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ORIGINAL ARTICLE

Green roles at home: exploring the impact of household social dynamic processes on consumption at the food-energy-water (FEW) nexus

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Abstract

Capturing the social dynamic processes among household members that work to shape consumption patterns presents a complex problem for household resource conservation studies. To bridge the gap between the individual and household, we propose and test a series of quantitative measures that explore the underlying structure of household social dynamic processes through the lens of social practice theory. Based on previous qualitative research, we develop measures to test five distinct social dynamic processes that either encourage or deter pro-environmental action: enhancing, norming, preferring, constraining, and allocating. In a sample of households ($n = 120$) from suburban Midwestern USA, we find that positively framed social dynamic processes (enhancing and positive norming) positively predict variance in frequency of food-, energy-, and water-conserving pro-environmental actions. Pro-environmental orientation of the individual respondent, in turn, is positively associated with perception of positively framed dynamics. These findings suggest that social dynamic processes influence individual decision-making about household consumption, supporting previous research that illustrates consumption as embedded within the relationships that form residential life. We suggest ways forward for quantitative social science researchers to explore consumption through a practice-based approach that considers the influence of social institutions on emission-intensive lifestyles.

Keywords Sustainable consumption · Social practices · Household resource consumption · Food-energy-water nexus · Behavior change

Introduction

To significantly reduce emissions associated with global climate change on a short timescale, many scholars stress the importance of targeting greenhouse gas (GHG) intensive consumption at the residential scale, particularly among high-income individuals (Dietz et al. 2009; Nielsen et al. 2021). To this end, recent behavioral science research explores the social drivers of household consumption to facilitate sustainability transitions. This paper contributes to this body of research by exploring how social dynamic processes within the household influence household consumption at the food-energy-water (FEW) nexus. We focus on two central questions: (1) Can we measure the structure of household social dynamic processes quantitatively? and (2) Are perceived household social dynamic processes correlated with frequency of self-reported pro-environmental food, energy, and water actions?

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While other existing research on household dynamic processes primarily collects qualitative data to capture detailed snapshots of household life, we look quantitatively at the prevalence of specific social dynamic processes, as perceived by a main respondent, in a larger sample of households. We measure the household social dynamic processes of enhancing, norming, preferring, constraining, and allocating resource consumption behavior (characterized by Lytle et al. 2021) as they relate to household practices that require food, energy, and water use. Our analysis measures the impact of these social dynamic processes on the frequency of self-reported individual resource consumption actions of a main respondent. We find that social dynamic processes influence individual decision-making about household consumption, supporting previous research that conceptualizes consumption as embedded within the social relationships that shape residential life. By measuring the structure of household social dynamic processes and their influence on consumption, we aim to inform future interventions to curb household emissions.

Background

Responsible for 60% of direct and indirect global greenhouse gas emissions, household consumption plays a key role in climate mitigation efforts (Ivanova et al. 2016).[1] Globally, these emissions are concentrated among high socio-economic status (SES) people and countries, where behaviors of those in the global top 1% of income are linked to twice the amount of consumption-based emissions as those in the bottom 50% (Kartha et al. 2020; Nielsen et al. 2021). Much of these emissions are the byproduct of mundane, everyday activities embedded within infrastructural systems that rely on fossil fuel inputs, like producing and accessing hot water, transportation fuels, thermal comfort, food production, processing, and transport, and other activities associated with daily living (Valkonen et al. 2022; Lytle et al. 2022).[2] Recent estimates found that food systems, for example, are associated with a third of global anthropogenic GHG emissions (Crippa et al. 2021). These systems are further embedded within political-economic institutions that force cycles of economic expansion and increased consumption, setting in motion economic and ecological treadmills of production and consumption (Gould et al. 2015; Boucher 2016; Lorenzen 2018).

[1] Grappling with resource consumption is one piece of a dynamic puzzle required to mitigate global emissions. Interdiscpliary understandings of anthropogenic climate change highlight cultural, economic, geographic, historical, political, and social-structural factors as important drivers of and responses to climate change (Jorgenson et al. 2019).

The food-energy-water (FEW) nexus concept aims to capture a broader picture of household consumption, considering embedded energy and water use and capturing tensions and trade-offs between systems (Albrecht et al. 2018; Watkins et al. 2019). While household consumption change research aims to capture these systems, few intervention studies address all components of the nexus in an integrated way (Berman et al. 2019). Thus, exploring determinants of household consumption at the FEW nexus warrants further study. The following paragraphs (1) outline predominant approaches to household consumption research, (2) synthesize recent literature on household social norms as they relate to resource consumption, and (3) explore social practice literature in the context of household consumption, each motivating our research questions.

Social science research often accounts for GHG intensive household consumption behaviors through individualistic decision-making frameworks, framed by Shove (2010) as "ABC" models that explain consumption through individual attitude, behavior, and choice. Here, individual attitudes impact behavioral intentions, which, in theory, directly impact behavioral choice. While many of these predictors are correlated with actual or self-reported resource (often energy) consumption in recent studies (Berman Caggiano et al. 2021; Kumar et al. 2022), past and emerging research in environmental decision-making continues to find attitude-behavior and intention-behavior gaps (Kollmuss and Agyeman 2002; Nguyen et al. 2019; Farjam et al. 2019).

The ability of social norms, or "predominant behavioral pattern[s] within a group, supported by a shared understanding of acceptable actions and sustained through social interactions within that group," to support environmental behavior change has also been widely documented (Nyborg et al. 2016, p. 42; Constantino et al. 2022). Theories of normative conduct are often associated with the work of Cialdini et al. (1990), which identifies two types of norms: descriptive norms that characterize how common a behavior is perceived to be and injunctive norms that reflect social approval or disapproval. While social norms have been widely used to understand individual-level environmental attitudes and behaviors (see Keizer and Schultz (2018)), most studies examine norms with respect to reference groups outside of the household, like neighbors or peers. Examining norms within the household, Kleinschafer and Morrison (2014) identify various drivers of norms that shape energy use, including the role of a "champion" who encourages efficiency behavior and the passing down of intergenerational norms between parents and children. Others have found that adolescents' environmental decision-making was heavily influenced by family norms (Grønhøj and Thøgersen 2012). A comprehensive survey study that collected data from multiple household members found positive mental, physical, and life satisfaction impacts across household members in "greener" households that collectively engage in more pro-environmental behaviors (Netuveli and Watts 2020). Group behaviors, social influence, and norms among household members have much to reveal about opportunities for resource consumption shifts.

Despite these findings, existing research fails to address what Jorgensen et al. (2020) deem a level-of-analysis problem: household consumption studies typically apply theories that predict individual behavior to environmentally impactful actions that take place within households, which often consists of groups of people. While many psychological and economic theories are useful for exploring determinants of household behavior, applying individual-level theories to group-level phenomena "leads to erroneous empirical results and conclusions and, thereby, less-effective policy and management actions" (Jorgensen et al. 2020, p. 1). Lack of focus on the household as a socially constituted unit may also contribute to the often-cited gap between intention and action (Kennedy et al. 2009; Heberlein 2012). Jorgensen et al. (2020) conclude, "until appropriate household-level theories of resource consumption are developed, researchers are likely to continue to draw upon the wrong theories and develop incomplete or incorrect conclusions which, in turn, limit the effectiveness of household targeted resource management programs" (p. 2). Hargreaves and Middlemiss (2020) argue that the narrow focus on individual energy demand obscures energy use in places like homes, workplaces, and communities that predominantly feature complex webs of social relations. They identify, in a review of previous research, three types of significant social relationships that shape energy demand outside the home: those with family and friends, with agencies and communities and with social identities. Prevalent in the household context, relationships between friends and family impact energy demand in multiple ways including learning and shaping practices as well as sharing energy services and energy consumption advice. Hargreaves and Middlemiss (2020) argue, "it is through the enactment of these relations, for example, that people become socialized into particular ways of thinking about and using energy, and thus that cultural conventions with associated levels of service expectation become normalized or reinforced, stigmatized, and challenged" (p. 197).

Other strands of research, primarily qualitative, have documented various inter-household dynamics that appear to shape resource consumption. Beyond early family decision-making studies of the 1970's (see Holman and Burr 1980), researchers as far back as 2006 have called for increased focus on the household, following findings that family decision-making shapes practices around food, energy, water, waste, and transport (Grønhøj 2006). Bell et al. (2015) describe households as sites of negotiation between members in efforts to coordinate practices around resource consumption to minimize conflict. Through in-depth interviews, they uncover the complex impacts of social dynamics around gender, generation, and household change on electricity consumption. Similar processes serve to socialize children into the process of electricity consumption, shaping consciousness about resource use and behavior (Aguirre-Bielschowsky et al. 2018). Additionally, studies have explored the role of conflict, particularly around energy consumption. For example, Sintov et al. (2019) draw attention to conflicts around thermal comfort (adjusting thermostats) that drive household energy use, suggesting gendered differences in resident interactions with home energy technology, perceived control, and negotiation. Household thermal conflicts take place within a "socio-material environment" that includes both material factors like heating fuels and technologies and social factors like control, convenience, monitoring, and dependence (Sovacool et al. 2020).

To account for variance in decision-making that is not clearly shaped by individual attitudes and values, another body of work explores the infrastructural and social factors that shape consumption and pro-environmental behavior. Theories of social practice present one approach to studying consumption, framed as a series of everyday practices shaped by the relationships between people and material technologies (Shove et al. 2012; Bell et al. 2015). One understanding of practices characterizes them as "constellations of actions," with social life comprised of a wide range of practices (Schatzki 2002). Hargreaves (2011) attempts to integrate practice theory with the predominant focus on behavior, interpreting behavior change through a "practice lens," although Shove argues that practice theory, as put forth by Giddens (1984), is not behavioral. Shove's framework stands in contrast to that which focuses on behaviors themselves, which act as the building blocks of practices and are often studied in isolation from the context that practice theory affords. Understanding consumption as a collection of practices, Røpke (2009) suggests that theories of practice might shift blame away from the individual consumer and encourage the consideration of collective action for sustainability. Understanding consumption as a series of "practices" rather than "behaviors" broadens the subject of inquiry beyond the individual, acknowledging that external factors, including social dynamic processes, work to shape and reshape practices. To study social practices in their residential context, however, researchers typically use qualitative methods to capture nuance, details, and often, otherwise, unpredicted findings (Schelly 2016). The work presented here integrates theories of social practice with attitudinal variables and social normative theories more typically used in quantitative household consumption research (see Steg and Vlek 2009), offering a novel perspective. Furthermore, some scholars disagree on the value of attempting to integrate theories of practice with behavioral approaches—Shove labels the paradigms as different as "chalk and cheese" (Shove 2011). We

Table 1 Social dynamic processes influencing household consumption, adapted from Lytle et al. (2021)

Process	Description	Example quotation
Enhancing	Enhancing or supporting other members' efforts to be more sustainable	"I am trying to like vegetables. My wife loves them, she makes a lot of salads but I am not that fond of it, but I am trying to."
Norming	Internal family social norms insulate individual behaviors	"I have three other people in this family who like to sit in a tub or take a long hot shower. Can I talk them out of it?"
Constraining	Constraining or deterring other members' efforts to be more sustainable	"I don't think we need to wash the clothes as much as we do but my sister has a habit of just washing them."
Preferring	Individual preferences or requirements dictate group behavior	"My wife has allergies and you can't leave the window open."
Allocating	Decision-making or practices are allocated to another member of the household	"The easiest [thing we do to conserve resources at home], and this is going to sound goofy, is I do everybody's laundry."

posit, however, that this integration might more closely align with the practice of coating shredded cheese in cellulose to prevent clumping and increase consumer palatability. Even if the elements are not traditionally compatible, they may help bring new perspectives to a larger audience.

Motivated by the absence of social relations in household consumption studies, our research seeks to bridge this conceptual gap by understanding household behavior as embedded within residential life and shaped by social dynamic processes. This research aims to address the limitations associated with previous research that addresses environmentally significant household behaviors by incorporating insights from innovations in sociological research coming from theories of social practices and asks whether we can measure the impacts of and potential to change these practices quantitatively. Rather than measuring group-level behavior with individual-level theories, we ask: how do household-level social dynamic processes predict variation in individual behavior?

Acting as a starting point for our current research, Lytle et al. (2021) conducted a series of exploratory qualitative interviews ($n=44$) with residential dwellers in the Midwestern USA to further understand how household decision-making processes shape food, energy, and water consumption. These interviews revealed that in addition to being driven by individual attitudes or values, decisions about consumption were largely embedded within the dynamic of social relationships that constitute the household. Lytle et al. (2021) point to five social dynamic processes related to household consumption: enhancing, norming, constraining, preferring, and allocating (see Table 1). Enhancing occurs when certain members of the household support other members' efforts to engage in sustainable consumption, while constraining refers to the inverse, deterring other members' pro-environmental behavior. Norming (in the same vein as social norms described above, though not differentiated between descriptive and injunctive norms) represents the social cues within a household that work to enforce individual behaviors. Constraining occurs when some members deter other members' efforts to engage in sustainable consumption. Preferring indicates individual preferences or requirements that determine consumption patterns for the rest of the household. Allocating occurs when one member typically makes decisions for the entirety of the household (for example, food shopping might be allocated to one member of the household, while another exclusively waters the garden). Although Lytle et al. (2021) explain that norming can have both positive or negative consequences for sustainable resource consumption, this research considers only the positive aspects of norming that drive pro-environmental behaviors. This research sought to explore whether and to what extent these dynamic processes were present in a different sample of households. As this work utilizes the perceptions and self-reported behaviors of a single respondent in the household, our models contain variables across levels of analysis. In contrast to previous work, however, we examine variance in individual behavior through perceptions of household social relationships as opposed to solely individual level theories like values, personal norms, and attitude.

Research objectives

To address the gap in the literature that addresses quantitative approaches to uncovering household social dynamic processes, this research asks two central questions: (1) Can household social dynamic processes be measured quantitatively? (2) Are perceptions of household social dynamic processes correlated with frequency of individual self-reported pro-environmental food, energy, and water actions? In response to question 1, we hypothesize that these measures will structurally map onto qualitative findings, measuring five distinct dynamic processes. With regard to question 2, we hypothesize in line with qualitative findings that enhancing, norming, and allocating dynamics will predict positive variance in frequency of individual pro-environmental behaviors, while preferring and constraining will predict negative variance.

Methods

Participants and procedure

This research was conducted as part of a larger, multi-institutional, interdisciplinary study examining household food, energy, and water consumption and testing interventions to reduce climate and environmental impacts (FEWCON, NSF Grant # 1639342) among single-family homeowners in Lake County, IL in the Midwestern USA. Study participation requirements included continued residence in Lake County, internet connection, completion of web-based surveys tracking socio-demographic profiles and household composition, and sharing food, energy, and water consumption data with the research team. Participants were compensated monetarily using a graduated compensation scheme to encourage continued participation. Survey participants were given the option to refuse to answer questions or to withdraw from the study at any time without consequence. The study was reviewed and approved by the Rutgers University Institutional Review board in conjunction with review and approval from other participating universities' IRBs (Rutgers IRB # 2018002,308).

The study participants were recruited in late 2019 and early 2020 using multiple recruitment approaches, including direct e-mail invitation with addresses gleaned from publicly available online educational and government resources, requests on Lake County Facebook groups, in-person presentations to community groups, and the web-based Qualtrics survey tool panel. We then took a snowball approach, requesting volunteers to nominate additional participants they knew in the area. This mixed-methods approach to recruitment renders calculating a specific response rate unfeasible. With an initial enrollment of 404 participants in late January 2020, the number of participants dropped to 299 and 273 in the two-part enrollment surveys conducted in February–March 2020. Due to the emergence of the COVID-19 pandemic, the originally planned intervention testing study could not be carried out. Stay-at-home orders in the area were instituted on March 21, 2020 in response to the pandemic. Despite this, the team continued to administer monthly surveys for enrolled participants, beginning March–April 2020, shifting focus to study other aspects of consumption (the study concluded in August 2021). The research reported in this paper only uses data from households with more than one resident and for which survey responses to the variables of interest were completed for the initial enrollment survey (February–March 2020) and the third survey wave (June–July 2020) for a total of 120 participants. Although study protocol asked for one adult household member to consistently respond to surveys, it is not possible to confirm this was the case.

Table 2 Sample socio-demographic characteristics ($n = 120$)

Sex (%)	
0 = male; 1 = female	
Female	70.2
Age (%)[1]	
Under 25 years old	0
25–34 years old	13.3
35–44 years old	42.6
45–54 years old	27.3
55–64 years old	14.1
65 and older	2.7
Education level (%)	
Some college/associate degree	9.6
Bachelor's degree	28.1
Master's degree	47.4
Professional degree	2.6
Doctorate	12.3
Household income (%)	
Less than $74,999 k/year	16.7
$75–94,999 k/year	11.4
$95–114,999 k/year	17.5
$115–144,999 k/year	21.9
$145–199,999 k/year	21.9
$200 k/year or more	20.5
Political ideology (%)[2]	
Very conservative	0
Conservative	9.8
Moderate	39.2
Liberal	38.2
Very liberal	12.7
Number of household members	
Two	27.2
Three	24.6
Four	35.1
Five	9.6
Six	3.5
Children in household	
Yes	70.2
No	29.8

[1] missing value for age; age range of 26–69

[2] 12 missing values for political ideology.

Table 2 displays the socio-demographic profile of respondents including sex, age, education level, and political ideology of the respondent for the household as well as household income, number of household members, and presence of children in the household. The 2019 American Community Survey (ACS) reports 265,519 households in Lake County, IL and a population estimate of 696,535. These households contain approximately 165,842 children. The child dependency ratio is 38.9 (number of children aged 0–14 per 100 persons aged 15–64), lower than the US average of 59.1.

Females are overrepresented in our sample as main respondents (per ACS, 50.3% of the Lake County adult population identifies as female). We note that participants were asked “with which gender do you most identify?,” with options for female, male, non-binary/third gender, prefer to self-describe, and prefer not to answer. Respondents in this sample exclusively identified as male or female. The median age in Lake County is 38.7. The population median household income is $92,511 and mean income of $129,550. Thus, our sample overrepresents higher income households. A total of 45.3% of adults over 25 in Lake County have a bachelor’s degree, showing an overrepresentation of highly educated main respondents in our sample (US Census Bureau 2019).

Measures

Household dynamics

We developed the household dynamic process scales based on previous research (Lytle et al. 2021). We explored enhancing, norming, preferring, allocating, and constraining household dynamic processes relating to food, energy, and water use, utilizing responses to 18 items each measured with a seven-point agreement scale, ranging from 1 (strongly disagree) to 7 (strongly agree). We added measures for “enhancing” based on Kleinschafer and Morrison’s (2014) concept of a household “champion.”

- Some members of my household encourage other members not to waste food [enhancing].
- There is one member of our household who often takes the role of making sure we do not waste food [enhancing].
- Some members of my household hamper other members’ efforts to conserve food [constraining]. In our household, it is expected that we all make an effort to reduce food waste [norming].
- At least one member of our household prefers to eat red meat more often than other members [preferring].
- One member of our household primarily manages our food shopping [allocating].
- Some members of my household encourage other members to conserve energy [enhancing].
- There is one member of our household who often takes the role of making sure we do not waste energy [enhancing].
- Some members of my household hamper other members’ efforts to conserve energy [constraining].
- In our household, it is expected that we all make an effort to conserve energy [norming].
- At least one member of our household prefers to turn up the air conditioning/heating in the house more than other members [preferring].
- One member of our household primarily manages our energy bills [allocating].
- Some members of my household encourage other members to conserve water [enhancing].
- There is one member of our household who often takes the role of making sure we do not waste water [enhancing].
- Some members of my household hamper other members’ efforts to conserve water [constraining].
- In our household, it is expected that we all make an effort to conserve water [norming].
- At least one member of our household prefers to take long showers, using more water than other members [preferring].
- One member of our household primarily manages our water bills [allocating].

We did not collect responses for this scale from respondents that reported living alone. These constructs were measured in the third survey wave and appeared in three separate sections of the survey grouped as questions about food, energy, and water consumption (rather than organized by theorized household dynamics). The next section details the computation of factor scores for these measures.

New ecological paradigm (NEP)

We used a shortened, eight-item version of the new ecological paradigm (NEP) scale (Dunlap et al. 2000) to assess variance explained by individual pro-environmental orientation. This scale contains five items for which agreement indicates a pro-ecological view:

- When humans interfere with nature, it often produces disastrous consequences.
- The balance of nature is very delicate and easily upset.
- Humans are severely abusing the environment; if things continue on their present course, we will soon experience a major ecological catastrophe.
- Plants and animals have as much a right as humans to exist.

For three items, disagreement indicates a pro-ecological view:

- The so-called “ecological crisis” facing humankind has been greatly exaggerated.
- Humans have the right to modify the natural environment to suit their needs.
- Humans were meant to rule over the rest of nature.

Respondents indicated agreement with items on a 5-point scale, ranging from 1 (strongly disagree) to 5 (strongly agree). After reverse coding the second set of items, we computed a variable with the mean of the eight-item scale ($\alpha = 0.80$, $M = 3.92$, $SD = 0.72$).

Perceptions of resident environmental awareness

As NEP score was used to measure the pro-environmental orientation of the respondent, we used another variable to measure respondent perceptions of environmental awareness of other members in the household. As we only surveyed one household member for the duration of the study, we asked them to rate all other household members, including children, by asking "How environmentally aware would you say (name) is?" for each member of their household. Respondents answered for each of their household members on a four-point scale, ranging from 1 (not aware at all) to 4 (very aware). We computed a variable by taking the average of each household's scores ($M = 2.84$, $SD = 0.74$).

Pro-environmental FEW consumption

To measure pro-environmental food, energy, and water consumption, we asked respondents to indicate how often they undertake 20 different actions, measured on a seven-point scale, ranging from 1 (never) to 7 (always), with an option to indicate if an action was not applicable. We took the mean of respondents' scores to create a pro-environmental action frequency variable ($\alpha = 0.769$, $M = 4.41$, SD = 0.76).

Food actions included.

- Eating meals without any kind of animal meat ($M = 3.26$, SD = 1.47)
- Planning food preparation and portions carefully to avoid waste ($M = 4.82$, SD = 1.80)
- Eating meals without any kind of animal meat and without any kind of dairy (vegan) ($M = 2.36$, SD = 1.35)
- Eating leftovers ($M = 5.29$, SD = 1.63)
- Growing your own food ($M = 2.11$, SD = 1.3)
- Shopping from local farms or farmers' markets for food ($M = 2.54$, SD = 1.23)
- Talking to friends or family members about the impacts of our food choices ($M = 2.61$, SD = 1.48)

Energy actions included.

- Programming the thermostat ($M = 5.33$, SD = 2.15)
- Setting heat to a lower temperature in the winter ($M = 5.44$, SD = 1.93)
- Setting the air-conditioner to a higher temperature in the summer ($M = 5.26$, SD = 1.87)
- Drying clothes on a rack or line ($M = 2.97$, SD = 1.89)
- Turning off lights when I leave a room ($M = 6.20$, SD = 1.11)
- Washing clothes in cold water ($M = 4.85$, SD = 1.78)
- Talking to friends or family members about the impacts of our energy choices ($M = 2.99$, SD = 1.80)
- Turning off computers when not using ($M = 4.75$, SD = 2.20)
- Turning off televisions when not watching ($M = 6.23$, SD = 1.25)

Water actions included:

- Wearing clothes more than once ($M = 4.84$, SD = 1.76)
- Taking showers less than 5 min ($M = 3.79$, SD = 1.95)
- Running the dishwasher only when full ($M = 6.37$, SD = 0.97)
- Watering the lawn only when needed ($M = 6.45$, SD = 1.24)

Analysis

Data analysis was conducted with de-identified survey data using SPSS Statistics Version 27. Our results section organizes analysis by research objectives. To accomplish research objective 1, exploring the underlying structure of household dynamics, we used exploratory factor analysis (EFA). We used principal axis factoring with varimax rotation and Kaiser normalization in SPSS 27. To determine the appropriate number of factors, we considered eigenvalues greater than one, examined the scree plot, assessment, and interpretability of factors based on variance explained by each as well as the theoretical exploration of the analysis (Reise et al. 2000). Following the creation of factor scores, outlined below, we conducted a stepwise multiple linear regression to measure the effects of variables of interest on pro-environmental action and three additional multiple linear regression analyses to measure the effects of NEP score and perceived household environmental awareness score on the three different household dynamics constructs.

Results

Research objective 1: Exploratory factor analysis to determine quantitative household dynamic process measures

First, we used factor analysis to explore the underlying structure of the set of 18 household dynamic process scales. The model met the assumptions of independent sampling, normality, and linear relationships between pairs of variables (Costello and Osborne 2005). The Kaiser-Meyer Olkin measure of sampling adequacy was > 0.6 (KMO = 0.630) (Pallant 2010). Bartlett's test of sphericity was also significant ($\chi 2$ (153) = 900.418 $p < 0.001$) (Tobias and Carlson

Table 3 Factor loadings from principal axis factoring with varimax rotation for a three-factor solution for household dynamics questions. Bold type denotes factor loadings having values greater than or equal to 0.35

Item	Factor loading			Communality
	1	2	3	
Some members of my household encourage other members to conserve water (*M* = 5.45, SD = 1.52)	**0.752**	0.106	−0.025	0.794
There is one member of our household who often takes the role of making sure we do not waste water (*M* = 4.83, SD = 1.71)	**0.696**	0.150	0.172	0.750
In our household, it is expected that we all make an effort to conserve water (*M* = 5.31, SD = 1.49)	**0.684**	−0.233	−0.201	0.676
Some members of my household encourage other members not to waste food (*M* = 5.98, SD = 1.00)	**0.627**	−0.031	0.189	0.579
Some members of my household encourage other members to conserve energy (*M* = 6.05, SD = 1.11)	**0.623**	0.083	0.216	0.640
In our household, it is expected that we all make an effort to conserve energy (5.65, SD = 1.21)	**0.542**	−0.358	−0.144	0.688
In our household, it is expected that we all make an effort to reduce food waste (*M* = 5.54, SD = 1.37)	**0.529**	−0.406	−0.276	0.603
There is one member of our household who often takes the role of making sure we do not waste food (*M* = 5.39, SD = 1.49)	**0.519**	0.080	0.246	0.450
There is one member of our household who often takes the role of making sure we do not waste energy (*M* = 5.58, SD = 1.46)	**0.515**	0.171	**0.365**	0.636
Some members of my household hamper other members' efforts to conserve water (*M* = 3.53, SD = 1.84)	0.028	**0.780**	−0.046	0.651
Some members of my household hamper other members' efforts to conserve energy (*M* = 3.81, SD = 1.92)	−0.021	**0.743**	−0.001	0.666
Some members of my household hamper other members' efforts to conserve food (*M* = 3.18, SD = 1.77)	0.027	**0.698**	0.023	0.496
At least one member of our household prefers to turn up the air conditioning/heating in the house more than other members (*M* = 4.92, SD = 1.88)	0.038	**0.510**	0.108	0.436
At least one member of our household prefers to take long showers, using more water than other members (*M* = 4.78, SD = 1.89)	0.042	**0.476**	0.309	0.410
One member of our household primarily manages our energy bills (*M* = 6.30, SD = 1.12)	0.010	−0.055	**0.555**	0.374
One member of our household primarily manages our water bills (*M* = 6.20, SD = 1.29)	0.028	0.072	**0.484**	0.405
One member of our household primarily manages our food shopping (*M* = 5.95, SD = 1.41)	0.070	0.056	**0.361**	0.236
At least one member of our household prefers to eat red meat more often than other members (*M* = 4.73, SD = 1.77)	0.167	0.081	0.209	0.169
Eigenvalues	4.046	3.313	1.651	
% variance explained by factor after Varimax rotation	22.478	18.404	9.171	

Bold type denotes factor loadings having values greater than or equal to 0.35

1969). After rotation, the first factor accounted for 22.48% of the variance, the second factor accounted for 18.40%, and the third factor accounted for 9.17%. Together, the three factors account for 50.05% of the variance. Table 3 includes the survey items and factor loadings for the rotated factors (Matsunaga 2010).

Each factor appears to correspond with a different household dynamic process or set of processes initially identified by Lytle et al. (2021). The first factor captures the survey items that represent the hypothesized positive dynamic processes, enhancing and norming. The second captures the survey items that represent the hypothesized negative processes, preferring and constraining. The third construct, allocating, is consistent with Lytle et al. (2021). We note that the last item, measuring food preferences, did not map onto any of these three factors, and we excluded it when computing factor scores for further analysis. This exploratory factor analysis suggests that the survey items are related to each other in terms of household social dynamic processes, as opposed to resource domains.. Our hypothesis that constructs would reflect the five dynamics identified in qualitative research is not supported; instead, we see three constructs that measure positive (enhancing) dynamics, negative (constraining) dynamics, and allocating dynamics. Going forward, we use the terms enhancing, constraining, and allocating. Here, "enhancing" also captures positive norms, and "constraining" also captures "preferring."

Following the factor analysis, we created factor scores by averaging the values for each scale item on a factor. In the following analysis, we used three variables derived from the

Table 4 Hierarchical linear regression, DV: pro-environmental action frequency ($n=120$)

	Step 1			Step 2			Step 3			Step 4		
	B	SE_B	β	B	SE_B	β	B	SE_B	β	B	SE_B	β
NEP score	0.349	0.112	0.279**	0.132	0.103	0.106	0.071	0.107	0.057	0.068	0.109	0.055
Resident env awareness	0.166	0.093	0.167	0.127	0.080	0.128	0.114	0.080	0.115	0.114	0.080	0.114
Education	0.067	0.058	0.106	0.115	0.051	0.183*	0.113	0.050	0.179*	0.113	0.050	0.179*
Gender	0.093	0.149	0.058	0.049	0.129	0.031	0.064	0.128	0.040	0.067	0.130	0.042
Children (dummy)	−0.115	0.151	−0.070	−0.117	0.131	−0.072	−0.074	0.131	−0.045	−0.073	0.132	−0.044
Enhancing				0.428	0.068	0.519***	0.441	0.068	0.534***	0.442	0.069	0.536***
Constraining							−0.082	0.044	−0.150	−0.082	0.044	−0.150
Allocating										−0.009	0.064	−0.011
(Constant)	2.250	0.590		0.650	0.570		1.157	0.626		1.211	0.729	
R^2	0.140			0.362			0.382			0.382		
Adjusted R^2	0.102			0.328			0.343			0.337		
F for change in R^2	3.712**			39.363***			3.502			0.021		

Gender: 0, female; 1, male

B, unstandardized regression coefficient; SE_B, standard error of the coefficient; β, standardized coefficient

* sig < 0.05 ** sig < 0.01 *** sig < 0.001

factor scores: enhancing ($M=5.53$, SD = 0.91), constraining ($M=4.04$, SD = 1.36), and allocating ($M=6.16$, SD = 0.90) dynamics. We chose this method of creating factor scores because mean scores allow for easy interpretation and comparison between factors and preserve the variation of the original data. Although less sophisticated than refined procedures for generating factor scores, DiStefano et al. (2009) suggest this method for exploratory research with previously untested scales. In creating average scores, each item on the factor is given equal weight regardless of high or low factor loading. Additionally, the three scores are uncorrelated.

Research objective 2: Stepwise multiple linear regression analysis to measure correlation of household dynamics with pro-environmental actions

After creating variables with the household dynamic process factor scores, we ran a stepwise multiple linear regression model, regressing self-reported frequency of pro-environmental actions on household dynamic process scales, NEP scores, and demographic control variables. Using exploratory factor analysis, we determined that food, energy, and water actions in this sample are not distinct constructs that could be reduced to three unique scales, aligning with our findings from a national survey earlier in this project (Floress et al. 2022). Thus, for this analysis, we used the average of the 20 items to compute a score for each respondent ($\alpha=0.77$, $M=4.36$, SD = 0.72). Analysis of standard residuals showed that the data contained no outliers. Tolerance (all > 0.3) and VIF statistics (all < 2.5) indicated that the data met the assumption of non-collinearity (Hair et al. 2009). The Durbin-Watson statistic (2.010) indicated the model met the assumption of independent errors (Field 2013). A histogram of standardized residuals indicated that the data contained approximately normally distributed errors, as did the normal P-P plot of standardized residuals. A scatterplot of standardized residuals showed the data met assumptions of homogeneity of variance and linearity.

As shown in Table 4, the full model statistically significantly predicted pro-environmental action frequency, explaining 38.2% of the variance in the dependent variable ($F(8, 111)=8.564$, $p=0.000$). The individual predictors were examined further and indicated that enhancing dynamic processes ($t=6.423$, $p=<0.001$ and education ($t=2.252$, $p=0.026$) were significant predictors in the full model. Step 2 of the model, adding the "enhancing" variable, produces the largest change in R^2 across models.

As NEP score and household environmental awareness score were not statistically significant predictors of pro-environmental action in the MLR, we suspected that these measures may have direct impacts on household dynamic processes, indirectly impacting pro-environmental action frequency. To test this, we ran a series of linear regression models, measuring the effect of NEP and household environmental awareness on each of the three household dynamics (Table 5).

Table 5 describes results of three linear regression models that test the effects of NEP and household environmental awareness on enhancing, constraining, and allocating household dynamic processes. NEP is a statistically significant predictor of enhancing and constraining household dynamic processes, and neither variable explains variance in allocating processes.

Table 5 Linear regression of household dynamic processes on NEP score and household environmental awareness ($n = 120$)

	B	SE_B	B	t	R^2	F	p
DV: enhancing					0.174	4.807	< 0.001
NEP	0.507	0.134	0.335	3.794***			
Household env. awareness	0.090	0.110	0.075	0.820			
DV: constraining					0.134	3.520	0.005
NEP	— 0.659	0.206	— 0.290	— 3.202**			
Household env. awareness	— 0.140	0.170	−0.077	— 0.826			
DV: allocating					0.060	1.466	0.206
NEP	— 0.194	0.143	— 0.128	— 1.361			
Household env. awareness	— 0.050	0.118	— 0.041	— 0.425			

B, unstandardized regression coefficient; SE_B, standard error of the coefficient; β, standardized coefficient

* sig < 0.05 ** sig < 0.01 *** sig < 0.001

Each model included controls for education, gender, and children in the home (dummy). None were statistically significant where $p < 0.05$

Discussion

This analysis provides one way to measure the structures of household social dynamic processes (as perceived by one main respondent within a household) quantitatively, a novel empirical step for household consumption research. Working with rich data in a small sample, this study aims to make a primarily theoretical, rather than empirical, contribution to the literature, exploring the determinants of household resource consumption. By measuring household social dynamic processes quantitatively, we begin to develop a broader picture of the ways these interactions impact consumption practices. Specifically, we contribute to a growing body of research that considers how social processes within the household shape the behavior of its individual residents (see, for example, Lytle et al. 2021). Empirically examining and theoretically refining our understandings of how social dynamic processes at the household scale are shaping individual behaviors within a residential home can inform new directions in research and policy intended to study and intervene in consumption decisions to lessen their negative impacts. This work will require collaborations across disciplines (for example, linking engineering, computational, and behavioral sciences) and integration of multiple scales (individual, household, and even neighborhood or region) to fully understand the structures and processes impacting consumption behaviors within the household.

Our findings illustrate that the five initial constructs from a qualitative phase of this research with other participants (Lytle et al. 2021) are better represented, in this sample, by three unique social dynamic processes influencing household consumption: positively framed enhancing and norming, negatively framed preferring and constraining, and allocating. Further exploration of the optimal ways to measure these constructs is warranted. Including these measures in a stepwise multiple linear regression analysis shows that enhancing (positively framed) dynamics act to encourage individual pro-environmental actions in our respondents. Furthermore, perceptions of these dynamics may be in part explained by individual pro-environmental attitudes.

Impacts of positive vs. negative social dynamics

Positively framed social dynamic processes were positively associated with pro-environmental action in the model, while negatively framed processes (constraining and preferring) did not have a statistically significant effect on behavior Although we hypothesized that constraining would be negatively associated with pro-environmental actions, this relationship was not evident in our data. We suggest that future research develop additional items to capture constraining and other negatively framed social dynamic processes. Furthermore, we did not find evidence that perceptions of allocating resource consumption behaviors predict variance in individual pro-environmental actions. We suggest that future work continue to untangle the various roles of household members in shaping resource consumption norms. For instance, it is possible that the allocating items we developed are more strongly related to potentially gendered household responsibilities rather than allocating food, energy, and water resources.

Some research has considered how conflict arises in the household in response to resource consumption or conservation (Dillahunt et al. 2010; Schmidt et al. 2014; Aguirre-Bielschowsky et al. 2018; Sovacool et al. 2020). One recent study found evidence that smart thermal technology (heating and cooling) drives a variety of different types of household conflicts, including those between parents and children, hosts and guests, roommates, couples, and landlords and tenants (Sovacool et al. 2020). Other studies have similarly focused on conflict and constraining aspects of interpersonal relationships, with fewer exploring the ways household members can and do encourage each other to make pro-environmental decisions about consumption (Dillahunt et al. 2010; Ástmarsson et al. 2013; Schmidt et al. 2014; Aguirre-Bielschowsky et al. 2018). Respondent gender may also play a role in our findings, as one study found (counter to our results) that women more frequently reported conflicts over thermostat adjustment, while men more often referred to compromises and agreements (Sintov et al. 2019). To tease apart these complex relationships, household resource consumption might be further explored through the social-psychological lens of family and household decision-making and consumer research. There is room for research to explore both positive and negative social dynamics across specific types of relationships, such as those between family members or landlords and tenants, as communities build specific sets of practices that drive consumption (Hargreaves and Middlemiss 2020).

Effects of sociodemographic variables

The limited variability in some sociodemographic characteristics was intentional in this specific sample, which was originally recruited to take part in a 12-month messaging intervention study. In choosing the study area, the team considered likely homogeneity in characteristics like household income and education. Based on available census data, household income and education are higher in the study area than for the average American (U.S. Census Bureau 2019). The research team posited that households with higher income levels are more likely to have more impactful consumption patterns, time, and financial resources to take actions to conserve, as well as, arguably, the moral responsibility to change their behaviors. By choosing this specific study area, these variables are already controlled for, to some degree, so their lack of statistical significance in our model is not unexpected or reflective of results in larger, nationally representative samples. In our model, however, education was positively associated with frequency of pro-environmental action, which follows established trends (Meyer 2015).

Limitations

As with most exploratory research, this project is not without limitations. The qualitative research (Lytle et al. 2021) that preceded this study was not nationally or regionally representative, nor is our current sample. We believe, however, that the preferring, constraining, and allocating constructs provide novel theoretical insight into the relationships that shape the social dynamic processes impacting household consumption and should be further developed both qualitatively and quantitatively across diverse, representative, and larger samples.

With regard to study design, research prompts asked that data be provided from a single respondent in each household who served as the household's representative. Thus, the representative household member in some cases answered questions on behalf of other members (household environmental awareness). The research was designed this way to ensure consistency in respondent identity and awareness of research processes in the longer intervention study, but the accuracy of our data could be improved if each member of the household were surveyed (similarly to the methodology employed by Netuveli and Watts 2020).

One alternative explanation for the exploratory factor analysis results might be that respondents responded similarly to the questions that shared the same wording and sentence structure. To attempt to avoid this, the household dynamics questions appeared in three separate sections of the survey grouped as questions about food, energy, and water consumption (rather than organized by theorized household dynamics). Furthermore, we did not ask respondents if other household members engaged in the measured pro-environmental behaviors or how tasks are shared between household members. Additional research utilizing only one respondent per household can continue to develop creative ways to measure household-level behaviors rather than solely focusing on individual behaviors.

Our third survey was deployed in March 2020, and COVID-19 pandemic stay-at-home orders issued in Illinois took effect on March 21, 2020. This changed both our study and household consumption broadly in drastic ways. The study lost participants by the June—July 2020 survey, resulting in a smaller sample size for this survey. More significantly, stay-at-home orders changed daily household life in unprecedented ways, including working and attending school from home. These changes shifted some consumption that would have likely taken place outside of the home before the stay-at-home orders (e.g., using the air conditioner all day as opposed to only at night; purchasing larger quantities and/or different types of food). Additionally, household social dynamic processes may have shifted in response to spending more time together in the same space. This research, however, acknowledges that household social dynamic processes are fluid and likely change over time and in specific situations.

Finally, this research proceeds from the assumption that consumer behavior change is an integral piece of climate mitigation action. We do not take the position that individual or household action can or should be the central driver of emission reductions or obscure necessary structural changes to political-economic systems. We believe, however, that attention to the disproportionately emission-intensive consumption patterns of high SES individuals is an important project with implications for equitable climate action (Nielsen et al. 2021). As mentioned above, sociological scholarship on treadmills of production and consumption provides crucial insights on the barriers to significant change through individual behavior alone (Schnaiberg et al. 2002; Gould et al. 2015). Theories of social practice can further reckon with the ways in which elements of practice are tied to economic social stratification, linking class to the development of lifestyle groups and different ways of being (Lytle et al. 2022).

Implications and future research

Our findings suggest the importance of interdisciplinary collaboration in the field of household resource consumption, blending disciplinary traditions to answer questions about the diverse set of factors that drive decision-making. Attitudinal variables like those found in survey measures such as NEP typically come out of social psychology (Dunlap et al. 2000), while social practice theories are commonly utilized in anthropology and sociology (Rouse 2007). Fully understanding household consumption requires integration of physical features of the built environment as examined by engineering sciences and novel ways of collecting and integrating datasets as provided by computational sciences. A central debate in climate mitigation research considers individual behaviors vs. political, structural, and cultural constraints, arguing either that focus on the former obscures the latter or that too much focus on the latter disengages individual sense of responsibility (Maniates 2001; Shove 2010; Lorenzen 2018).

Here, we view a social practice-based approach as one way to center the social arrangements and institutions (i.e., the household) without placing the full burden of responsibility on the individual, as acknowledging complex systems of provision highlights social structure (Spaargaren 2011). We return here to Shove's "chalk and cheese" metaphor— earlier in this paper, we suggest that the incompatibility between paradigms centering practice and those centering behavior might be more like shredded cheese covered in cellulose. Manufacturers add this coating to increase palatability and utility by preventing clumping during processing, thus providing a product that consumers are accustomed to and can easily integrate into their daily routines. While research methodologies and analysis techniques developed to measure behavior may not be perfectly suited to account for practices (a different unit of analysis), it is our hope that we might begin to move toward more practice-based approaches. While decades of research show that policies based on rational choice theories like provision of incentives and information are not typically as effective as expected, climate mitigation policy at the household level still largely targets this model (Shwom and Lorenzen 2012). Shwom and Lorenzen argue for more interdisciplinary empirical studies that explore "the ways in which technologies and household behaviors are produced and reproduced and become embedded routines" (p. 12). This study takes one theoretical step toward this goal. We suggest that future research aim to develop our proposed scales. Looking at the intersections between household technologies, social dynamics, and behaviors gives researchers a more holistic picture of household consumption practices.

Furthermore, this study used stepwise multiple linear regression to test effects of perceived household social dynamic processes on frequency of individual pro-environmental actions, finding that the effects of NEP score and household environmental awareness were potentially masked when controlling for other variables. Thus, we conducted a second series of regression models to test if these variables predicted variance in household social dynamics, finding evidence that perceived household dynamics mediate the relationship between NEP and individual behavior. Future research in larger samples should use more sophisticated statistical techniques, such as structural equation modeling, to model casual pathways between these variables.

Finally, the larger FEWCON project develops and tests interventions aimed at reducing household consumption. These findings might aid in the development of future intervention research, as we learn more about the composition of households and the ways in which social dynamic processes facilitate or constrain pro-environmental decision-making. Intervention messages might be tailored toward specific household dynamics, encouraging communication among household members. Robust interventions will likely target household decision-makers while reaching the entire household. Some research has shown that children influence environmental decision-making (Boudet et al. 2016), and this should be explored with attention to household social dynamics and power dynamics. Following the disproportionate climate impacts of wealthy individuals largely located in the USA and Western Europe, we suggest that interventions target the highest per capita emitters.

Conclusion

To explore influences on resource consumption that have potential to drive climate mitigation efforts among high SES groups, this study developed and tested a novel set of scales to measure household social dynamic processes associated with resource conservation at the residential scale. We found that positively framed processes, including enhancing and norming, predict variance in self-reported pro-environmental actions in the household. Furthermore, environmental attitudes predict variance in positive and negative household social dynamic processes. This research extends the scope of household consumption research at the FEW nexus, offering opportunities for researchers to think about consumption in ways that consider the intersection between the individual and social institutions, linking individual behavioral choices to structures and processes at the household scale that shape those behaviors. This work empirically examines and theoretically refines our understandings of how structural processes at the household scale shape occupant behavior to inform new directions in research and policy targeted at consumption-side climate action. It is our hope that this work encourages future intervention research that crosses disciplinary boundaries to facilitate climate mitigation efforts.

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Data Availability The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Competing interests The authors declare no competing interests.

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