Social Influence, Consumer Behavior, and Low-Carbon Energy Transitions

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Abstract

Realizing a low-carbon energy future requires pervasive changes in consumer behavior. Here, we examine the role of social influence in transitioning toward new low-carbon products and practices. We review and critique five research perspectives of how social interactions affect the spread of new behaviors through social networks: diffusion of functional information across social groups; conformity to others’ behaviors; dissemination by organized, resourceful social groups motivated to promote societal goods; translation of consumers’ perceptions between social groups; and reflexivity of individuals’ continual search for self-development and expression through lifestyle practices, including their social context and consumption. Each perspective observes different social processes and holds different implications for policies and strategies to achieve low-carbon energy transitions. No single perspective seems adequate to characterize social influence. We conclude with a set of priorities to develop an integrative framework to guide strategy and policy.

Keywords

proenvironmental behavior, social networks, social interactions, interpersonal influence, diffusion, reflexivity
1. INTRODUCTION

Realizing a low-carbon energy future requires pervasive changes in consumers’ energy consumption and behavior (1–3); technological change alone will not be enough (4). For example, achieving goals to cut greenhouse gas (GHG) emissions 60–80% by 2050 will require widespread uptake of low-carbon products and practices (5). As examples, low-carbon product purchases might include hybrid, electric, and hydrogen fuel-cell vehicles; low-energy homes; and residential solar panels. Low-carbon practices may include ongoing behaviors, such as reduced demand for household heating, air-conditioning, vehicle miles traveled, and air travel, or taking up the use of lower-carbon travel modes.

Improved understanding of consumer purchases and practices will facilitate the design of strategies and policies to achieve deep GHG abatement goals (6). Within the broad possibilities of such a transition, this article reviews five perspectives on the role social influence plays in consumer perceptions, values, and behavior, and ultimately on the impacts of climate and energy policy.

Social influence is often poorly theorized or simply absent from behavioral models and research (7). Confusion about the role of social influence stems from confounding factors in behavioral data as well as inconsistent and imprecise use of terminology, concepts, and theory across literatures (8). Although the concept of social influence can include interactions and relationships among and between consumers and institutions, here we focus on interpersonal influence as a subcategory that occurs between individual consumers. Our review attempts to disentangle such confusion and point toward an integration of ideas on interpersonal influence and consumer uptake of low-carbon products and practices.

To illustrate our discussion on the differences between the five perspectives, we draw examples from research on a particular behavior—the purchase (or lease) of automobiles that can achieve carbon reductions through the displacement of petroleum-based fuels by electricity. The actual environmental impacts are shaped by the particular vehicle...
technology that is purchased, the context (including the carbon-content of the electricity and petroleum-based fuels), and ongoing practices (including the daily practices of driving and recharging), but the actual estimations of such impacts are beyond the scope of this review (9, 10). Although we provide fewer examples of changes in practice, e.g., reducing energy or travel demand, these practices may also be viewed from the perspectives discussed.

We offer three contributions. First is a two-by-two typology of attributes to help conceptualize how consumers may perceive and value a low-carbon product or practice. Second, we review the literature regarding the role of interpersonal influence in the uptake of such low-carbon products and practices. This literature is organized into five perspectives: diffusion, conformity, dissemination, translation, and reflexivity. Each perspective is summarized in turn, drawing out concepts and language that can improve the understanding of interpersonal influence regarding low-carbon products and practices. Third, we point toward the integration of key concepts from the five perspectives to address the complex roles of social influence in the adoption of low-carbon behaviors.

2. OVERVIEW OF BEHAVIORAL MODELS

Behavioral models are necessary to understand and represent what consumers do and why. With respect to the purchase of energy-consuming products, we define the consumer as both the purchaser of products and the cause of energy consumption through ongoing practices in the use of the product. Behavioral models vary widely by theory, concepts and applications, and in their appropriateness for different climate policy problems (11). Thorough reviews of behavioral models of energy and proenvironmental behavior are provided elsewhere (7, 12, 13). Here, we provide a concise overview to contextualize our focus on interpersonal influence. We briefly consider several dominant behavioral models from economics, social psychology, and sociology, as reviewed by Jackson (7), who organized his discussion according to the models’ emphasis on individual versus social aspects of behavior.

From economics, the rational actor model depicts consumers as autonomous, rational, and deliberative decision makers who choose behaviors from a choice set to maximize individual net benefit (or satisfaction or utility) according to their static preferences. Such individual-focused models have been prevalent in research on consumer energy behavior over the past three decades, particularly in alternative-fuel vehicle market research (14–17). Some recent applications incorporate social factors through the addition of parameters representing aggregated preference changes (18, 19), word-of-mouth effects (20), information search channels (21), and social network position (22). However, such aggregations do not yield insight into the specific processes of interpersonal influence.

Social psychology has widely embraced attitude-behavior models that explain an individual’s engagement in a behavior as resulting from their evaluation of the behavior in question, and/or beliefs regarding related ideas, such as the environment. Such models have struggled with an attitude-behavior gap, for example, where proenvironmental attitudes do not correspond with the observed behavior (12). One approach to address this gap has been to build models in which intentions intervene between attitudes and behaviors. In this vein, the theory of reasoned action described individual beliefs and attitudes as antecedents to behavior (23). Yet in applications of this theory, beliefs and attitudes are typically represented as static and, as in the rational actor model, socially isolated from other consumers (24). Subsequently, the theory of planned behavior included the influence of values and more social concepts, including norms (25). Still, the individual consumer remains the unit of analysis, and even the theory of planned behavior offers little explanation of

Diffusion: the one-way, person-to-person sharing of functional information across social groups

Conformity: when behavior is influenced by perceptions of what others are doing or feeling, e.g., collective action

Dissemination: the efforts of organized, resourceful social groups that are motivated to promote societal goods, e.g., collective action

Translation: the social negotiation of the meaning and benefits of a new technology or behavior, e.g., social construction of technology (SCOT)

Reflexivity: the dynamic, continuous, self-aware process of defining and expressing oneself, guided by one’s efforts toward a sense of order, direction, and development
Social norms: perceptions of what behaviors are typical of others (descriptive) or what behaviors are approved by others (injunctive)

EV: electric vehicle
HEV: hybrid-electric vehicle
PHEV: plug-in hybrid electric vehicle

the origins and dynamics of these individuals’ attitudes and values or of the social norms to which they may ascribe.

In contrast to a focus on the individual, social models of behavior explicitly represent the social embeddedness of consumer behavior and decision making (7, 13). Consumer behavior is seen to be both a manifestation and reflection of social relations and obligations, where individuals engage in behavior as part of the social units to which they belong, e.g., family, household, community, workplace, or other social network (12). For example, symbolic interactionism describes how consumers assign meaning to objects and behavior, and these meanings are tested and revised within and among different social groups over time (26). Giddens’ (27) structuration approach posits an ongoing, iterative relationship between individual behavior (agency) and the social and institutional context (structure) for that behavior. The preferences, attitudes, and values of an individual are not represented as existing in a social vacuum but rather in a social context that is itself influenced by the behaviors and interactions of its members (24).

We suggest that a policy-relevant perspective on low-carbon purchases and practices requires multiple viewpoints, considering the individual, household, and relevant social systems, such as previous adopters of the low-carbon product or practice, observers, manufacturers, media, interest groups, and governments. Furthermore, the individual and relevant social system are inherently dynamic and change under a variety of conditions, including consideration, adoption, and use of a low-carbon product.

Here, we focus on processes of interpersonal influence between individuals and small social groups (e.g., families, friends, and coworkers) and do not explicitly address the broader aspects of social influence [e.g., the dynamics of societal institutions (27), the roles of infrastructure, and systems of provision (24)] or the importance of technological regimes and processes of lock in (28, 29). We leave these institutional considerations to future research.

3. CONSUMER PERCEPTIONS OF LOW-CARBON BEHAVIOR

Consumers may perceive new low-carbon products and behaviors as complex and as being made up of new levels of familiar attributes as well as new attributes. Consider the case of electric-drive vehicles—a low-carbon technology we use to illustrate several concepts in this review. These vehicles include pure electric vehicles (EVs) powered only by electricity from the grid; hybrid-electric vehicles (HEVs) fueled only by gasoline, but using a small electric motor and battery to improve fuel economy; and plug-in hybrid electric vehicles (PHEVs) that combine aspects of the EV and HEV, potentially operating like an EV for a limited distance, with the addition of a gasoline engine to extend driving range and increase power.

The previous sentence defines electric-drive vehicles according to their functional, technological characteristics in comparison to conventional internal combustion vehicles. Analysts often assess the likelihood of market success purely on the basis of these technology (and cost) components (17, 30–32), following the notion that a more technically discontinuous product with dramatically different attributes and higher initial costs than the incumbent technology, i.e., EVs, will be less successful than a relatively more continuous product, i.e., HEVs (33, 34).

Consumer perceptions may not easily—or solely—map onto these technical, functional descriptions. Consumer behavior vis-à-vis such new products can be related to a paradigm shift in the consumers’ beliefs, perceptions, values, and lifestyles (35) as these relate to any technological or functional change. Drawing from a review of theoretical and empirical literature, we conceptualize the perceived attributes of a new low-carbon technology according to two dimensions: functional/symbolic and private/societal (Table 1). In other words, we categorize the consumers’ perceptions of a low-carbon product or practice according to (a) functional or symbolic benefits and (b) how these benefits relate to the individual or society.
Table 1  Typology and examples of consumers’ perceptions of the attributes of a product or practice

<table>
<thead>
<tr>
<th>Benefit</th>
<th>Functional attributes</th>
<th>Symbolic attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private</td>
<td>Mobility/accessibility</td>
<td>Express self-identity</td>
</tr>
<tr>
<td></td>
<td>Save money</td>
<td>Convey status</td>
</tr>
<tr>
<td></td>
<td>Reliable</td>
<td>Attain group membership</td>
</tr>
<tr>
<td>Societal</td>
<td>Reduce air pollution</td>
<td>Inspire other consumers</td>
</tr>
<tr>
<td></td>
<td>Reduce global warming</td>
<td>Send message to manufacturers,</td>
</tr>
<tr>
<td></td>
<td>Reduce oil use</td>
<td>government, energy companies</td>
</tr>
</tbody>
</table>

Adapted from Axsen & Kurani (109).

more broadly. As described below, consumers may perceive attributes as more than one of these types for a given product or practice.

3.1. The Functional/Symbolic Dimension: What It Does and Represents

The functional/symbolic dimension distinguishes between what the consumer perceives the product or behavior does and what it represents, respectively. Hirschman (36) explains that functional attributes are tangible, whereas symbolic attributes are intangible but communicate a social meaning, such as sexiness, membership, or status. Symbolic attributes are valued according to fundamentally different processes than functional attributes. Hirschman describes both functional and symbolic attributes as being important for goods, e.g., automobiles, though perhaps in different ways. Her proposal is supported by empirical research on motor vehicles (37, 38), which have been a symbol of wealth, freedom, and leisure in American culture since their introduction in the late nineteenth century (39). Furthermore, Heffner et al. (40) discovered that symbolism played an important role in HEV buyers’ purchase decisions. Participants described their HEVs as representing both widely shared denotations, including “preserving the environment” and “embracing new technology,” as well as more personal connotations, including ethics and individuality. In Table 1, function denotes attributes including the basic services of accessibility and mobility provided by an automobile and the incremental fuel savings provided by an electric-drive vehicle; the symbolic dimension includes less tangible attributes, including the owner’s desire to express a certain value or meaning. As an example of an ongoing practice, an individual who bicycles to reduce her motor vehicle usage may gain the functional benefits of saving money on gasoline and vehicle maintenance and experience symbolic benefits by sending a message to coworkers and observers that she is a fit, active person who cares about the environment.

3.2. The Private/Societal Dimension: Whom It Benefits

The second dimension in Table 1, private/societal, provides a clear distinction between electric-drive and conventional vehicles. Green (41) describes a private good as fully purchased and consumed by the individual, where benefits are excludable. A public (or prosocietal) good is characterized by collective payment and nonexclusive benefits; common examples include air quality and biodiversity. Canzler (42) asserts that automobiles have been perceived as primarily private goods, dating back to the early “race-travel-limousine” vision, where vehicle demand was driven by goals of luxury and prestigious racing. Low-carbon vehicles may diverge from this private good vision given their potential to produce prosocietal benefits. Thus, low-carbon vehicles (and low-carbon practices more generally) can be associated with...
public welfare, leading Brown (43) to classify EV technology as a mixed good with aspects of a private and a prosocietal good. In other words, the emergence of low-carbon behaviors may not just be an extension to the private benefits associated with incumbent behaviors but could represent a new vision of consumption that benefits individuals and society.

3.3. How Perceptions Change
Behavioral models must also account for dynamics in consumer perceptions of functional, symbolic, private, and societal attributes. For an emerging technology, attributes and perceptions relating to any quadrant of Table 1 may change and may do so quickly. Functional attributes of electric-drive vehicles change with advances in battery, motor, electronics, and materials technology. Current symbolic associations may evolve, solidify, or disappear, and new meanings may be added (44). Also, perceptions of prosocietal benefits are debated and negotiated along with health and emissions research, government regulation, and mobilization by interest groups (45, 46)—as observed with EVs in the 1990s (47) and HEVs in the 2000s (48). Thus, a behavioral perspective on low-carbon consumption should represent how such dynamics affect, and are affected by, the consumption behavior in a social context.

4. PERSPECTIVES OF INTERPERSONAL INFLUENCE AND LOW-CARBON BEHAVIOR
In light of the complexity of human perceptions, we review the literature from several areas, which we organize into five different perspectives on social influence. One goal is to help synthesize research from a variety of disciplines; Manski (8) explains that social influence terminology is typically extracted from sociology and social psychology and often loosely defined, sometimes interchangeably, with such terms as peer influence, imitation, epidemics, herd behavior, neighborhood effects, bandwagons and social norms, each representing similar concepts. We attempt to mitigate such confusion by precisely defining and comparing perspectives that describe five different processes of interpersonal influence: diffusion, conformity, dissemination, translation, and reflexivity. For example, the diffusion perspective focuses on one particular process of interpersonal influence: the person-to-person spread of information among consumers. In contrast, the conformity perspective views interpersonal influence as occurring through a consumer’s perceptions of how many other people have already taken an action. The spread of information is a different process than the perceiving of others’ behavior (though there can be some overlap).

Thus, each perspective sees interpersonal influence as occurring through different processes. We select and characterize these five perspectives on the basis of an extensive, interdisciplinary literature review, including theory and empirical research from sociology, social psychology, behavioral economics, marketing, health sciences, and other sources. We do not contend that these perspectives are exhaustive or mutually exclusive, but this categorization provides a useful starting point to conceptualize and guide meaningful dialogue within and between disciplines. Furthermore, although we presently apply these perspectives to low-carbon products and practices, in some cases application could be extended to a wide variety of prosocietal contexts, such as policy support, and potentially even to some private contexts.

As a result of the literature review, we pose five questions—inspired in part by Bruun & Hukkinen (49)—to distinguish the five perspectives. These questions address the ability of each perspective to explain the attribute categories identified in Table 1, the scope of the social system, the representation of behavioral dynamics, and the motivations for interpersonal influence and consumer behavior:

1. What is the new product or behavior? Is it viewed as static or dynamic? What types of attributes are perceived (Table 1)?
2. What are the system boundaries (social system, etc.)?
3. What individuals or groups adopt the new product or practice earlier and why?
4. What individuals or groups adopt later and why?
5. What interpersonal process is described as moving the product or practice from earlier to later adopters?

Following a discussion of each perspective, a summary of the five perspectives and their answers to these questions is presented in Table 2 at the end of Section 5. The remainder of this section summarizes each perspective and some recent applications. A succinct critique of each perspective is presented in Section 5.

4.1. Diffusion: Interpersonal Communication

The diffusion perspective describes interpersonal influence as the flow of information among individuals. The term diffusion is borrowed from physics and refers to the movements of a substance from areas of higher to lower concentration. An alternative process is contagion, a term borrowed from epidemiological studies of how diseases spread. In general, diffusion includes any approach to interpersonal influence that focuses on the effect of information flow. Here, we address four prevalent approaches to the diffusion of new products and behaviors throughout populations: diffusion of innovations (DOI), the Bass model, spatial diffusion, and social network analysis (SNA).

4.1.1. Diffusion of innovations. Rogers (50) characterizes diffusion as the process of communicating information about a new product or behavior, i.e., the innovation, through a social system. The innovation itself is an idea, behavior, or product that is perceived by members of the social system as being new (50). Discussions and applications of DOI often conflate diffusion with adoption. We distinguish the two: Adoption is the uptake of a novel practice or product; diffusion is the movement of information regarding the practice or product throughout the social system.

The relevant social system is a set of individuals that interact in pursuit of a common objective (50). In place of social systems, Moore’s (51) business-oriented version of DOI speaks of markets made up of potential customers with similar needs who reference one another. In both cases, the individuals or potential buyers are divided into adopter categories based on the empirical observation of adoption rates following a bell curve over time. The first to adopt are labeled innovators: individuals characterized as obsessively venturesome, progressive, cosmopolite, usually with a love of technology (especially in cases of markets for new products), with above average education and socioeconomic status (50). Next are early adopters, characterized as visionaries who use extensive social networks to diffuse information about the innovation to the majority of the social group or market that has yet to adopt the innovation. This diffusion is taken to be instrumental in later adoption by groups labeled (in time order) early majority, late majority, and, finally, laggards. Innovators and early adopters are taken to be more interested in the functions of the innovations, and later adopters are taken to be influenced by peer pressure and economic necessity. Tautologically, adopter categories are also defined according to the trait of innovativeness: the degree to which an individual tends to be earlier in adopting new ideas relative to their social system (50).

DOI hypothesizes that interpersonal influence is accomplished through communication, ranging from one-to-one exchanges to mass media. Rogers (50) classifies information into two types: (a) knowledge (which includes basic awareness of the innovation’s existence, how it can be used, and potentially its underlying principles) and (b) persuasion (which the persuaded individual uses to form attitudes about the overall value of adoption). Both types of information are thought to flow through the social system starting from innovators and moving first between them and then to later adopter categories. Early adopters are believed to play an important role as gatekeepers
<table>
<thead>
<tr>
<th>Perspective concepts</th>
<th>Diffusion</th>
<th>Conformity</th>
<th>Dissemination</th>
<th>Translation</th>
<th>Reflexivity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Diffusion of innovations</td>
<td>Social networks</td>
<td>Thresholds</td>
<td>Critical mass</td>
<td>Social construction</td>
</tr>
<tr>
<td>What is the new thing? (Static or dynamic?)</td>
<td>Innovation (static)</td>
<td>Innovation (static)</td>
<td>Behavior (static)</td>
<td>Collective good (static)</td>
<td>Artifact (dynamic)</td>
</tr>
<tr>
<td>System boundaries? (Static or dynamic?)</td>
<td>Social system of potential adopters (static)</td>
<td>Social network, typically a bounded community (static)</td>
<td>Relevant social group (static)</td>
<td>Social system, and critical mass within it (static)</td>
<td>Relevant social groups: consumers, organizations, government, etc. (dynamic)</td>
</tr>
<tr>
<td>Who adopts first?</td>
<td>Innovators, then early adopters</td>
<td>The most connected individuals, opinion leaders</td>
<td>Instigators</td>
<td>Organizers</td>
<td>Social groups that perceive artifact as a solution to a problem</td>
</tr>
<tr>
<td>Why?</td>
<td>Higher innovativeness</td>
<td>More likely to receive information</td>
<td>Low threshold for action</td>
<td>High interest and resources</td>
<td>Interpretation of solution</td>
</tr>
<tr>
<td>Who adopts later?</td>
<td>Imitators; early to late majority, laggards</td>
<td>Less connected individuals</td>
<td>Conservatives</td>
<td>Nonorganizers</td>
<td>Social groups that later reinterpret problems or solutions</td>
</tr>
<tr>
<td>Why?</td>
<td>Lower innovativeness</td>
<td>Less likely to receive information</td>
<td>High threshold for action, social norms, social learning</td>
<td>Efforts of organizers and those accelerating the production function</td>
<td>Closure</td>
</tr>
<tr>
<td>What drives social influence?</td>
<td>Diffusion: interpersonal communication</td>
<td>Diffusion: interpersonal communication</td>
<td>Conformity: motivation to mimic, learn from, or join others</td>
<td>Dissemination: willingness of organizers to achieve social good</td>
<td>Interpretation: perceived ability of innovation to solve a problem</td>
</tr>
<tr>
<td>Best applied to what types of attributes? (Table 1)</td>
<td>Private functional</td>
<td>Private functional</td>
<td>Symbolic (private and societal)</td>
<td>Societal (functional and symbolic)</td>
<td>All</td>
</tr>
</tbody>
</table>
between technology-loving innovators and the more financially oriented majority (51).

Both types of information—knowledge and persuasion—emphasize a functional view of the innovation. Consider the case of electric-drive vehicles; the targeted social system would be some subset of the market for motor vehicles. Researchers viewing the diffusion of, say, HEVs from the DOI perspective look to new car buyers with higher education and socioeconomic status (52, 53), perhaps with a history of being the first to buy new products. The motives of the first HEV buyers are explained as a general love of technology, along with their willingness and resources to pay a premium to be the first to own and try a new product. After gaining experience with this technology, it would be argued that these innovators diffuse knowledge and persuasion to their social networks. The early adopters influenced by this diffusion may then envision HEVs as having mass-market appeal and, through their channels of influence, accelerate the diffusion of positive HEV information to stimulate further demand.

Referring to Table 1, DOI focuses on the private functional attributes of a new product and may be inappropriate for describing new products characterized by symbolic attributes (36). Furthermore, DOI infers that these private functional attributes remain static throughout the relevant time frame—neglecting the potential for substantial change over time, such as improvements to vehicle performance, fuel savings, and variety of available designs.

4.1.2. The Bass model. Working from initial formulations of the DOI approach, Bass (54) constructed a simple quantitative model of diffusion that separates adopters into two categories: innovators and imitators. The Bass model has been applied to consumer demand for a wide variety of new products, including low-carbon technology. Examples include the diffusion of wind power in India (55); the uptake of photovoltaic systems (56, 57); purchase of hybrids in Japan (58) and Switzerland (52); and anticipation of future demand for biofuel, natural gas, and hybrid vehicles in the United States (59). Such applications include technologies adopted by consumers, organizations, and governments—sometimes without making a clear distinction or commenting on the suitability of using the same modeling assumptions and adopter categories for very different technologies, contexts, and types of actors.

4.1.3. Spatial diffusion. Another branch of diffusion represents information sharing and innovation uptake as a spatial process, relating to the work of Hägerstrand (60) and Pred (61). That is, the flow of information is a function of physical proximity among adopters and potential adopters. Recent applications have utilized spatial techniques to analyze the diffusion of low-carbon technologies, such as efficient residential heating, ventilation and air-conditioning systems (62), cycling (63, 64), hybrid vehicles, and Leadership in Energy and Environmental Design (LEED)-certified buildings (65). Such studies look for spatial clusters of related adoption behavior over time, which analysts explain according to neighborhood characteristics, including income, race, and political party support. However, the identification of low-carbon clusters does not necessarily reveal insight into behavioral or social processes, and it can be difficult to infer causality. For example, a correlation between residence in a proenvironmental community and engagement in proenvironmental travel behavior may result from self-selection in residence location choice, contextual factors, or social influence among neighbors (66), although methods are being developed to tease out such social network or social interaction effects (64, 67, 68).

4.1.4. Social network analysis. Instead of focusing on the characteristics of individuals as in DOI, SNA looks at how the structure of relationships between individuals influences diffusion processes (69, 70). In SNA, the timing of adoption is primarily determined by the connectedness of individuals to other individuals in the network more than the innovativeness of any one individual. Individuals
Comparing network structures. Although both networks A and B have the same linkage density, i.e., the number of effective links divided by the number of potential links, if all else is held constant, including the quality of the links, the diffusion of information is hypothesized to be more rapid and complete in network B. Reprinted with permission from SAGE Publications, Degenne & Forse (69).

Social learning: the process of learning from the outcomes of others’ actions to increase personal benefits

with many relationships (social ties) are more likely to adopt earlier (71); here, there is some correspondence with the notion of innovator “cosmopolitaness” from DOI.

If a social system is made up of every actor in a relevant group, the social network is a precise representation of the patterns or structures of interpersonal communication within the system determined by factors such as who talks to whom (72). Figure 1 illustrates the potential influence of social structure on diffusion patterns (69).

Notice the particular importance of the connection between individuals 4 and 5 in network A: If this linkage is blocked, further diffusion of information between 4 and 6, 7, or 8 is not possible. Granovetter (73) discusses the importance of this phenomenon in social networks, where the existence of weak ties—interpersonal connections scoring low in time, intimacy, and reciprocity—are more likely to serve as links (or blocks) between otherwise distinct clusters within a larger network and can do more to create cohesion in an extended social network than a prevalence of strong ties.

SNA has been applied to studies of travel behavior (74, 75), particularly the exploration of how social activities impact travel planning (76, 77). Furthermore, some recent agent-based modeling studies represent SNA concepts, including models of energy use and neighbor influence under different GHG policies (78) and energy savings behavior within an ecovillage context (79).

4.2. Conformity: Thresholds, Social Learning, and Norms

Conformity sees interpersonal influence as occurring through an individual’s perceptions of what others are doing or expecting. Conformity includes applications of threshold modeling, social learning theory, and social norm research, which we address below. Conformity does not address specific processes of communication or social interactions but may provide concepts and language to help understand adoption decisions in social contexts and, potentially, the formation of symbolic values.

Strang & Soule (80) describe threshold models as breaking with the concept of “direct contagion” (or diffusion) to represent an individual’s behavior as a function of the perceived presence (or absence) of previous adopters in the individual’s social system. Granovetter (81) illustrates conformity with his classic threshold model of rioting behavior. The system boundary or relevant social group for his example is a crowd of individuals in a particular space—say a sporting event or city street. The successive adoption of rioting behavior is determined by the distribution of individuals’ thresholds, defined as the proportion of fellow crowd members that must engage in the rioting behavior before a particular individual will join. The first rioters, i.e., instigators, have relatively low thresholds; conservatives riot later (or not at all) owing to their higher thresholds. Granovetter simulates how different distributions of thresholds across the crowd can significantly influence the overall outcome, often in counterintuitive ways, concluding that the behavioral outcomes can be highly influenced by the variations of thresholds within the group (81).

The threshold approach has also been used to explore patterns of innovation adoption within a social network. Valente (82) describes a simple model where an individual’s adoption is determined by their personal network exposure—the percentage of individuals in their personal network that have already adopted the innovation. Figure 2 demonstrates three different hypothetical individuals (A, B
Figure 2

Personal network exposure from direct contacts. A, B, and C are three different hypothetical individuals with varying levels of personal network exposure; an individual would be most likely to adopt with higher personal network exposure. Adapted from Valente (82); permission granted by Cambridge University Press.

Plausible mechanisms can be drawn from two related research areas. First, Bandura’s (85, 86) social learning theory is based on the same premise as threshold models; however, the driving force is less mimicry than a process of learning from the outcomes of others’ actions to increase personal benefits (87). In other words, the individual’s threshold is based on her ability to glean useful information from the behavior of the group. Social learning (or inferential learning) concepts have been applied to investigations of public participation in discussions regarding sustainable energy systems in Austria, England, and Spain (88) and hybrid vehicle adoption in the United States (89).

Second, social norm theory (90) describes two classes of norms: Descriptive norms are perceptions of what behaviors are typical, and injunctive norms are perceptions of what behaviors are approved (or disapproved). Cialdini (90) asserts that both types of norms can pressure individuals to conform to certain behaviors. Schultz et al. (91) applied this concept to household energy conservation, confirming that an injunctive message (conveying approval or disapproval) more consistently stimulated energy conservation behavior than did a descriptive message (conveying low or high energy use).
Critical mass: a group with high interest and access to resources that is willing to actively induce widespread uptake of a prosocietal product or practice.

Conformity may occur in the context of low-carbon technology in several ways. Again, consider the case of HEVs. A car buyer may want to see a certain number of HEVs on the road or purchased by friends and acquaintances before they are willing to buy one themselves. A social learning explanation would be that others’ behaviors serve as an indicator, where higher incidence of other HEV buyers is evidence of superior technical performance, reliability, realized fuel savings, or other attributes of importance to the car buyer in question. Threshold effects may occur within more specialized groups, e.g., an individual wants to see a certain percentage of fellow environmentalists adopt before he or she is convinced of the societal benefits of HEVs. The social norms perspective suggests that frequency information could be used to infer a trend in HEV adoption (a descriptive norm) or to interpret that HEV adoption is becoming socially desirable (an injunctive norm).

A promising, though as of yet unexplored, application of threshold processes is the formation and dynamics of perceived symbolic attributes. To establish that an innovation conveys a particular meaning, a certain threshold of prior adopters may be required. In other words, even if individuals believe an HEV is environmentally friendly, they might buy an HEV only after this belief is widely, or sufficiently, shared among their social group as demonstrated by others’ HEV purchases.

4.3. Dissemination: Collective Action and Critical Mass

Rogers (50, p. 6) defines dissemination as “diffusion that is directed and managed.” We relate dissemination to processes of collective action and critical mass, which apply specifically to products and behaviors offering prosocietal benefits. In an individual-centric world, we might expect prosocietal goods and behaviors to be underprovided and underadopted. For example, why would an individual buy an HEV to reduce environmental pollution when another buyer can purchase a large, conventionally fueled—and to the point, high-carbon emitting—sport-utility vehicle and still benefit from the HEV buyers’ emissions reductions? However, the idea of collective action states that individuals do not act in isolation. In most situations, people are aware of others’ actions, and social relations make influence and sanctions possible (92). In short, motivated individuals can interact and collaborate to provide prosocietal goods that would not be otherwise provided among self-interested individuals acting in isolation. Oliver et al. (93) categorize societal goods according to the shape of the production function of marginal returns, which can be, for example, decelerating or accelerating.

The challenge of collective action is to organize a small subset of the population that is sufficiently interested in the low-carbon technology or behavior to contribute sustained time, money, and/or effort to encourage other consumers to adopt also (93). This initial group is the critical mass: a group of individuals with high levels of interest and access to resources who are willing to set up the conditions to sustain more widespread action (93). From a dissemination perspective, those first to buy the new product or take up the new behavior are part of a critical mass whose members tend to have extraordinarily high interest in the behavior and above average access to resources, including income (93). Note that the concept of critical mass is often inappropriately conflated with the terms threshold or tipping point; in the collective action approach, critical mass is not equated to a change in system equilibrium.

A collective action approach has been used to explore how environmental groups have shaped the development of wind energy (94), including social movement organizations, such as the Sierra Club, the Audubon Society, and the Union of Concerned Scientists (95). Sine & Lee (95) describe how such groups helped to construct and disseminate cognitive frameworks, norms, and regulatory and social structures relating to wind power, thus facilitating private entrepreneurship and encouraging government support. The dissemination perspective has also been applied to the formation and
maintenance of a critical mass of supporters in community energy and sustainability programs (96, 97).

Critical mass theory has also been applied to private goods with prosocietal attributes. Markus (98) describes the initial challenges associated with high start-up network costs of interactive media, e.g., telephones and email, and susceptibility to later free-rider problems. Markus (98) highlights the importance of reciprocal interdependence, where one user's inputs depend on another user's outputs and vice versa. Potential buyers of low-carbon technology who are motivated by societal benefits may face similar barriers; reducing GHG emissions by an amount necessary to achieve climate stabilization cannot be achieved by an individual's consumption, but also relies on previous and subsequent decisions by others. Thus, when earlier HEV buyers generally faced higher private costs than did later buyers (as HEV prices dropped), additional sales were also spurred by the coordination among a critical mass of dedicated, resourceful low-carbon vehicle car buyers. This group acted not only through purchase of the particular vehicle technology, but also by testing, promoting, and assigning meanings and value to the vehicles. The critical mass may be formalized in some cases, but in many cases, it is a less formal network of loosely connected social groups.

In summary, the dissemination perspective conceptualizes efforts to coordinate the diffusion of information and adoption of behaviors with societal and symbolic attributes. A critical mass tries to create conditions to facilitate the widespread uptake of new behaviors that confer the societal benefits and convey the new meanings. The low-carbon technology movements and the critical masses that initiate and sustain them are likely to be less formalized than conventional applications of critical mass theory. However, the concepts and language provided by the dissemination perspective may be useful for further investigation of behaviors involving reciprocal interdependence among buyers in different time periods, such as for the purchase of low-carbon technologies.

4.4. Translation: Social Construction and Interpretation

What we are calling the translation perspective is drawn from the broader framework of sociotechnical systems (STS) in which technology and behavior are socially defined and interpreted by individuals—in part through social interaction (28), though applications of STS often don’t specifically address interpersonal influence. STS emphasizes the general importance of social structure and institutions in guiding technological development, transitions and adoption. STS has been applied to the framing and negotiating of environmental values and alternative technology (46); the social negotiation of ethanol in the United States (99); social barriers to and social shaping of renewable energy in the United States (100), the United Kingdom (101), and Papua New Guinea (102); as well as the adoption of efficient residential lighting (103) and plug-in EVs (104).

Two more formalized approaches to translation are social construction of technology (SCOT) and actor-network theory (ANT), although of the two only ANT formally uses the term translation. Taken together, SCOT and ANT provide a rich set of concepts and language to explore the development and adoption of new products as dynamic, socially defined “artifacts.” Clearly, SCOT is by definition focused on technology adoption rather than practices, but the translation perspective more generally holds implications for ongoing practices as well as purchase behavior.

4.4.1. Social construction of technology.

Rather than view adoption of an innovation as driven by individuals’ desires for a functionally advantageous technology, SCOT views technological change as a process of changing attitudes and understandings via ongoing social interaction (49). In SCOT, technology development can follow multiple pathways; the manifestation of a given pathway is affected by the changing problems and interpretations of relevant social groups (105). In other words, people and social groups negotiate and decide what a
new technology should do and should mean—what the SCOT theory labels as an interpretation. This negotiation of interpretations shapes the next iteration of technological development and potentially serves to develop a new market.

A newly introduced artifact—a term intended to emphasize the role of social processes in shaping the technology of interest—initially has a high degree of interpretive flexibility. People perceive a variety of different drawbacks and potential benefits. Different social groups may have differing interpretations of the product’s meaning and content, e.g., functional and symbolic benefits, as shown in Table 1, which aid or impede further development of the artifact along one or more pathways (105). These varying interpretations of the artifact are “socially and culturally embedded” in that individuals in a particular social group tend to develop a shared perception or “technological frame” (49). Through an ongoing negotiation of these interpretations within and between social groups, eventually the stages of interpretive flexibility (or controversy) reach a state of closure and stabilization, potentially reaching a single set of interpretations or perceived benefits (49). A general agreement emerges regarding the benefits of the technology and who should realize those benefits.

SCOT was originally developed to describe the design stages of a technology including engineering and manufacturing decisions (105). Kline & Pinch (106) extend SCOT to analyze the use of innovations, exploring the “reciprocal relationships between artifacts and social groups” and how social groups’ identities can be reformed and revised through use of the technology. Focusing on early automobile use among rural Americans, the authors illustrate how initially negative interpretations of automobiles were gradually overcome by positive interpretations that were both functional, e.g., providing stationary power assistance for farm tasks, and symbolic, e.g., reinforcing gender roles. In addition to demonstrating how different social groups shape the development of a technology, Kline & Pinch (106) highlight how development of the automobile also transformed social groups, increasing the connectivity of preexisting rural communities and facilitating new methods of reducing agricultural labor.

SCOT’s strength is in illustrating how interpretations by various social groups guide processes of technology development. Figure 3 is a prospective adaptation from Pinch & Bijker (105) that provides a diagram of the hypothetical development of electric-drive vehicles. The dominant vision of the race-travel-limo, i.e., vehicles as a luxurious private good as presented by Canzler (42), is represented in the gray hexagon, surrounded by several social groups with differing interpretations of what problems need to be solved. Many consumers may be concerned about high gasoline prices, whereas some environmentalists and governments target GHG emissions reductions. Vehicles with improved fuel economy emerge as a potential direction of development, consisting perhaps of smaller, more fuel-efficient vehicles using conventional gasoline engines. This solution solves one problem of consumers (fuel costs) and one problem of environmentalists and governments (GHG emissions). However, consumers also want to use automobiles for self-expression: They may interpret suitable self-expression as being unachievable by the smaller, cheaper, lower-power, higher fuel economy vehicles (107). In a different direction, prosocietal cars, e.g., lower carbon emitting electric-drive and hybrid vehicles, emerge as solutions that not only reduce fuel costs and GHG emissions, but also provide a visible, higher priced, technologically advanced symbol that meets the needs for self-expression of many consumers (40). If other social groups eventually formulate similarly positive interpretations of prosocietal cars, the overall interpretation of the prosocietal car as successor to the race-travel-limo could reach a state of interpretive closure. Thus, consumers would generally agree on the benefits offered by electric-drive vehicles, and widespread adoption would occur.

Brown (43) provides a further extension of SCOT, asserting that certain social groups can have particularly powerful influence over the
interpretations formed by other social groups. For instance, when the California Air Resources Board established the Zero Emission Vehicle (ZEV) Program in the early 1990s, clean air benefits were stressed as important criteria in the technological development of vehicles. Brown (43) argues that these statements and actions served to reopen the interpretive flexibility of the race-travel-limo vision of motor vehicles, prompting consumers to consider prosocietal attributes as an important concern in the purchase of motor vehicles (even though this consideration was quashed by later reframing of the policy). Thus, social groups that are not buyers, in this case a government agency, can also influence the interpretations of consumer groups. SCOT has been applied to other energy contexts, such as international discourse on the role of technology in sustainable development (108) but has only rarely been applied to specific cases of low-carbon technology (109).

4.4.2. **Actor-network theory.** Another branch of STS research is SCOT’s less tangible cousin: ANT (49, 110). The more abstract nature of ANT is its strength and weakness. Unlike SCOT, which conceptualizes a structure of roles and relationships among social groups and technologies, ANT provides a level playing field on which everything is an actor—people, groups, ideas, objects, and infrastructure. The only differences among

![Figure 3](image-url)

Figure 3
Illustration of relevant social groups, problems, and solutions in the development of the prosocietal car. Adapted from Pinch & Bijker’s (105) depiction of the penny-farthing bicycle; permission granted by SAGE Publications.
actors are the “methods and materials that they deploy to generate themselves” (111, p. 390); the relationship between actors can be very dynamic. Similar to later applications of SCOT, ANT asserts that technological change can influence social relations, just as the reverse is also true. The difference is that ANT also asserts that a social group can only be defined by its relationship to the technology and other actors: Every actor is defined by its interactions with other actors (112). SCOT states that technologies are socially defined with malleable interpretations, whereas ANT states that the entire network of actors (social, technical, and otherwise) is just as fluid.

The concept of translation is perhaps the greatest contribution of ANT to a discussion of interpersonal influence: Translation emphasizes that perceptions of artifacts change as a result of context and interactions among actors (113). Bruun & Hukkinen (49) define translation as the process of actors transforming themselves and redefining their identities and the identities of others. For some applications, translation may be a more accurate representation of how complex ideas spread among actors (such as social groups), similar to Blaut’s (114) concept of “crisscross diffusion” where reinvention is a continuous aspect of communication. For instance, information regarding a product’s symbolic and prosocietal attributes may be better described as translation, where interpretations of meaning are continually refined and negotiated among users and observers.

ANT also provides a less definitive concept of closure than SCOT. An innovation may have multiple interpretations, which are “mediated, translated, and even changed as time passes, being the product of domination, negotiation, and mutual adjustment” (110, p. 113). ANT presents the concepts of “alignment,” measuring the degree of agreement for a certain translation, and “coordination,” the restriction of interpretive flexibility by rules or conventions (115). Thus, although translations may occasionally align and coordinate through negotiations among social groups, these translations are always open to revision.

Callon (116) applies ANT to the case of EVs in France during the 1970s. He describes how Electricité de France’s (EDF) plan for EV deployment is a proposed actor world, a vision of the roles required by all relevant actors (depicted in Figure 4). For EDF’s vision to play out, consumers would have to be interested in buying the EVs, automakers would have to be willing to shift manufacturing efforts, governments would have to enact pro-EV legislation, and electrochemical batteries—another actor and network of further components—would have to perform adequately. In this sense, EDF is a spokesperson for the actor network, translating the roles and relationships among actors (116). In turn, any of these actors can reject such assigned roles and thus prevent EDF’s envisioned actor world from manifesting. The structure of each network may differ: Car buyers may include different social networks, governments include a hierarchical order of groups, and advanced batteries consist of specific components made up by still more specific components and organized by researchers.

For application to low-carbon products and practices, ANT provides flexibility. For instance, ANT allows for every item in Figure 4 to transform with the development and negotiation of prosocietal cars, including the technologies, social groups, problems, and solutions. For instance, the social groups are in part defined by their interpretations of motor vehicle technologies, and some interpretations of problems, e.g., GHGs, may not have emerged until after the presentation of their solution, e.g., prosocietal cars, for other reasons, e.g., air quality. The new interpretations of the problems in turn are translated to social groups that may contain some of the prior groups created around the air quality interpretation. The translations between social groups may stimulate an individual member of one group to reinterpret her own problems. The individual may then become part of a new social group of prosocietal car buyers whose existence results from the emergence of prosocietal cars, rather than preceding it.
Perhaps owing to its complexity and amorphous nature, to date ANT has only been applied to a few low-carbon contexts, such as the social translation of wind power in Europe (117) and residential energy behavior (118, 119).

4.5. Reflexivity: Lifestyle and Social Practices

The fifth perspective, which we call reflexivity, is drawn from Giddens' structuration approach (120). The context is modernity: a world Giddens describes as lacking the roles and expected behaviors previously enforced by tradition. Without tradition, individuals must actively create their self-identity as "a reflexive project." Reflexivity is defined as the dynamic, continuous self-awareness that requires and enables processes of self-definition and self-expression. An individual's behavior is guided in large part by this project to establish a sense of order, direction, and development for self-identity. As part of this project, individuals seek to create a lifestyle—a package of practices, including fashion, eating, and any other visible or symbolic display. Furthermore, an individual's self-concept and lifestyle practices are open to change if they are in a liminal state—characterized by "ambiguous and indeterminate attributes" (121). (Giddens' concept of reflexivity is more generally applied in his structuration approach to relations between and within institutions as well as between institutions and individuals. Here, we focus on reflexivity within and between people in this specific project of self-identity.)

For example, the purchase and use of a low-carbon technology may be one component, or trial, of the creation or extension of a proenvironmental or prosocietal lifestyle sector. The conspicuousness of some low-carbon technologies, e.g., the Toyota Prius HEV, which is...
overtly styled to be distinguishable from conventional North American cars, can facilitate reflexivity by prompting users and observers to share and negotiate interpretations. Observers may speculate as to the motivations and lifestyle choices of the HEV driver, assessing whether this practice might fit into their own trajectory of self-development. After purchase, the new users may solidify or modify their initial interpretations of the technology. Thus, similar to ANT, the technology or practice and its social context are subject to continuous uncertainty and revision of interpretations and meaning.

Giddens (120) explains that lifestyle sectors may be divided according to locales (e.g., home and workplace), relationships (e.g., marriage and friendship), and activities (e.g., work and recreation). Similarly, a given individual may construct several lifestyle sectors across different social groups, e.g., family, coworkers, and recreational friends. This concept of lifestyles helps explain why some individuals value and adopt low-carbon technology and others do not (122, 123). For example, if individuals negotiate sets of social practices across a wide spectrum of contexts, then it is possible that proenvironmental practices may not be consistent with some or all of their lifestyle sectors (124, 125). Moreover, given the wide variety of practices that can potentially be perceived as proenvironmental, people may incorporate different practices depending on their self-concept and their different lifestyle practices (124). Some individuals may separate low-carbon efforts in their residence from other lifestyle sectors such as holiday travel (126).

In one research stream, the reflexivity perspective was applied by EV researchers after discovering that car buyers did not reveal the stable preferences assumed by rational choice theory (127). These researchers then drew from Giddens and others to design an “interactive stated lifestyle-preference” technique to simulate decision making by allowing for education, learning, and interaction as part of the technology evaluation process (128, 129). These “constructive choice” principles were later applied to a US nationwide survey of potential PHEV buyers (109, 130). This approach demonstrates that sufficiently motivated households can create lifestyle sectors that incorporate novel electric-drive vehicle technologies—findings that have been validated by more recent studies of actual EV drivers (131–133).

Similarly, Axsen & Kurani (109) applied the reflexivity perspective to understand participant evaluations of PHEV technology in the context of interpersonal influence. Among those households that were sufficiently interested in shifting toward a proenvironmental lifestyle (and were sufficiently liminal or open to change), only those who found positive support through social interactions were willing to make such a lifestyle transition and came to value prosocial attributes of the PHEV. Thus, when participants talked about the PHEV, they not only shared functional information about the technology, they also negotiated different identities and lifestyles.

Social practice theory flows from, and to an extent critiques, the concepts of structuration and reflexivity. Social practice theory focuses on behaviors as fitting within different practices—the routinization of related bodily and mental activities (134, 135). Practices, such as the uptake and use of low-carbon technologies, are constructed and sustained by the individuals who participate (136), and, in a sense, normalize the practice. In social practice theory, the practice itself is the unit of analysis; the practice is socially constructed and reflexively refined. Individuals or social groups are just carriers of the practice (135). For example, the use of passenger vehicles has been argued to have become such an extensive, ingrained practice of autocentric behaviors and thoughts that the practice of vehicle use is a nearly imperceptible habit that nearly sustains itself (137). Social practice theory has also been applied to the study of how climate information can affect home energy use (138), the purchase of household appliances (139), and reliance on office air-conditioning (140), as well as proenvironmental behavior change (141) and sustainable consumption (142) more broadly.
Similar to the concept of lifestyle described above, individuals view behaviors as part of a coherent practice, not in isolation. However, in contrast to reflexivity, applications of social practice theory to date tend to neglect specific consideration of interpersonal interactions.

5. MOTIVATING SYNTHESIS: CRITIQUES OF THE FIVE PERSPECTIVES

The five perspectives we review span from those developed specifically to examine the spread of novel behaviors or products through a population, i.e., via DOI, to an explanation of the very meaning and mechanisms of modern society, i.e., reflexivity. We suggest that the dominant perspective, diffusion, is not conceptually equipped to explain the additional complexity of the spread of symbolic and prosocietal behaviors and also provides an incomplete representation of processes of social influence. To motivate our closing effort to initiate a synthesis, we review some critiques of the five perspectives to explore how the strengths of some may address the weaknesses of others.

5.1. Diffusion

Our exemplar of diffusion, DOI, has been subject to much criticism—including self-critiques by ardent supporters. A subset of critiques germane to the topic of interpersonal influence is summarized below:

- The concepts and language of DOI are subject to proinnovation bias because the approach has almost solely been applied in retrospective analyses of successful innovations (143, 144). Tests of hypotheses about the role of interpersonal influence (or anything else) would require the observation of settings in which an innovation can fail to spread throughout the relevant social group.

- Because most applications have been retrospective, DOI provides little insights as a predictive tool. One reason is that the size and characteristics of the relevant social group and description of the innovation in terms of knowledge and persuasion may be impossible to ascertain a priori. In the case of electric-drive vehicles, the market for automobiles is already deeply segmented by brand, model, body style, and lifestyle sectors. Automakers have learned that vehicles like EVs can confound their detailed consumer categories built upon the attributes of conventional vehicles; in the 1990s, a spokesperson for General Motors noted their EV1 electric coupe attracted interest from across all of their prior consumer categories.

- Conclusions about diffusion are vulnerable to errors of “dependent diffusion” where the diffusion of one product depends on another but is misread as independent, and “phantom diffusion” where adoption is thought to have been driven by the diffusion of information but was caused by other factors (114).

- By treating innovativeness as both an explanatory variable and observed outcome, DOI reduces underlying distinctions in motivations to try new products or behaviors to a tautology (145).

- Because innovativeness is likely to be a trait that changes throughout an individual’s lifetime and differs with respect to different innovations, it may be inappropriate to assign consumers to static categories (145).

- Information alone is not usually found to be influential particularly when compared to more sophisticated processes of social influence (109, 138), such as the translation and reflexivity perspectives discussed in this review, although information can be more influential when it directly addresses societal aspects of a product (146).

- Diffusion asserts that uptake of an innovation starts with some segment of innovators in a social system and diffuses unidirectionally to less innovative individuals and communities (114). Blaut (114) argues instead for the notion of “crisscross diffusion” in which new
products, ideas and uses can be “generated, transmitted and received” (p. 36) multidirectionally across all parts of a social system. Similarly, recent empirical research suggests that social influence regarding PHEVs can occur with different types of family, friends, casual acquaintances, and strangers, and the sources of influence regarding such a novel technology cannot be determined a priori (146).

Despite its more explicit focus on the relationships between people in a social network, SNA has been subject to many of the same general critiques as DOI, e.g., retrospective bias, exclusion of external factors, lack of theorizing consumers’ underlying motives, and focus on static private functional information and attributes. Furthermore, identifying the appropriate social network for analysis a priori proves challenging in practice because no single network serves all purposes (86). Owing to challenges of data collection, SNA has typically been used to study small and isolated or bounded communities, such as small-town farmers (82). See the sidebar Mapping Social Networks to Measure Interpersonal Influence for a summary of a method to map an individual’s social network. SNA is also vulnerable to spurious associations between adoption behavior and social proximity to other adopters. For example, Valente (82) explains that, although original analysis of medical innovation data from Coleman et al. (143) suggests the importance of social network influence, more recent reanalyses find no evidence of interpersonal influence playing a role once publicity, aggressive marketing, and other events external to the originally conceived network are accounted for (72, 147). Such misunderstandings can be described as phantom diffusion.

5.2. Conformity

Although diffusion lacks sophisticated explanations of different responses to new products and practices, conformity lacks explanations as to why distributions of thresholds exist across social groups. In particular, no explanation is offered for the low thresholds of instigators, who by definition act before the suggested mechanisms of social learning and social norms can play a role. Also, these thresholds are presumed to be static for the individual, without mechanisms for personal change or development. In addition, the conformity perspective does not explain the emergence of new behavior or innovations, where social norms come from, or how they can change. That said, the conformity perspective could potentially provide insights regarding novel products and practices with symbolic attributes.

5.3. Dissemination

Dissemination may help explain the motivations of some specific social groups to induce diffusion and conformity; however, it does
not otherwise explicitly address the fundamental critiques of those two perspectives. Social groups are also statically defined with little explanation as to why some individuals become part of the critical mass rather than the noncritical mass, which is the balance of the social system. Furthermore, dissemination is inherently limited to the prosocietal aspects of products and practices, with few applications to private goods. Given that low-carbon technologies, such as electric-drive vehicles, can be conceptualized as mixed goods (43), the dissemination approach alone does not provide a broad enough explanation.

5.4. Translation
Overall, SCOT is useful for conceptualizing the dynamics of innovation, identifying social groups that can guide development (including groups other than direct consumers of the product), and mapping the interplay between competing problems and interpretations (perceived benefits). However, SCOT alone is not sufficient to explore social influence and the purchase process; its origins in design stage applications make it less appropriate for the more complex problems of user groups and symbolic interpretations. Hannemyr (110) warns that the SCOT concept of closure is overly definitive; consumer perceptions may streamline at times but may not fully converge, and any convergence may only be temporary. Moreover, SCOT does not account for the processes of collective action in technological controversies or explain how the overall structure of social groups may be heavily influenced or even defined by the technology (49).

By contrast, ANT includes no causal theory of action (49) and cannot serve as a predictive model of adoption. However, taken as a supplement to the more rigid structure of SCOT, the concepts and language of ANT enhance the ability of the translation perspective to facilitate the discussion of social influence and adoption, including the roles of and relationships among multiple heterogeneous social groups and the dynamic, reciprocal relationships between all the actors involved, including the product or practice itself. The explicit incorporation of individual and group-based interpretations and translation can aid the investigation of products and practices with attributes in all of the Table 1 categories.

5.5. Reflexivity
What we have called the reflexivity perspective is not meant as a stand-alone approach to interpersonal influence and consumption behavior; processes of reflexivity are difficult to quantify or to generalize beyond a particular empirical context. The perspective does not address specific instances of social interactions and influence but instead describes the dynamics of the larger social system. Furthermore, Giddens’ framework has been critiqued as representing consumers as overly deliberative and conscious of relating their practices to self-identity, which may not apply to less conspicuous, more habitual behaviors (136).

However, reflexivity provides a theoretical framework to help guide and structure the other four perspectives. Lifestyle sectors are a dynamic and more theoretically elaborate version of the concept of a relevant social group introduced in other perspectives. DOI’s concept of innovativeness may relate to a particular lifestyle sector created by individuals who sustain narratives about themselves as being technologically advanced. The practices of this lifestyle sector include the purchase and use of new technologies. The instigator does not merely have a low threshold. She may be enacting a lifestyle sector in which she does not merely react to others but wishes to be part of making change visible to others. The critical mass groups described in the dissemination perspective may represent another lifestyle created by people who want to develop and portray themselves as environmentally aware, socially active individuals, including the practice of using low-carbon technology to establish positive interpretations of prosocietal benefits. The concept of reflexivity itself can be infused in SCOT and fully suffuses ANT.
5.6. Toward Synthesis

Table 2 presents a summary of how the five perspectives address the five questions posed at the beginning of Section 4. The bottom row highlights the types of product and practice attributes categorized in Table 1 that a given perspective may be designed or otherwise well suited to address. These perspectives are in some senses complementary; viewed together, each may yield particular insights into how interpersonal interactions influence the adoption of low-carbon products and practices. DOI is well suited to private functional attributes and the flow of functional information. Conformity has the potential for incorporating symbolic attributes and highlights how the behaviors of others can influence an individual’s interpretations of a behavior, as well as tendencies to observe or oppose existing social norms. Dissemination describes intentional efforts to promote the adoption of products and practices with prosocietal attributes, hypothesizing a role for an initial critical mass willing to accept high initial costs. Both the translation and reflexivity perspectives address all four types of attributes through the interpretations of individuals and social groups. Translation describes innovations as socially dynamic; interpretations are continuously redefined and renegotiated among social groups, which are themselves redefined and renegotiated. Reflexivity provides a theoretical framework for the underlying motivations to take up new practices and buy new products, describing the individual as a self-aware work in progress, continually searching for development and expression through lifestyle practices.

In our view, no single approach reviewed here seems adequate for the study of interpersonal influence in the context of prosocietal consumption and transitions to a low-carbon society. Each perspective observes different processes and holds different implications for policies and strategies to achieve low-carbon energy transitions, and no single approach seems adequate to characterize social influence in all contexts of low-carbon transitions.

6. IMPLICATIONS FOR CLIMATE POLICY

Different behavioral models hold different implications for policy analysis. Individualistic, rational actor models of behavior suggest two primary levers for policy makers to influence consumer behavior: changing cost (via financial incentives or disincentives) and providing functional information (e.g., cost, performance, and availability) about the product or behavior (7). The perspectives reviewed in this article point to the additional importance of social interactions and interpersonal influence, although there has been little application of interpersonal influence to climate policy design to date. As an example, some perspectives can view the government as another actor, where implemented policies are social interactions between the government and consumers (43). Careful consideration of how different policies and types of information and experiences influence consumption practices can help policy makers to better design policy, foresee its effects, and measure its impacts. In particular, policy makers might consider the different processes of diffusion, translation, and reflexivity.

For example, a publicity campaign can intentionally diffuse (or disseminate) awareness and functional information about low-carbon technologies. Policy makers might also disseminate this information through labeling standards or energy information Web sites. But diffusion is not the only process that influences behavior. Product labeling serves as one type of translation, whereby policy makers frame the low-carbon technology according to particular benefits, such as cost savings (a private benefit) or GHG emissions (a societal benefit). Other policies may also be intentionally (or unintentionally) translated by actors. A subsidy directly affects the price of a PHEV and may also help diffuse awareness about the technology. In addition, the subsidy may be variously translated by different groups to mean that PHEVs are (a) good for society, (b) expensive, (c) ineffective technologies that need government help to compete with conventional vehicles, or (d) a waste taxpayers’ money.
Furthermore, a government mandate can also reflexively contribute to social discourse about what kind of vehicles consumers should desire or at least what attributes of vehicles should be pertinent to consumers’ self-concepts, e.g., whether consumers should value private or societal benefits (43).

7. SUMMARY AND CONCLUSIONS

The intent of this review is to identify perspectives on interpersonal influence, illuminate key similarities and differences among these perspectives, and help mitigate the confusion from these different perspectives. We use purchases of new prosocietal products, e.g., buying a lower carbon-emitting vehicle, for most of our examples but also refer to the uptake of ongoing, low-carbon practices, e.g., cycling. We encourage researchers investigating the role of interpersonal influence in the adoption of low-carbon products and behaviors to be explicit in identifying the perspective or perspectives from which they view the problem and in explaining strengths and weaknesses of their approach.

We see many potential directions for future research. In addition to improving diffusion models, research could further explore the use of conformity models to explain symbolic benefits, as well as the role of dissemination processes that may be less formal than the organized social movements addressed by collective action and critical mass approaches. Although translation and reflexivity can effectively represent social dynamics over time, further research to investigate their potential for predictive applications and implications for climate policy may be fruitful.

Our review (summarized in Table 2) maps each perspective onto different types of attributes of a new technology; however, we do not necessarily suggest that each perspective should be independently applied to these different attributes. Such a patchwork of concepts and language might not be particularly useful or interesting. Instead, this discussion can be used as fodder for the construction of an integrative model of interpersonal influence and consumption that can address all the relevant attributes of prosocietal goods and consumption practices. A major lesson from the popularity of Rogers’ DOI model is that a simple, common language can enormously enhance the communicability and longevity of a research approach. Additional research should explore the validity and usefulness of each perspective in various technological, behavioral, regional, and cultural contexts, and perhaps develop alternative integrative models.

SUMMARY POINTS

1. Interpersonal influence is an important lever in the adoption of new low-carbon products and practices.

2. Five perspectives on interpersonal influence are reviewed: diffusion, conformity, dissemination, translation, and reflexivity. These perspectives differ in their conceptualization of consumer perceptions, e.g., the functional, symbolic, private, and societal attributes of new products and practices; system boundaries; and motivations for action. Researchers should explicitly identify the perspective(s) they are employing, explaining its strengths and weaknesses.

3. Diffusion describes interpersonal influence as the flow of primarily functional information along some gradient of individuals’ innovativeness through a social system. While describing changes in consumer awareness and adoption of an innovation, diffusion lacks a sophisticated theory of consumer behavior and is rarely applied to symbolic or prosocietal attributes.
4. Conformity represents interpersonal influence as occurring through an individual's perceptions of what others are doing or expecting but ignores specific social interactions and does not explain the emergence of new behaviors or norms.

5. Dissemination seeks to explain how motivated individuals interact and collaborate to provide societal benefits that would not have been provided otherwise but does not address innovations with private or mixed societal-private benefits.

6. Translation describes innovations as socially dynamic such that interpretations are continuously redefined and renegotiated among social groups, which are themselves redefined and renegotiated in relationship to the innovation and their ongoing translation of it. The translation perspective is behaviorally sophisticated but has rarely been applied to low-carbon technologies.

7. Reflexivity is dynamic, continuous awareness of one's self in relation to a life project to establish a sense of order, direction, and development for self-identity. It provides a theoretical framework for the underlying motives of interpersonal influence and adoption behavior.

8. These five perspectives form a complementary set; viewed together, each yields insights into how interpersonal interactions influence the adoption of low-carbon technologies, pointing toward the importance of developing an integrated framework.

FUTURE ISSUES

Research should undertake the following activities:

1. Construct and test integrated frameworks of different perspectives on social influence, generally and in the instance of low-carbon products and practices.

2. Explore the validity and usefulness of each of the five perspectives and integrate the frameworks in various technological, regional, economic, political, and cultural contexts.

3. Use an understanding of social influence to inform the design of effective climate change policy.

4. Investigate the application of the conformity perspective to the development of the symbolic attributes of low-carbon products and practices.

5. Develop the dissemination perspective to consider less formal manifestations of collective action and critical mass, such as hybrid and EV buyer groups.

6. Increasingly apply the translation and reflexivity perspectives to the adoption of low-carbon products and practices, with a particular focus on tangible, policy-relevant results.

7. Work to increase the behavioral sophistication of the diffusion perspective. In instances where appropriate, utilize the strengths of the perspective, such as its application to the flow of simple information across a social system.

8. More readily include social influence processes in models of transitions to a low-carbon society, and consider a wider set of prosocietal applications, including public acceptance of climate policies, e.g., carbon taxes and emissions standards.
DISCLOSURE STATEMENT

The authors are not aware of any affiliations, memberships, funding, or financial holdings that might be perceived as affecting the objectivity of this review.

ACKNOWLEDGMENTS

The authors thank the California Air Resources Board, the California Energy Commission, and the Social Sciences and Humanities Research Council of Canada. Thanks also to Dr. Thomas S. Turrentine for his thoughtful input, as well as to Drs. Daniel Sperling, Ashok Gadgil, and Diana Ürge-Vorsatz for advice in shaping this review article. We also acknowledge the useful comments provided by Drs. Erik Kjeang and Curran Crawford.

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Annual Review of Environment and Resources  
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