly shaped through social processes. In this respect, a Bourdieusian perspective of agency and structure would lend itself well to generating accounts of sociotechnical change and stasis that pays attention to individuals, but conceives of their attributed as socially-derived and reproductive of social structure.

Second, value-focused approaches seem a valuable pathway for further research, particularly (but not only) in terms of 'landscape' level studies. Research on the role of values in socio-technical transitions has been rare (Miller et al., 2014), but values are a core concept in much if not most psychological work seeking to explain behaviour and also when seeking to understand cultural and national differences (Beckers et al., 2012). Values as relatively long term phenomena tend to be located by those using the MLP at the landscape level, perhaps reflecting the assumption of unalterability, the 'landscape remains something of a "black box"' (Whitmarsh, 2012, p. 485). Yet, as fundamental sustainability transitions are likely to require changes at the landscape levels in relatively short timeframes, this perspective could be reconsidered (see for example Duru et al. (2015) re transitions in agriculture).

Examining the values held by stakeholders and their influence on transitions processes would deepen our understanding of the landscape level. For example, societal level approaches such as Inglehart's theory of post-materialistic value change are closely connected to the core concerns of sustainability transitions, such as how to change consumption patterns, or even achieving a "post-consumerism" as Cohen (2013) discuss. Questions such as how de-consumption might become an integral part of our shared values require the application of values-related concepts. There are also potential connections to other psychological concepts such as well-being (cf. Bowerman, 2014). Value-oriented research on socio-technical transitions could benefit from approaches to values that involve individual as well as societal constructs and that build on theories from sociology, e.g. Inglehart's work, as well as psychology, e.g. Schwartz's basic human values.

4.5. Rethinking the consumer focus

As the above review illustrates, the literature on individual agency in socio-technical transitions to date focuses largely on consumers. We have noted that this contrasts with Geels' (2012, p. 417) statement that "[t]he elements in socio-technical systems are maintained, reproduced and changed by various actor groups (e.g. firms and industries, policy makers and politicians, consumers, civil society, engineers and researchers)". In line with this assumption, previous studies have identified several other social groups that are of relevance for the dominant regimes, e.g. the automobile system. For example, concerning cars with alternative propulsion systems, Bakker et al. (2014) identify barriers to the diffusion of electric cars on the demand side but also on the supply side. Most car manufacturers in the EU still concentrate in incremental improvements of the combustion engine, while cars with alternative propulsion are only a small part of the portfolio (Geels 2012; Bakker et al., 2014). Some early work by Gössling (2017) indicates that – beside the factors usually mentioned to explain resistance to change, e.g. lack of governmental support, uncertainty of the further development of the technology – the mechanisms mentioned above, particularly identity processes, influence the action of other actors, too, and thus function as a barrier to system change. Identity-processes are thus themselves a lock-in mechanism (see Geels, 2012 re lock-in mechanisms in the transport sector), not only on the demand side but also on the supply side. For example, change may threaten experts' or workers' knowledge and status (e.g. Zapata and Nieuwenhuis, 2010, re the difference between a drop-in fuel substitute for an internal combustion engine and an electric powertrain that renders a range of sunk investments obsolete).

Similarly via interviews with EU policy officers involved with transport policy, Gössling et al. (2017) highlight not only institutional (structural) but also individual (agency-based) barriers to change. Policy officers are restricted by inflexible rules, subject to varying personalities and (perceived or real) external pressures influencing personal viewpoints (Gössling et al. (2017), p. 91).

While these examples illustrate the use that the application of psychological theories can have for transition research beyond its application to studies in the field of consumption, it has to be noted that most of our experience with psychological theories in transitions nevertheless derive from the consumption strand of research. Further research is needed to examine the adaptation of psychological theories to the study of other social groups. For example, the instances of theory referred to above suggest that identity-based theories are of relevance to understand organizational change in the context of socio-technical transitions, too, but the selection and application of specific theories will need to be adapted to specific contexts.

5. Conclusions

Agency in the sense of actor behaviour in the socio-technical, sustainability transitions literature has mostly been addressed in collective contexts and at collective levels, with relative neglect of the psycho-social processes of both individuals per se and of individuals in their social context. We have documented and discussed the ways in which actor psychology is described and theorised in the said literature, both implicitly and explicitly. While actor motivation and behaviour are often implicitly referred to, these are rarely theorised explicitly using psychological concepts. Furthermore, so far, only a small set of psychological theories has been applied to transitions research, and mainly those with an individualistic focus such as the Theory of Planned Behaviour.

We have discussed reasons for the lack of integration of psychological theories in sociotechnical transitions thinking, of which the predominance of rational choice models in contemporary behavioural psychology – which rely on the assumption of individual agency and emphasise cognition – are identified as possible factors. Nonetheless we have shown the range of social psychological theories that have been used in socio-technical transitions research and that take a different approach to the "ABC-model" of

psychology. Concerning an agenda for further research, we strengthen the case for the application of further these psychological theories such as identity-based, value-based or socio-cognitive psychological approaches that seem promising for bridging individual and social levels. The above suggestions for further research on the psychology of agents in socio-technical transitions are inevitably illustrative rather than comprehensive. In principle, one could traverse the depth and breadth of psychology for further connections.

Nonetheless, the literature review and analysis of barriers for integration of psychological theories also show that there are – and probably always will be – limits regarding the incorporation of psychology in transition research. If we take into account Geels and Schot's (2010) characteristics of transitions, namely (1) co-evolution and multiple changes in socio-technical systems or configurations; (2) multi-actors interactions between social groups including firms, user groups, scientific communities, policy makers, social movements and special interest groups; (3) 'radical' change in terms of scope and of change (not speed); (4) long-term processes over 40–50 years periods, then while there are some aspects beyond those presented in the literature review that psychology could add to transition research, e.g. theories on symbolic consumption and identity (re-)building could help understand mechanisms of co-evolution, there are also aspects for which other disciplines are more suitable, e.g. the analysis of multi-actor interactions on the system-level. Thus, our key argument is most definitely not for the superiority of psychology for transition research, but for its complementary value in particular contexts. As such, we would concur with, for example, Davis (1993), that making use of both psychological and sociological accounts in understanding human behaviour is likely to have greater explanatory potential than making use of one discipline alone.

References

- Adil, A.M., Ko, Y., 2016. Socio-technical evolution of Decentralized Energy Systems. A critical review and implications for urban planning and policy. *Renew. Sustain. Energy Rev.* 57, 1025–1037. <http://dx.doi.org/10.1016/j.rser.2015.12.079>.
- Ajzen, I., 1991. The theory of planned behavior. *Organ. Behav. Hum. Decis. Process.* 50 (2), 179–211. [http://dx.doi.org/10.1016/0749-5978\(91\)90020-T](http://dx.doi.org/10.1016/0749-5978(91)90020-T).
- Ajzen, I., 2011. The theory of planned behaviour. Reactions and reflections. *Psychol. Health* 26 (9), 1113–1127. <http://dx.doi.org/10.1080/08870446.2011.613995>.
- Amenta, E., Ramsey, K.M., 2010. Institutional theory. *Handbook of Politics*. pp. 15–39. <http://doi.org/123-567>.
- Aronson, E., Wilson, T., Akert, R., 2014. *Sozialpsychologie [Social Psychology]*. Pearson Studium, Hallbergmoos.
- Audet, R., Guyonnaud, M.-F., 2013. Transition in practice and action in research. A French case study in piloting eco-innovations. *Innovation* 26 (4), 398–415. <http://dx.doi.org/10.1080/13511610.2013.850019>.
- Axsen, J., Kurani, K.S., 2014. Social influence and proenvironmental behavior. The reflexive layers of influence framework. *Environ. Plann. B: Plann. Des.* 41 (5), 847–862. <http://dx.doi.org/10.1068/b38101>.
- Bakker, S., Maat, K., Wee, B., 2014. Stakeholders interests, expectations, and strategies regarding the development and implementation of electric vehicles: The case of the Netherlands. *Transp. Res. Part A: Policy Pract.* 66, 52–64.
- Büschler, C., Sumpf, P., 2015. Trust and confidence as socio-technical problems in the transformation of energy systems. *Energy Sustain. Soc.* 5 (1), 1–13. <http://dx.doi.org/10.1186/s13705-015-0063-7>.
- Batel, S., Devine-Wright, P., Tangeland, T., 2013. Social acceptance of low carbon energy and associated infrastructures: a critical discussion. *Energy Policy* 8, 1–5. <http://dx.doi.org/10.1016/j.enpol.2013.03.018>.
- Batel, S., Castro, P., Devine-Wright, P., Howarth, C., 2016. Developing a critical agenda to understand pro-environmental actions. *Contributions from Social Representations and Social Practices Theories*. *Wiley Interdiscip. Rev. Clim. Change* 7 (5), 727–745. <http://dx.doi.org/10.1002/wcc.417>.
- Beckers, T., Siegers, P., Kuntz, A., 2012. Congruence and performance of value concepts in social research. *Surv. Res. Methods* 6 (1), 13–24.
- Bijker, W.E., Hughes, T.P., Pinch, T.J., 1987. *The Social Constructions of Technological Systems*. MIT Press, Cambridge, Massachusetts.
- Bijker, W.E., 2009. Social construction of technology. In: Olsen, J.K., Pedersen, S.A., Hendricks, V.H. (Eds.), *A Companion to the Philosophy of Technology*. Chichester: Wiley-Blackwell, UK, pp. 88–94. <http://dx.doi.org/10.1002/9781444310795.ch15>.
- Blumer, H., 1969. *Symbolic Interactionism: Perspective and Method*. Prentice-Hall, Inc, New Jersey.
- Bourdieu, P., 1986. The forms of capital. In: Richardson, J.G. (Ed.), *Handbook of Theory and Research for the Sociology of Education*. Greenwood, New York, pp. 241–258.
- Bowerman, T., 2014. How much is too much? A public opinion research perspective. *Sustain.: Sci. Pract. Policy* 10 (1), 14–28.
- Bristow, G., Healy, A., 2014. Regional resilience. An agency perspective. *Reg. Stud.* 48 (5), 923–935. <http://dx.doi.org/10.1080/00343404.2013.854879>.
- Brones, F.A., Carvalho, M.M.D., Zancul, E.D.S., 2017. Reviews, action and learning on change management for ecodesign transition. *J. Clean. Prod.* 142, 8–22. <http://dx.doi.org/10.1016/j.jclepro.2016.09.009>.
- Brown, H.S., Vergragt, P.J., 2016. From consumerism to wellbeing. Toward a cultural transition? *J. Clean. Prod.* 132, 308–317. <http://dx.doi.org/10.1016/j.jclepro.2015.04.107>.
- Chaiklin, H., 2011. Attitudes, behavior, and social practice. *J. Sociol. Soc. Welfare XXXVIII* (1), 31–54. Retrieved from: http://heonlinebackup.com/hol/cgi-bin/get_pdf.cgi?handle=hein.journals/jrlsasw38§ion=5.
- Chatterton, P., 2016. Building transitions to post-capitalist urban commons. *Trans. Inst. Br. Geogr.* 41 (4), 403–415. <http://dx.doi.org/10.1111/tran.12139>.
- Clayton, S., Devine-Wright, P., Stern, P.C., Whitmarsh, L., Carrico, A., Steg, L., Swim, J., Bonnes, M., 2015. Psychological research and climate change. *Nat. Clim. Change* 5, 640–646.
- Cohen, M.J., 2013. Collective dissonance and the transition to post-consumerism. *Futures* 52, 42–51. <http://dx.doi.org/10.1016/j.futures.2013.07.001>.
- Davis, J., 1993. Psychological versus sociological explanations for delinquent conduct and gang formation. *J. Contemp. Crim. Just.* 9 (2), 81–93. <http://dx.doi.org/10.1177/104398629300900202>.
- Dawson, N., Martin, A., 2015. Assessing the contribution of ecosystem services to human wellbeing. A disaggregated study in western Rwanda. *Ecol. Econ.* 117, 62–72. <http://dx.doi.org/10.1016/j.ecolecon.2015.06.018>.
- Devine-Wright, P., 2009. Rethinking NIMBYism. The role of place attachment and place identity in explaining place-protective action. *J. Commun. Appl. Soc. Psychol.* 19 (6), 426–441. <http://dx.doi.org/10.1002/casp.1004>.
- Dijk, M., Wells, P., Kemp, R., 2016. Will the momentum of the electric car last? Testing an hypothesis on disruptive innovation. *Technol. Forecast. Social Change* 105, 77–88. <http://dx.doi.org/10.1016/j.techfore.2016.01.013>.
- Duru, M., Therond, O., Fares, M., 2015. Designing agroecological transitions; A review. *Agron. Sustain. Dev.* 35 (4), 1237–1257. <http://dx.doi.org/10.1007/s13593-015-0318-x>.
- Edwards, K., Smith, E.E., 1996. A disconfirmation bias in the evaluation of arguments. *J. Pers. Soc. Psychol.* 71 (1), 5–24. <http://dx.doi.org/10.1037/0022-3514.71.1.5>.
- Elliott, R., Wattanasuwan, K., 1998. Consumption and the symbolic project of the self. *Eur. Adv. Consum. Res.* 3, 17–20.
- Emery, F.E., Trist, E.L., 1960. Socio-technical systems. In: Churchman, C.W., Verhulst, M. (Eds.), *Management Science Models and Techniques*. Pergamon, Oxford UK, pp. 83–97 Keine Angabe.
- Evensen, D., Stedman, R., 2016. Scale matters. Variation in perceptions of shale gas development across national, state, and local levels. *Energy Res. Social Sci.* 20, 14–21. <http://dx.doi.org/10.1016/j.erss.2016.06.010>.

- Feola, G., Nunes, R., 2014. Success and failure of grassroots innovations for addressing climate change. The case of the transition movement. *Global Environ. Change* 24 (1), 232–250. <http://dx.doi.org/10.1016/j.gloenvcha.2013.11.011>.
- Fielding, K.S., Terry, D.J., Masser, B.M., Hogg, M.A., 2008. Integrating social identity theory and the theory of planned behaviour to explain decisions to engage in sustainable agricultural practices. *Br. J. Soc. Psychol.* 47, 23–48.
- Fischer, P., Lea, S., Kastenmüller, A., Greitemeyer, T., Fischer, J., Frey, D., 2011. The process of selective exposure. Why confirmatory information search weakens over time. *Organ. Behav. Hum. Decis. Process.* 114 (1), 37–48. <http://dx.doi.org/10.1016/j.obhdp.2010.09.001>.
- Folke, C., 2016. Resilience. *Ecol. Soc.* 21 (4). <http://dx.doi.org/10.5751/ES-09088-210444>. Republished.
- Gössling, 2017. The psychology of the car. Automobile admiration and addiction. Elsevier, Amsterdam.
- Gazheli, A., Antal, M., van den Bergh, J., 2015. The behavioral basis of policies fostering long-run transitions. Stakeholders, limited rationality and social context. *Futures* 69, 14–30. <http://dx.doi.org/10.1016/j.futures.2015.03.008>.
- Geels, F.W., Schot, J., 2010. Introduction to the dynamics of socio-technical transitions: a socio-technical perspective. In: Grin, J., Rotmans, J., Schot, J. (Eds.), *Transitions to Sustainable Development: New Directions in the Study of Long Term Transformative Change*. Routledge, New York London, pp. 11–17.
- Geels, F.W., 2002. Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. *Res. Policy* 31, 1257–1274.
- Geels, F.W., 2012. A socio-technical analysis of low-carbon transitions. Introducing the multi-level perspective into transport studies. *J. Transp. Geogr.* 24, 471–482. <http://dx.doi.org/10.1016/j.jtrangeo.2012.01.021>.
- Giddens, A., 1984. *The Constitution of Society*. Cambridge Polity Press, Oxford, UK.
- Goedkoop, F., Devine-Wright, P., 2016. Partnership or placation? The role of trust and justice in the shared ownership of renewable energy projects. *Energy Res. Social Sci.* 17, 135–146. <http://dx.doi.org/10.1016/j.erss.2016.04.021>.
- Habermas, J., 1996. *Between Facts and Norms. Contributions To a Discourse Theory of Law and Democracy*. Polity Press, Cambridge. <http://dx.doi.org/10.2307/2941077>.
- Hassink, J., Grin, J., Hulsink, W., 2013. Multifunctional agriculture meets health care. applying the multi-level transition sciences perspective to care farming in the Netherlands. *Sociologia Ruralis* 53 (2), 223–245. <http://dx.doi.org/10.1111/j.1467-9523.2012.00579.x>.
- Hibbert, J.F., Dickinson, J.E., Gössling, S., Curtin, S., 2013. Identity and tourism mobility: an exploration of the attitude-behaviour gap. *J. Sustain. Tour.* 21 (7), 999–1016.
- Hynes, M., 2016. Developing (tele)work? A multi-level sociotechnical perspective of telework in Ireland. *Res. Transport. Econ.* 57, 21–31. <http://dx.doi.org/10.1016/j.retrec.2016.06.008>.
- Jackson, T., 2005. *Motivating Sustainable Consumption, A Review of Evidence on Consumer Behaviour and Behavioural Change. A Report to the Sustainable Development Research Network* Online. Checked on March 5th, 2016, Retrieved from: http://www.sustainablelifestyles.ac.uk/sites/default/files/motivating_sc_final.pdf.
- Jonas, E., Schulz-Hardt, S., Frey, D., Thelen, N., 2001. Confirmation bias in sequential information search after preliminary decisions: an expansion of dissonance theoretical research on selective exposure to information. *J. Pers. Soc. Psychol.* 80 (4), 557–571.
- Jones, E.E., Harris, V.A., 1967. The attribution of attitudes. *J. Exp. Soc. Psychol.* 3 (1), 1–24. [http://dx.doi.org/10.1016/0022-1031\(67\)90034-0](http://dx.doi.org/10.1016/0022-1031(67)90034-0).
- Keller, M., Halkier, B., Wilska, T.-A., 2016. Policy and governance for sustainable consumption at the crossroads of theories and concepts. *Environ. Policy Govern.* 26 (2), 75–88. <http://dx.doi.org/10.1002/eet.1702>.
- Kent, J.L., 2015. Still feeling the car—the role of comfort in sustaining private car use. *Mobil.* 10 (5), 726–747. <http://dx.doi.org/10.1080/17450101.2014.944400>.
- Koutiva, I., Gerakopoulou, P., Makropoulos, C., Vernardakis, C., 2017. Exploration of domestic water demand attitudes using qualitative and quantitative social research methods. *Urban Water J.* 14 (3), 307–314. <http://dx.doi.org/10.1080/1573062X.2015.1135968>.
- Levidow, L., Upham, P., 2016. Socio-technical change linking expectations and representations. Innovating thermal treatment of municipal solid waste. *Sci. Public Policy*. <http://dx.doi.org/10.1093/scipol/scw054>.
- Levidow, L., Upham, P., 2017. Linking the multi-level perspective with social representations theory. Gasifiers as a niche innovation reinforcing the energy-from-waste (EFW) regime. *Technol. Forecast. Social Change* 120, 1–13. <http://dx.doi.org/10.1016/j.techfore.2017.03.028>.
- Leviston, Z., Browne, A.L., Greenhill, M., 2013. Domain-based perceptions of risk. A case study of lay and technical community attitudes toward managed aquifer recharge. *J. Appl. Soc. Psychol.* 43 (6), 1159–1176. <http://dx.doi.org/10.1111/jasp.12079>.
- Lilliestam, J., Ellenbeck, S., Karakosta, C., Caldés, N., 2016. Understanding the absence of renewable electricity imports to the European Union. *Int. J. Energy Sect. Manage.* 10 (3), 291–311. <http://dx.doi.org/10.1108/IJESM-10-2014-0002>.
- Liu, Y., Qu, Y., Lei, Z., Jia, H., 2017. Understanding the evolution of sustainable consumption research. *Sustain. Dev.* 33 (1), 24. <http://dx.doi.org/10.1002/sd.1671>.
- Lord, C.G., Ross, L., Lepper, M.R., 1979. Biased assimilation and attitude polarization: the effects of prior theories on subsequently considered evidence. *J. Pers. Soc. Psychol.* 37, 2089–2109.
- Ma, G., Andrews-Speed, P., Zhang, J., 2013. Chinese consumer attitudes towards energy saving. The case of household electrical appliances in Chongqing. *Energy Policy* 56, 591–602. <http://dx.doi.org/10.1016/j.enpol.2013.01.024>.
- Macmillan, A., Davies, M., Shrubsole, C., Luxford, N., May, N., Chiu, L.F., et al., 2016. Integrated decision-making about housing, energy and wellbeing. A qualitative system dynamics model. *Environ. Health A: Global Access Sci. Source* 15. <http://dx.doi.org/10.1186/s12940-016-0098-z>.
- Martin, C.J., Upham, P., 2016. Grassroots social innovation and the mobilisation of values in collaborative consumption. A conceptual model. *J. Clean. Prod.* 134, 204–213. <http://dx.doi.org/10.1016/j.jclepro.2015.04.062>.
- McCracken, G., 1986. Culture and consumption: a theoretical account of the structure and movement of the cultural meaning of consumer goods. *J. Consum. Res.* 13 (1), 71–84.
- McLellan, B.C., Chapman, A.J., Aoki, K., 2016. Geography, urbanization and lock-in – considerations for sustainable transitions to decentralized energy systems. *J. Clean. Prod.* 128, 77–96. <http://dx.doi.org/10.1016/j.jclepro.2015.12.092>.
- Mead, G., 1956. The problem of society-How we become selves. In: Mead, G. (Ed.), *Georg Herbert Mead on Social Psychology*. University of Chicago Press, Chicago, pp. 19–42.
- Miller, T.R., Wiek, A., Sarewitz, D., Robinson, J., Olsson, L., Kriebel, D., Loorbach, D., 2014. The future of sustainability science. A solutions-oriented research agenda. *Sustain. Sci.* 9 (2), 239–246. <http://dx.doi.org/10.1007/s11625-013-0224-6>.
- Missimer, M., Robèrt, K.-H., Broman, G., 2017. A strategic approach to social sustainability—part 1. Exploring the social system. *J. Clean. Prod.* 140, 32–41. <http://dx.doi.org/10.1016/j.jclepro.2016.03.170>.
- Murphy, J., Smith, A., 2013. Understanding transition-periphery dynamics. Renewable energy in the highlands and Islands of Scotland. *Environ. Plann. A* 45 (3), 691–709. <http://dx.doi.org/10.1068/a45190>.
- Nilsson, M., Nykvist, B., 2016. Governing the electric vehicle transition – near term interventions to support a green energy economy. *Appl. Energy* 179, 1360–1371. <http://dx.doi.org/10.1016/j.apenergy.2016.03.056>.
- Noppers, E.H., Keizer, K., Bolderdijk, J.W., Steg, L., 2014. The adoption of sustainable innovations: driven by symbolic and environmental motives. *Global Environ. Change* 25, 52–62. <http://dx.doi.org/10.1016/j.gloenvcha.2014.01.012>.
- Nye, M., Whitmarsh, L., Foxon, T., 2010. Sociopsychological perspectives on the active roles of domestic actors in transition to a lower carbon electricity economy. *Environ. Plann. A* 42 (3), 697–714. <http://dx.doi.org/10.1068/a4245>.
- Oswald, M.E., Grosjean, S., 2004. Confirmation bias. In: Pohl, R. (Ed.), *Cognitive Illusions. A Handbook on Fallacies and Biases in Thinking, Judgement and Memory*. Psychology Press, Hove, New York, pp. 79–96.
- Phillips, M., Dickie, J., 2015. Climate change, carbon dependency and narratives of transition and stasis in four English rural communities. *Geoforum* 67, 93–109. <http://dx.doi.org/10.1016/j.geoforum.2015.10.011>.
- Pinch, T.J., Bijker, W.E., 1984. The social construction of facts and artefacts: or how the sociology of science and the sociology of technology might benefit each other. *Soc. Stud. Sci.* 399–441.
- Puhe, M., Schippl, J., 2014. User perceptions and attitudes on sustainable urban transport among young adults. findings from Copenhagen, Budapest and Karlsruhe. *J.*

- Environ. Policy Plann. 16 (3), 337–357. <http://dx.doi.org/10.1080/1523908X.2014.886503>.
- Managing technology in society. In: Rip, A., Misa, T.J., Schot, J. (Eds.), *The Approach of Constructive Technology Assessment*. Pinter, London, New York.
- Rivers, W.H.R., 1916. *Sociology and psychology*. *Sociol. Rev.* 9, 1–13.
- Ruppert-Winkel, C., Hussain, W., Hauber, J., 2016. Understanding the regional process of energy transition in Marin County, California. Applying a three-phase-model based on case studies from Germany. *Energy Res. Social Sci.* 14, 33–45. <http://dx.doi.org/10.1016/j.erss.2016.01.003>.
- Süsser, D., Döring, M., Ratter, B.M.W., 2017. Harvesting energy. Place and local entrepreneurship in community-based renewable energy transition. *Energy Policy* 101, 332–341. <http://dx.doi.org/10.1016/j.enpol.2016.10.018>.
- Sarrica, M., Brondi, S., Cottone, P., Mazzara, B.M., 2016. One, no one, one hundred thousand energy transitions in Europe. The quest for a cultural approach. *Energy Res. Social Sci.* 13, 1–14. <http://dx.doi.org/10.1016/j.erss.2015.12.019>.
- Schulz-Hardt, S., Frey, D., Lüthgens, C., Moscovi, S., 2000. Biased information search in group decision making. *J. Pers. Soc. Psychol.* 78 (4), 655–669. <http://dx.doi.org/10.1037//0022-3514.78.4.655>.
- Scott, T.J., Politte, A., Saathoff, S., Collard, S., Berglund, E., Barbour, J., Sprintson, A., 2014. An evaluation of the stormwater footprint calculator and the hydrological footprint residence for communicating about sustainability in stormwater management. *Sustain.: Sci. Pract. Policy* 10 (2), 51–64.
- Seyfang, G., Haxeltine, A., 2012. Growing grassroots innovations. Exploring the role of community-based initiatives in governing sustainable energy transitions. *Environ. Plann. C: Govern. Policy* 30 (3), 381–400. <http://dx.doi.org/10.1068/c10222>.
- Shadish, W.R., Cook, T.D., Campbell, D.T., 2002. *Experimental and Quasi-Experimental Designs for Generalized Causal Inferences*. Houghton Mifflin, Boston, Massachusetts.
- Shove, E., 2010. Beyond the ABC. Climate change policy and theories of social change. *Environ. Plann. A* 42 (6), 1273–1285. <http://dx.doi.org/10.1068/a42282>.
- Smith, A., Stirling, A., Berkhout, F., 2005. The governance of sustainable sociotechnical transitions. *Res. Policy* 34, 1491–1510.
- Sopha, B.M., Klöckner, C.A., Hertwich, E.G., 2013. Adoption and diffusion of heating systems in Norway. Coupling agent-based modeling with empirical research. *Environ. Innov. Soc. Trans.* 8, 42–61. <http://dx.doi.org/10.1016/j.eist.2013.06.001>.
- Sorrell, S., 2015. Reducing energy demand. A review of issues, challenges and approaches. *Renew. Sustain. Energy Rev.* 47, 74–82. <http://dx.doi.org/10.1016/j.rser.2015.03.002>.
- Spreng, D., 2017. On physics and the social in energy policy. *Energy Res. Social Sci.* 26, 112–114. <http://dx.doi.org/10.1016/j.erss.2017.01.011>.
- Stangor, C., McMillan, D., 1992. Memory of expectancy-congruent and expectancy-incongruent information: a review of the social and social developmental literatures. *Psychol. Bull.* 111, 42–61.
- Stedman, R.C., 2016. Subjectivity and social-ecological systems A rigidity trap (and sense of place as a way out). *Sustain. Sci.* 11 (6), 891–901. <http://dx.doi.org/10.1007/s11625-016-0388-y>.
- Steg, L., Vlek, C., 2009. Encouraging pro-environmental behaviour. An integrative review and research agenda. *J. Environ. Psychol.* 29 (3), 309–317. <http://dx.doi.org/10.1016/j.jenvp.2008.10.004>.
- Stephenson, J., Hopkins, D., Doering, A., 2015. Conceptualizing transport transitions. *Energy Cultures as an organizing framework*. Wiley Interdiscip. Rev.: Energy Environ. 4 (4), 354–364. <http://dx.doi.org/10.1002/wene.149>.
- Thoits, P.A., 1995. *Social psychology: the interplay between sociology and psychology*. *Soc. Forces* 73 (4), 1231–1243.
- Upham, P., Lis, A., Riesch, H., Stankiewicz, P., 2015a. Addressing social representations in socio-technical transitions with the case of shale gas. *Environ. Innov. Soc. Transit.* 16, 120–141. <http://dx.doi.org/10.1016/j.eist.2015.01.004>.
- Upham, Paul, Oltra, Christian, Boso, Alex, 2015b. Towards a cross-paradigmatic framework of the social acceptance of energy systems. *Energy Res. Social Sci.* 8, 100–112. <http://dx.doi.org/10.1016/j.erss.2015.05.003>.
- Upham, P., Dütschke, E., Schneider, U., Oltra, C., Sala, R., Loes, M., Klapper, R., Bögel, P., 2018. Agency and structure in a sociotechnical transition: hydrogen fuel cells, conjunctural knowledge and structuration in Europe. *Energy Res. Soc. Sci.* 37, 163–174. <http://dx.doi.org/10.1016/j.erss.2017.09.040> Upham.
- Walsh, C.J., Booth, D.B., Burns, M.J., Fletcher, T.D., Hale, R.L., Hoang, L.N., et al., 2016. Principles for urban stormwater management to protect stream ecosystems. *Freshw. Sci.* 35 (1), 398–411. <http://dx.doi.org/10.1086/685284>.
- Webb, Thomas L., Sniehotta, Falko F., Michie, S., 2010. Using theories of behaviour change to inform interventions for addictive behaviours. *Addiction* 105 (11), 1879–1892. <http://dx.doi.org/10.1111/j.1360-0443.2010.03028.x>.
- Whitmarsh, L., Nash, N., Upham, P., Lloyd, A., Verdon, J.P., Kendall, J.-M., 2015. UK public perceptions of shale gas hydraulic fracturing. The role of audience, message and contextual factors on risk perceptions and policy support. *Appl. Energy* 160, 419–430. <http://dx.doi.org/10.1016/j.apenergy.2015.09.004>.
- Whitmarsh, L., 2012. How useful is the multi-level perspective for transport and sustainability research? *J. Trans. Geogr.* 24, 483–487. <http://dx.doi.org/10.1016/j.jtrangeo.2012.01.022>.
- Yun, S., Lee, J., 2015. Advancing societal readiness toward renewable energy system adoption with a socio-technical perspective. *Technol. Forecast. Social Change* 95, 170–181. <http://dx.doi.org/10.1016/j.techfore.2015.01.016>.
- Zapata, C., Nieuwenhuis, P., 2010. Exploring innovation in the automotive industry: new technologies, technologies for cleaner cars. *J. Clean. Prod.* 18, 14–20.
- Zehr, S., 2015. The sociology of global climate change. *Wiley Interdiscip. Rev. Clim. Change* 6 (2), 129–150. <http://dx.doi.org/10.1002/wcc.328>.