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A Mental Accounting Perspective on Energy Decision-Making and Behavior

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Abstract

Mental accounting refers to the fact that people create mental budgets to organize their resource use and to create linkages between specific acts of consumption and specific payments. Research on financial decision-making and consumer behavior shows that these mechanisms can have a large impact on decisions and behaviors, deviating from normative economic principles. Here we introduce a theoretical framework illustrating how mental accounting mechanisms may influence individual decisions and behaviors driving energy consumption and carbon emissions. We demonstrate the practical relevance of mental accounting in the context of designing carbon pricing mechanisms and discuss the ethical dimensions of applying the concept to intervention design. By bridging the mental accounting literature and research in the energy domain, we aim to stimulate the study of the cognitive mechanisms underlying energy-relevant decisions and the development of novel theory-based interventions targeting reductions of energy use and carbon emissions.

Keywords: mental accounting; behavioral economics; consumer behavior; energy conservation; carbon pricing; rebound effects; spillover effects

Consider the following scenario: At the end of the year, your employer surprises you with a substantial "green bonus" which is meant to be used for environmentally friendly investments, but which you can spend any way you want. You think about replacing your old car by investing the money in a new energy-efficient model. Given its lower consumption, you would save money on fuel, and could drive the new car more often than your old gasoline guzzler. After playing with the idea for a while, you decide that right now it is more important to plan your upcoming vacation. You mention to the travel agent that as you are currently making an effort to reduce your energy consumption at home, you could allow yourself to book a flight to a distant vacation destination.

The events outlined above serve to illustrate a number of important effects of mental accounting mechanisms[1,2]. Mental accounting refers to the fact that people create mental budgets to organize and keep track of their resource use and create linkages between specific acts of consumptions and specific payments[1–3]. Metaphorically speaking, these accounts are comparable to saving jars dedicated to specific purposes (e.g., "rent", "food", "leisure"). By ascribing financial transactions to separate mental accounts, people strive to keep revenues and expenditures in balance[4–6]. This principle of mental organization has far-reaching consequences for decision-making and consumer behavior, interfering with normative economic principles[7]. Despite the visibility that mental accounting theory has attained in the finance sector[4,5,8–10], research on mental accounting in the energy and climate change domain is scarce[11–14], leaving its potential value for a more comprehensive understanding of energy-relevant decision-making and the development of intervention strategies to foster energy conservation unexploited.

In this Perspective, we discuss three central mental accounting principles that could have considerable impact on decisions and behaviors relevant for energy consumption (Table 1). We review empirical findings from financial and non-financial contexts, describe the functioning of key mechanisms at the cognitive level, and discuss how mental accounting

principles can be relevant for energy behavior and behavior change. In light of the scarce research on mental accounting of energy behavior and the theoretical nature of our arguments, we also point to future research avenues to stimulate the study of the cognitive mechanisms underlying energy-relevant decisions. This research within the energy domain could reveal conditions under which consumers refer to mental accounting, deploy other more or less deliberative cognitive strategies, or do not mentally represent energy-relevant consumption at all.

PLEASE INSERT TABLE 1 ABOUT HERE

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1 Creating mental accounts

Few people still have saving jars at home to organize expenses. However, most online banking accounts offer the option to create dedicated subaccounts allowing people to plan, for example, how much money to set aside for rent payments or for a future vacation. The option to create subaccounts mirrors the cognitive mechanisms applied to internally categorize resources using multiple mental accounts. Once a mental account is created, it determines how the resources booked on this account will be spent. One key result from mental accounting research is that resources booked on two different mental accounts are not fungible[1,2]. For example, financial savings due to lower gas prices have a disproportionally high likelihood to be spent on higher quality gasoline[15], despite the fact that economic considerations based on utility maximization would expect the money to be spent on other items yielding higher utility[16]. Importantly, the principle of non-fungibility does not only apply to money, but is observed for other types of resources as well. Time saved by postponing a work-related activity is more often spent on other work-related activities, time saved by postponing a non-work related activity is more often spent on amusing activities[17].

Mental accounting mechanisms also influence how people integrate and balance the consequences of a series of actions[18]. For example, people who previously had worked to help maintain a local forest donated less to a local association promoting sustainable land management than people who did not contribute their work[19]. Thus, different types of behaviors that are "grouped" onto one mental account (here, working to maintain a forest and donating for sustainable land management) will be considered equivalent and thus fungible.

Topical accounts dedicated to a specific theme are embedded within an overall representation of all available resources (i.e., comprehensive account)[20,21]. If an event becomes so big that it is perceived to impact overall resource availability, it is integrated in a more comprehensive manner, thus affecting multiple topical accounts. For instance, consumers perceived the costs associated with gasoline price spikes to have a pervasive influence on their overall economic well-being. As a consequence, the price information strongly affected planned spending within and beyond the concerned domain. The framing of price information in terms of the specific target action (price increase per trip instead of price increase per gallon) made a topical representation more likely and attenuated price effects on planned spending[20].

1.1 Integrated versus diversified mental accounts

The notion of fungibility within, but not between, mental accounts may have an important impact on behavior in the energy domain. The mental accounting literature indicates that negative spillover[22], i.e., elevated resource consumption after sustainable acts, may be facilitated by a mental organization that bundles different energy-consuming actions together into one broad "carbon account" (Figure 1). As outlined in the introductory example, the action "I saved energy at home" may be perceived as entitling to the action "I go on vacation by plane". Compensatory resource allocations may potentially be prevented by increasing the differentiation of mental accounts by highlighting the distinctiveness of

different consumption behaviors[23,24]. A more fine-grained mental representation of carbon-emitting behaviors should make mental compensation less likely due to the lack of fungibility between accounts. In Box 1, we discuss salient carbon pricing and labeling as potential means to facilitate more fine-grained mental accounting of consumption actions.

PLEASE INSERT FIGURE 1 ABOUT HERE

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2 Limiting mental accounts

Whether it is income level that restricts expenses, or a self-imposed limit that restricts chocolate consumption[25], budgets affect a wide range of behaviors, ranging from household financial management[5] to time allocation between work and non-work activities[17]. Here mental accounts operate as a self-regulation tool: When a limit is set for a specific account, people keep track of corresponding expenses and adapt their consumption accordingly to keep the account in balance[1,2,6,25,26]. Setting mental budgets, for instance, helped people reduce their candy consumption. Consistent with research on the impact of social norms[27], mental budgets were more effective in reducing consumption when budget limits were based on an external reference group[25]. People who imagined spending for entertainment purposes afterwards were willing to spend less on entertainment, but were only marginally affected in the amount they were willing to spend on food and clothing. Willingness to spend for entertainment purposes in turn was only marginally affected when an initial amount was spent on food or clothing[6]. The effective monitoring of mental budgets requires decision makers to be able to link specific consumption acts with their corresponding mental accounts[2,25]. To this end, the individual needs to notice that a given expense is relevant for the respective account and be able to link the unit of the expense to the account.

2.1 Fuzzy versus realistic mental budgeting

Effective mental budgeting requires consumers to know their consumption impacts, while misconceptions about behavioral impacts may lead to situations where actions cannot accurately be "booked" to the corresponding mental accounts. In the energy domain, consumer knowledge about product-related emissions is limited so far[24,28]. As detailed in Box 1, providing continuous feedback about consumption impacts may result in more realistic mental models of energy consumption, triggering behavioral change[14,29].

Inefficient mental budgeting may moreover be one underlying cause of the well-documented rebound effect[30,31], when limits of mental budgets are not adapted to changing external conditions. As outlined in the introductory example, newly purchased energy-efficient cars are indeed found to be used more frequently than their predecessors[31]. Behavioral rebound may occur when consumers do not update (i.e., reduce) their budget limits after the purchase of energy-efficient technologies (Figure 2). As long as the now oversized budget does not provide appropriate feedback signals, people may be inclined to overconsume. This cognitive perspective on the rebound effect is complementary to research on moral self-regulation which posits that behavioral compensation depends on the relevance of the target action for the self and the salience of previous moral actions[32,33].

Rebound effects due to non-adapted mental budgeting may be counteracted by dynamically adapting the respective mental budget subsequent to energy efficiency investments. For instance, providing consumers with explicit information on expected fuel costs as a function of personalized or population-based annual mileage may help attenuate increased vehicle use after fuel-efficient car purchases. As lower mental budgets are expected to signal overconsumption at an earlier stage[1,2,6,25], this strategy could make behavioral rebound less likely.

PLEASE INSERT FIGURE 2 ABOUT HERE

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3 Labeling mental accounts

Using birthday money to buy a special treat you would not allow yourself every day illustrates the operation of another fundamental mechanism of mental accounting: The characteristics of the mental account on which an income is booked determines how it is spent[1–4,34]. Consumers create distinct mental accounts based on the source of an income[35]. Money received as a gift or windfall is more likely to be spent on hedonistic products such as vacations or luxury items, money earned through work is more likely to be used for utilitarian products such as tax books[36]. Money won in a casino gamble bet is more likely to be used to go to a restaurant, a tax refund is more likely to be used to repay debts[37]. Even arbitrary labels given to a specific income can influence what it is spent on. In the United Kingdom, elderly people receive a supplement for heating purposes during wintertime. This "Winter Fuel Payment" is basically a direct, unconditional cash transfer (i.e. the money can be spent on anything), but is given a name which points to a distinctive purpose. Households spend on average 42% of the winter fuel payment on fuel (whereas they would be expected to spend only 3% of the payment on fuel if it were treated as unlabeled cash)[38,39]. In the same vein, giving consumers a free 8€ voucher labeled "beverages" increased spending on beverages compared to a voucher labeled "gourmet" by about 26%[40].

3.1 Arbitrary versus goal-directed mental accounts

While the guiding function of mental accounting can have an important impact on how incomes are reinvested, energy efficiency revenues are rarely communicated with an emphasis on the origin of the income, making it unlikely that consumers will reinvest the money to promote energy conservation and emission reduction goals. As illustrated in

Figure 3, non-labeled revenues may be more likely to be booked on accounts unrelated to energy efficiency. Strategies aiming to promote sustainable reinvestments of related revenues would explicitly label these revenues in line with their sustainable origin. Thus, the "green bonus" mentioned in the introductory example may indeed be expected to be rather used to buy an energy-efficient car than an off-road SUV. In Box 1 we discuss how this labeling mechanism is relevant for the design of carbon tax dividends.

PLEASE INSERT FIGURE 3 ABOUT HERE

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4 Future directions

Substantial accumulated evidence illustrates that humans mentally organize and keep track of a vast range of resources such as money, time, and food[17,25,41]. Despite the attention mental accounting received in the financial domain and beyond, research on mental accounting of energy-relevant behavior is still scarce. Here we develop a mental accounting perspective on energy decisions and actions. We suggest that many decisions and behaviors driving energy consumption are represented in mental accounts similar to those applied to consumption actions outside the energy field. We acknowledge, however, that in the absence of systematic empirical investigation our argument primarily remains a theoretical one that needs to be tested by future research within the energy domain. Here we identify three core avenues for future research on the mental accounting of energy behavior to address this gap.

4.1 Cognitive representations of energy consumption

Whereas studies on energy behavior naturally tend to be focused on behavioral outcomes[42], we argue that energy research can benefit from a deeper understanding of how people cognitively represent energy resources, actions, and their associated impacts. It is an intriguing research objective to explore the conditions under which consumers integrate

energy-relevant actions in their mental models of consumption and thus refer to cognitive strategies such as mental accounting or disengage from a thorough cognitive processing of these actions. A comprehensive picture of the cognitive representations of energy-relevant actions, in turn, can contribute to a better implementation of existing policy instruments and the development of novel intervention strategies (Box 1). Statistical techniques such as multidimensional scaling can be applied to reveal and visualize systematic differences in the representation of energy consuming actions[43]. Potential differences at the cognitive level can then be associated with different behavioral outcomes, for example to test the hypothesis that diversified mental accounting has beneficial effects for energy conservation (Figure 1). This line of research should moreover analyze the limits and boundary conditions of diversified mental accounts, for instance, when specific open accounts drive people to increase resource consumption (e.g., "I did not fly this year, so I can allow myself a flight") or when the non-fungibility between diversified mental accounts attenuates positive spillover[13,14].

4.2 Dynamic nature of the mental accounting of energy behavior

Mental accounting is not a static process. Consumers dynamically create mental budgets and continuously track their resource consumption[1,2,4]. Future energy-specific research should borrow experimental paradigms from classic mental accounting research and examine the dynamic nature of the mental accounting of energy behavior[6,25,26]. This research could experimentally trigger new or adapt existing mental accounts related to energy consumption, provide external reference values for consumption boundaries, or increase specific knowledge on the emission impact of consumption actions. This would allow testing the hypothesis that rebound effects are based on non-adaptive budget limits and thus can be attenuated by providing updated consumption targets after energy efficiency investments (Figure 2). Analysis of the dynamic aspects of mental accounting should encompass changes at the cognitive level in addition to behavioral effects. Research aiming to increase energy-

related knowledge could test the hypothesis that information provision facilitates diversified mental accounting, which in turn may lead to beneficial behavioral outcomes (e.g., reduced negative spillover).

Incorporating the cognitive level can moreover be beneficial to disentangle mental accounting mechanisms from those associated with moral self-regulation. An emerging literature in social psychology indicates that compensatory spillover of moral actions is subject to moral self-regulation processes in which actions are evaluated with respect to their relevance for a person's values, goals, and identity[32,33]. We consider both approaches to be complementary, as mental accounting theory adds a cognitive perspective to moral self-regulation theory, which has a strong focus on the self-concept. To illustrate, a recent study showed that behavioral spillover occurs to a larger extent for behaviors that are perceived as highly similar (and thus more likely to be booked on the same account)[18]. This result can be easily explained by a mental accounting approach, while it is less obvious from a moral self-regulation approach. Our perspective is in line with research arguing that moral self-regulation is one of multiple processes determining spillover and rebound effects rather than the sole determining factor[30,44].

4.3 Novel mental accounting interventions in the energy field

A central goal of behavioral energy research is to develop effective interventions for policy and practice to foster energy conservation. Here we argue that mental accounting theory can contribute to this objective by adding a new, complementary perspective. Interventions should be built on the assumption that mental accounting represents a cognitive strategy aiming to optimize resource consumption in an ecologically rational manner rather than a driver of suboptimal decision-making. As illustrated in our theoretical analysis mental accounting mechanisms may nevertheless sometimes trigger behavior leading to energy

overconsumption. Tailored interventions should target these specific instances rather than aiming to generally align decision-making with "economically rational" principles[45].

The costs associated with policy implementation require a thorough cost-benefit analysis of mental accounting interventions under controlled and ecologically valid conditions. Effect sizes should be evaluated in light of context-specific barriers and opportunities[46], considering the size of the population targeted by the intervention[47,48]. In Box 1 we illustrate how mental accounting theory can inform the implementation of carbon taxes and labels, policy instruments that can have considerable effects on large populations[49,50]. Due to their cognitive nature, mental accounting-based interventions moreover have the potential to complement interventions based on social and moral levers at early stages of policy implementation and technology adoption when social and moral norms have not yet been established[51]. Future research should test this assumption as well as analyze the joint impact of interventions combining mental accounting principles with social and moral behavioral levers at later diffusion stages.

Finally, when applying the mental accounting toolbox to develop behavior change interventions, researchers and practitioners both have the responsibility to evaluate whether an intervention is ethically acceptable[52]. To give an example, a rebound effect may be the result of a person's motive to increase personal comfort rather than the consequence of non-adaptive budget functions or moral self-regulation processes[44]. When designing policy interventions, relevant goals and needs have to be analyzed broadly, going beyond the mere optimization of environmental objectives. As demonstrated by the emerging stream of the literature on boosting techniques as an alternative to nudging techniques, translating product information in way that addresses consumers' diverse goals and concerns can support them in making decisions that are not only in the interest of the society, but also in their own best interest[53,54].

5 Conclusions

This Perspective suggests that mental accounting theory can advance understanding of how people cognitively represent energy resources and how this influences their actions. We introduce three key mental accounting principles that we consider pertinent for energy consumption and outline three avenues for future research to advance our understanding of mental accounting of energy behavior. Ultimately, this new line of research could equip scholars and policymakers with a more enriched portfolio of tools from psychology and behavioral economics to tackle energy overconsumption and associated climate change impacts.

BOX 1| IMPLICATIONS OF MENTAL ACCOUNTING FOR CARBON TAX DESIGN

Putting a price on carbon emissions is considered an essential instrument to meet the Paris Agreement objective to limit worldwide temperature increase[50]. Integrating mental accounting theory into the design of carbon taxes can yield direct benefits for the effectiveness of the policy instrument. Carbon pricing operates by encouraging preferences for less carbon-intensive options due to changing price signals. In British Columbia the introduction of a carbon fuel tax increased preferences for fuel-efficient cars and reduced per-capita gasoline demand by about 15%[55]. Despite this potential, only about 22% of the worldwide greenhouse gas emissions are currently covered by carbon pricing systems, with most emissions being priced too low to meet the climate goals[50,56]. One reason for the slow uptake is low public support, pointing to the need for well-designed revenue systems and transparent communication[57–59].

Salient emission pricing. According to principles of mental accounting, carbon pricing mechanisms should be especially effective when the emission price is salient to the consumer[13]. Fuel taxes result in higher demand elasticity than temporal price fluctuations, which can be attributed to the higher salience of tax increases[55,60]. Commodity taxes have a stronger influence on purchases when the tax is made salient at the point of sale[61]. From a mental accounting perspective, price spikes related to a salient carbon tax would be associated with a comprehensive mental account that subordinates multiple topical accounts, thus affecting behavior in multiple domains[20]. Increasing the salience of carbon pricing and thus the transparency of the instrument is ethically sound and should be preferred over strategies in which taxes are "hidden" in product prices.

Realistic feedback and information provision. The mental accounting literature suggests that salient carbon pricing mechanisms may have important co-benefits. An explicit tagging of carbon prices provides continuous feedback about emission impacts to the consumer, resulting in a more realistic model of one's energy consumption and emission production (realistic mental budgeting). This seems especially important given consumers' limited knowledge about product-related emissions[24,28]. A widespread introduction of carbon pricing mechanisms and labels should moreover result in a more fine-grained mental organization of consumption actions in the long-term, potentially

decreasing negative spillover effects (diversified mental accounting). While widespread carbon labeling would require cost-intensive life-cycle analyses[49,62], a progressive roll-out strategy could address this cost-benefit issue: Taxes related to the direct use of fossil fuels can be computed relatively easily and thus should be implemented first, followed by widespread labeling requiring more complex analyses[49].

Reinvestment of carbon tax revenues. Mental accounting provides insights for the design of carbon pricing revenue systems. If the policy goal is to increase the likelihood that citizens reinvest the dividends from a carbon tax for pro-environmental purposes, the labeling should emphasize the goal of the tax ("emission reduction tax") rather than the underlying causes ("emission tax"). Moreover, dividends should be clearly and saliently linked to their origin. In Switzerland, a part of the carbon levy is paid back to citizens via a reduction in health insurance costs, whereas in Canada revenues are returned via a "Climate Action Incentive Payment". The latter dividend is clearly linked to the underlying environmental goal, making it more likely that it will be categorized and spent accordingly (goal-directed mental accounting). Such labeling, however, requires special ethical deliberation, especially as low-income households should benefit most from carbon revenues to avoid regressive tax effects[58]. Accordingly, it would be ethically inacceptable to design a label obscuring the origin of the revenue (e.g., by labeling general income tax credits as "climate revenues") or to restrict individual freedom by putting constraints on how the dividend can be spent.

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Author contributions

U.J.J.H, G.C., T.B planned and conceptualized the research; B.C., V.P. provided scientific and practical input; U.J.J.H. wrote the original draft; T.B. contributed to subsequent drafts; all authors reviewed and edited the manuscript, including the final version; T.B. acquired funding for the research

Competing interests

The authors declare no competing interests.

Figure Legends

Fig. 1 | Integrated and diversified mental accounting. (a) Under integrated mental accounting, distinct actions with varying impacts on energy consumption and carbon emissions are bundled together into one broad mental account. (b) Diversified mental accounting implies that different actions are organized in separate mental accounts. Negative spillover is facilitated under integrated mental accounting and should be impeded under diversified mental accounting due to the lack of fungibility between accounts.

Fig. 2 | Non-adaptive and adaptive mental budgeting. (a) Under non-adaptive mental budgeting individuals stick to pre-defined budget limits after the purchase of energy-efficient products. (b) Under adaptive mental budgeting individuals reduce their budget limits after energy-efficient purchases. Behavioral rebound should be more likely under non-adaptive mental budgeting and impeded under adaptive mental budgeting, as the latter triggers internal feedback mechanisms prior to overconsumption at an earlier stage.

Fig. 3 | Mental accounting of non-labeled and labeled income. (a) Non-labeled incomes are likely to be booked on non-specific accounts such as an overall leisure activity account. (b) Incomes labeled as “green” or “energy efficiency returns” are likely to be booked on corresponding accounts, increasing the likelihood that they are reinvested for energy efficiency purposes.

Tables

Table 1 | Key mental accounting principles that could be relevant for energy consumption and examples from the literature.

Mental accounting principle	Example	Relevance for energy-relevant behavior
Creating mental accounts: Integrated versus diversified mental accounting		
People create mental accounts to organize their resource use. Resources on the same account are fungible, resources on different accounts are not.	Money saved in a specific context is more likely to be reinvested within the same context[15].	Spillover effects should be less likely when energy-relevant behaviors are represented by multiple mental accounts.
Limiting mental accounts: Fuzzy versus realistic mental budgeting		
Mental accounts are self-regulation tools. When an account limit is set, people seek to stay within the budget.	People strive to adapt their food intake according to self-defined budgets[25].	Rebound effects should be less likely when budget limits are adapted after an investment in energy-efficient technologies.
Labeling mental accounts: Arbitrary versus goal-driven mental accounting		
The mental account on which an income is booked determines how the income is spent.	A "winter fuel" supplement is more likely to be spent for heating[38].	Revenues from pro-environmental sources (e.g., carbon tax dividends) should be more likely to be re-invested for pro-environmental purposes when the link between income and source is salient.