

ARTICLE

# Sticky brown sludge everywhere: can sludge explain barriers to green behaviour?

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## Abstract

Behavioural science has sought to promote pro-environmental behaviours including climate-friendly dietary change, and to reduce travel emissions and excessive wastes. Nevertheless, there is a debate about how effective behavioural interventions are, and in turn, about the real barriers to enduring pro-environmental behaviour change. In this context, we conceptualise brown sludge as multi-level impediment to pro-environmental behaviour change, which results in higher environmental costs shared by the broader society, rather than solely by the individual actor. We propose that brown sludge comprises an array of additional transaction costs, encompassing, but not restricted to, psychological, temporal, and uncertainty costs. Brown sludge can occur at the individual, social, institutional, and societal levels. Examples include confusing eco-information, delay and disinformation campaigns, and complicated systems and infrastructure leading to carbon lock-in.

**Keywords:** behaviour change; brown infrastructure; pro-environmental behaviour; pro-environmental motivation; sludge

## Introduction

Behavioural science has long sought to promote pro-environmental behaviours such as changing one's diet and reducing one's travel and household waste. Some (Fischhoff, 2021; van der Linden *et al.*, 2021) are positive about using behavioural science for pro-environmental purposes. Others (Nisa *et al.*, 2019; Shreedhar, 2023) are sceptical about solely relying on behavioural science tools like nudging. Others still (Gravert and Shreedhar, 2022; Mills and Whittle, 2023) emphasise the importance of a policy mix which includes nudging and more interventionist approaches like taxation and mandates. This perspective reflects the position of the Intergovernmental Panel on Climate Change (IPCC), whose recent report on 'Mitigation' includes 'choice architecture' as one of several tools for building an environmentally sustainable future (IPCC, 2022).

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What prevents people from pursuing pro-environmental behaviours? In this article, we argue the behavioural science concept of ‘sludge’ is useful for understanding why individuals and communities may struggle to pursue these ends, even when they want to undertake green behaviours. While sludge is subject to some definitional debate (Sunstein, 2018; Soman, 2020; Sunstein and Gosset, 2020; Newall, 2022; Mills, 2023), it is generally understood as frictions or burdens which impede individual behaviours (Thaler, 2018). All these perspectives draw on the complementary, and often overlapping, literature on administrative burden (e.g., Herd *et al.*, 2013; Moynihan *et al.*, 2015; Christensen *et al.*, 2019; Madsen *et al.*, 2020; Baekgaard and Tankink, 2022), though this literature focuses less on choice architecture compared to the sludge literature (Sunstein, 2022).

Newall’s (2022, p. 6) comprehensive review of sludge defines it as, ‘many different techniques ... that make [people] worse off, as judged by themselves,’ a perspective shared by others (e.g., Thaler and Sunstein, 2021; Sunstein, 2021, 2022; Hortal and Contreras, 2023). Shahab and Lades (2021) relate sludge to the transaction cost literature in economics. They argue sludge is a type of transaction cost induced through choice architecture. For instance, poor information disclosure may make valuable information harder to find. This creates a search cost, which is understood as a kind of sludge. Broadly, in this article, we follow the transaction cost approach to sludge as presented by Shahab and Lades (2021). We extend their framework to include a broader variety of costs, such as psychological, time, and uncertainty costs; and to include those techniques that increase environmental costs which are borne by society at large, apart from possibly (but not necessarily always) the individual themselves.

We use the concept of sludge to examine several examples of barriers to pro-environmental behaviour. In doing so, we develop the concept of *brown sludge*, a form of sludge that specifically impedes pro-environmental behaviours. Much like regular sludge, brown sludge emerges from different places. Some is due to poor design: for instance, where a green policy is preferable but requires excessive paperwork relative to carbon-intensive alternatives, which may impose an administrative burden on people and thereby lead them to stick with the status quo. Some may be ‘legacy sludge’: for instance, green alternatives, which are likely newer choices, might be poorly ‘tacked onto’ existing systems (such as government websites). Additionally, some may be intentional. For instance, we argue *greenwashing* through unverifiable eco-labels, as well as disinformation about environmental harms from fossil fuels, can be understood as purposeful attempts to misdirect individuals and obscure important information, thereby creating additional uncertainty about the costs and benefits of alternatives in the choice environment – this is to say, *sludge* (Shahab and Lades, 2021).

In dissecting various examples through the lens of brown sludge, we contribute an explicitly behavioural perspective to the question of pro-environmental barriers and the transition to green alternatives. We also highlight the limits of sludge as a conceptual tool for explaining these barriers. In doing so, we reveal some of the limits of behavioural public policy. Some barriers to pro-environmental behaviour can be understood as brown sludge and lead one to speculate on behavioural science solutions (e.g., green nudges). However, others firmly stretch the explanatory power of

brown sludge and, in turn, lead one to conclude that traditional economic and public policy changes are likely needed to affect pro-environmental behaviour. We hope these contributions represent a constructive development within the emerging ‘critical’ behavioural policy debate, of which environmental policy has been a key focus (Nisa *et al.*, 2019; Chater and Loewenstein, 2022; De Ridder *et al.*, 2022; Gravert and Shreedhar, 2022; Mills and Whittle, 2023).

The structure of this article is as follows. In the section ‘Brown sludge’, we review several examples of barriers to green behaviours and relate them to brown sludge. We loosely organise these examples into categories of individual, social, and institutional levels, though there is some overlap between these categories, which are used illustratively rather than definitively. Individual-level examples include confusing eco-labels and some examples of greenwashing and carbon-washing. Here, confusing information creates search and time costs which can be understood as brown sludge. Social-level examples include climate disinformation and distraction campaigns. Here, confusing information combines with some social elements and framing strategies to create search and uncertainty costs which can be understood as brown sludge. Institutional-level examples include poorly designed green investment schemes, delays, and the complex provision of green services. Here, institutional myopia and administrative burdens create time and uncertainty costs which can be understood as brown sludge.

Each ‘level’ reveals the applicability, but also the limits, of brown sludge as an explanation of barriers to green behaviours. In the section ‘Brown infrastructure’, we contrast brown sludge with the concept of *brown infrastructure* to reveal the conceptual limits of brown sludge as an explanation of barriers and thus the limits of behavioural interventions as policy solutions to some barriers to environmental barriers. The section ‘Conclusion’ offers some discussion of brown sludge (and brown infrastructure).

## Brown sludge

As above, we loosely organise the examples of barriers to green behaviours into three levels such as individual, social, and institutional. These are illustrative levels for the purposes of discussion and are summarised in Table 1. Generally, individual-level barriers focus on individual understanding and decision-making. Social-level barriers focus on interpersonal and community behaviours. Institutional-level barriers focus on interactions between individuals and institutions, such as government. These barriers can increase sludge by increasing time, uncertainty, search, evaluation, and psychological costs. They can further interact with brown infrastructure, which physically and spatially structures the choice architecture at all three previous levels.

### *Eco-labels, greenwashing, and carbonwashing*

Individually, brown sludge can take the form of confusing eco-information. Many products have different eco-labels, or similarly vague environmental–social–governance (ESG) disclosures. Eco-information is not in itself brown sludge. There are several benefits of eco-information and environmental disclosure. Conventional

**Table 1.** Brown sludge: mechanisms, behavioural effects, and mitigation measures

Level	Brown sludge or brown infrastructure?	Examples	Sludge mechanisms/ transaction costs	Impact on pro-environmental motivations and behaviour	Some ways to reduce it
Individual	Brown sludge in the choice architecture	Vague claims via eco-labels and packaging, greenwashing	High search costs, increased time costs, reduced trust and psychological costs, increased evaluation costs, increased moral wiggle room	Delays behaviour change, fools people into purchasing non-green goods	Verifiable and integrated labels (Langer and Eisdend, 2007), well-designed carbon labels (Taufique <i>et al.</i> , 2022), third-party verification and alignment with regulations (van't Veld, 2020).
Social	Brown sludge in the choice architecture	Discourses of denial and delay, framing and fossil fuels as 'clean' or transitional	Increased search costs, greater uncertainty, and increased moral wiggle room	Demotivates action and polarises groups	Effective science communication and dissemination (Oreskes and Conway, 2010b), deliberative public engagement (Devaney <i>et al.</i> , 2020; Rand and Pennycook, 2020) such as citizen climate assemblies (Wells <i>et al.</i> , 2021); inoculation and consensus messaging (Goldberg <i>et al.</i> , 2019); climate litigation (Setzer and Vanhala, 2019).
Institutional	Brown sludge in the choice architecture	Delays and unclear instructions, inconsistent	High search costs, unnecessary time costs from delays,	Delays or stops choices, regressive effects	Simplification of language and process, gradual rolling out of schemes (de Vries <i>et al.</i> , 2020),

		incentives, and regulations	and outcome uncertainty costs		sludge audits (Sunstein, 2022); aligned incentives across groups and polluter pay principle (Ambec and Ehlers, 2016).
Societal	Brown infrastructure in the spatial and physical context underlining the immediate choice architecture	Cities and roads designed around cars, widespread availability and reliance on fossil fuels, and lack of green space access	There is no real alternative, nominal choices, exacerbated sludge, and additional source of moral wiggle room	Prevents and slows behaviour change, and creates cultural and individual habits and norms	Investments in cleaner infrastructures, e.g., the Green New Deal (Pettifor, 2020); strategic investment (Mazzucato and Penna, 2016)

economic theory suggests that disclosing eco-information allows firms to signal their green credentials. Consumers can, in turn, identify and choose brands that they perceive to be more eco-friendly. Behavioural theories suggest green consumers are motivated by personal 'warm glow' effects when they choose eco-labelled alternatives (Delmas and Lessem, 2017). Thus, eco-information creates mutual benefit for brands and consumers (van't Veld, 2020). Disclosures such as individual carbon footprints may also educate and nudge people towards pro-environmental choices (Taufique *et al.*, 2022).

Eco-information is also popular across the ideological spectrum (Clark and Russell, 2005). Liberals see it as a cost-effective and voluntary way of promoting pro-environmental choices. Rights-advocates see it as a way of keeping polluters publicly accountable. Policymakers may use it as a mechanism for regulation. Finally, conservatives support the freedom-of-choice approach which comes from disclosures rather than mandates.

Yet, eco-information becomes brown sludge when it is vague or false, hard to understand, and costly (or impossible) to verify. The sheer amount of eco-information alone may create search costs for consumers. The 'Ecolabel Index' tracks 456 eco-labels in 25 industry sectors across several countries. In just the UK, there are 87 eco-labels. Some, like Fairtrade and the Marine Stewardship Council (MSC), are from non-profit certifiers. Others, like Organic Farmers and Growers certification, come from for-profit organisations, though organisations which are still compliant with UK regulations. People find the meaning of eco-labels confusing, creating uncertainty costs, and limiting the benefits of transparency (Brécard, 2014). Uncertainty, evaluation, and search costs may also give 'moral wiggle room' (Dana *et al.*, 2007), by providing situational excuses to avoid confusing eco-information and remain ignorant of environmental impacts (Momsen and Ohndorf, 2020).

Further still, for-profit firms may create labels themselves. These do not necessarily correspond to specific regulations and are not verified by third-party certifiers, for instance, Procter and Gamble's 'Future Friendly' label. In some instances, firms may simply use visual information, like green-coloured packaging or pictures of 'happy' animals, to trigger pro-environmental associations (Seo and Scammon, 2017). Where labels come from third-parties, procedural transparency can vary. Where firms create their own labels, harmful practices can emerge. For instance, firms can adopt eco-labels to pass off brown products as green. This is known as *greenwashing*. Greenwashing practices mislead consumers about the environmental credentials of products and services (Delmas and Burbano, 2011), creating further uncertainty, mistrust, and related psychological costs (Chen and Chang, 2013; Szabo and Webster, 2021). Consumers may further avoid efforts to deliberately debunk misinformation, given the evaluation costs from verifying labels and the added moral wiggle room afforded by greenwashing (Momsen and Ohndorf, 2022).

In addition to greenwashing, In and Schumacher (2021) describe what they call 'carbonwashing'. This is when firms selectively communicate carbon information which does not match their environmental impact and unsubstantiated promises about future ambitions. Firms engage in carbonwashing by taking advantage of a lack of standardisation in Environmental Social and Governance (ESG) indicators and carbon reporting. For instance, they launch unverified carbon reduction plans

and ‘Net Zero’ targets, or they emphasise (marginal) carbon reduction efforts undertaken by the firm. In terms of costs, and thus sludge, the effects of carbonwashing are likely similar to those of greenwashing.

### *Disinformation and distraction campaigns*

Climate disinformation is a form of brown sludge, misdirecting people by misrepresenting or misstating climate information. This creates uncertainty costs, leading policymakers and the public to question anthropogenic global warming, and search costs, as fact must be disassociated from fiction. Lobbying campaigns that cast doubt on climate science are perpetrators of this sludge. Oreskes and Conway (2010b) show how these ‘merchants of doubt’ funnel resources to contrarian scientists and think tanks in order to sow climate change doubts. Climate doubt can delay policy support and action (van der Linden *et al.*, 2015; Shreedhar and Mourato, 2020). It also causes legitimate perspectives to be questioned, discouraging individuals and communities from responding to environmental threats (Oreskes and Conway, 2010b).

For instance, since the 1980s, climate change has become a contested, politicised issue in the USA. This is a result of lobbying and disinformation campaigns (Oreskes and Conway, 2010b; McCright and Dunlap, 2011). These strategies are not new and have been used to influence individuals and institutions in the past. For instance, to cast doubt on links between cigarettes and cancer, or links between man-made pollution and acid rain (Oreskes and Conway, 2010b). Politicising the scientific consensus redirects social discourse away from discussing solutions to a problem and towards debating the existence of the problem in the first place (McCright and Dunlap, 2011). Disinformation creates ambiguity and uncertainty costs, which can entrench the status quo (Sunstein, 2018).

Recent disinformation campaigns have focused on distracting or delaying action, rather than outright denial of anthropogenic climate change. Fossil fuel firms have hired public relation firms to emphasise the benefits of fossil fuels. For instance, in 2020, several social media influencers participated in the #CookingWithGas campaign, which claimed that food tasted better when cooked with natural gas. This campaign was funded by the American Gas Association and the American Public Gas Administration, two trade groups (Lever, 2020). Another example concerns the wildfires which afflicted Australia in 2020. News Corp – an Australian media organisation – promoted claims that arsonists were responsible for the fires, rather than climate change causing overly-dry conditions. Rumours of arsonist involvement could be traced back to a bot-induced social media disinformation campaign (Readfearn, 2020). These distraction campaigns come to dominate narratives, creating search costs.

Climate disinformation qualifies as brown sludge in two ways. Firstly, it impedes individuals through misdirecting individual efforts, creating time costs. This could be misdirection towards behaviours which have marginal effects. Furthermore, fostering misunderstanding could lead to deleterious behaviours, even when performed in good faith. Secondly, it impedes individuals through misdirecting social discourse. Delaying discourses that impede institutions and communities in supporting

pro-environmental behaviours create impediments for those same groups and sow uncertainty and distrust, resulting in significant costs. For example, misinformation may delay political action on climate change, as recently occurred with the Republican Party in the USA voting down the climate health law.

One response to disinformation and social misinformation is direct public engagement in science and politics. Oreskes and Conway (2010a) note that scientists have traditionally focused on research, believing that truth will triumph provided the research is credible – a viewpoint which has not been borne out by the facts. Additionally, involving citizens in deliberative assemblies over economic, social, and environmental issues has been shown to reduce polarisation and increase engagement with climate evidence (Devaney *et al.*, 2020). More active collaboration between experts and citizens could be the basis for tackling some brown sludge at the social level.

### *Unclear instructions and complicated systems*

Brown sludge can also exist at the institutional level. Often, this is in the form of complex processes; confusing language and instructions; burdensome paperwork; and long waiting times (Herd *et al.*, 2013; Moynihan *et al.*, 2015). All create costs. Considering recycling is managed by local authority councils in the UK. For many, recycling is difficult because there is uncertainty about which materials can be recycled. Likewise, instructions can be confusing and collection schedules are subject to change. The variability of recycling regimes in the UK means it is difficult to get consistent information. Housing circumstances (e.g., house type and ownership) also impact access to recycling resources. All these factors create barriers between generally pro-recycling intentions and inconsistent recycling behaviours (Geiger *et al.*, 2019; Roy *et al.*, 2022).

Poor instructions and high costs of accessing recycling infrastructure are examples of brown sludge. One solution might be simpler recycling instructions on packaging. However, this subsection emphasises that some brown sludge also emerges from institutional design. For instance, tedious paperwork which deters the adoption of environmental policies is brown sludge. The UK's Green Home Grants scheme is considered. This scheme allows homeowners in UK to apply for a cash voucher to undertake energy-efficient home improvements: installing double-glazing, insulation, and heat pumps.

Preliminary evidence suggests that brown sludge pervades this scheme. Launching in September 2020, the scheme is closed in March 2021. During this 6 months, 8,557 applicants had work completed and vouchers paid. Another 54,500 received approval for payment pending work. Another 23,500 needed to provide more information before approval. Reasons included incorrect paperwork, or applications being for work not covered by the scheme. Thus, approximately 27% of applicants struggled with the scheme when it was available. While there is no published processing time-scale, some applicants reported waiting *months* for approval (Ingrams, 2022) – quite the feat of sludge, given the brevity of the policy itself.

De Vries *et al.* (2020) discuss the administrative burden involved in greening one's home through a series of 'stages'. At the 'awareness' stage, homeowners must navigate



complex and technical energy efficiency information. At the ‘consideration’ stage, homeowners must identify reliable and trustworthy contractors. At the ‘decision’ stage, homeowners must navigate institutional processes for grants, subsidies, or tax exemptions. Each stage places new frictions on the homeowner. Some stages, such as the ‘decision’ stage, also create uncertainty – one does not know if they will receive approval. Both friction and uncertainty may deter any action at all (Sunstein, 2018).

Misaligned incentives and regulations across groups may exacerbate brown sludge. For instance, renters often have limited incentives to invest in greening their home because it is a large, upfront cost in an asset they do not own. Equally, landlords have limited incentives to invest in their assets beyond meeting relatively low legal energy standards (in the UK, landlords must comply with a poor energy standard of E, rising to D in 2024), because they often do not pay the cost of the energy bills. These are economic impediments, not sludge, yet where such impediments already exist, institutional brown sludge is likely to be especially potent.

This is because brown sludge can reduce take-up of green subsidies and programmes. Lades *et al.* (2021) discuss how administrative burden can reduce pro-environmental investments in the case of heat pumps and show that these burdens can exacerbate tendencies to procrastinate. Johnson *et al.* (2022) suggest that transaction costs may be so large that they eliminate incentives for households to implement landscape conservation programmes. Simplification of processes to apply for and access programs can help. Grieder *et al.* (2022) find that small and medium enterprises (SMEs) are more likely to adopt energy-efficiency measures when the benefits of doing so are simplified. As above, simplification could be an individual-level approach such as clearer recycling instructions. Equally, simplification could be at an institutional level, such as removing unnecessary paperwork, reducing uncertainty in processes, and conducting sludge audits to ensure policy incentives align with desired behaviours (Sunstein, 2022).

### Brown infrastructure

The above discussion presents various opportunities for using behavioural science interventions to remove barriers to green behaviour. Simplification, standardisation, and other ‘sludge-busting’ techniques all respond to transaction costs, which arise from choice architecture. Yet, some examples discussed begin to touch on policy solutions which go beyond choice architecture. We call barriers to green behaviour that arise due to factors beyond choice architecture – such as economic barriers – brown infrastructure.

Brown infrastructure can be understood as barriers which effectively exclude preferable options from individuals’ choice sets. For instance, imagine one wishes to cycle to work, rather than drive. Lacking a cycle lane, one could still cycle, but the risks and discomfort of doing so will remain high. Likewise, any benefits are also reduced. The best policy response is unlikely to be nudging, as the issue is not low motivation to cycle or a lack of knowledge that cycling exists. Instead, the solution is likely to be expanding the choice set, so that cycling becomes a viable, beneficial – and indeed attractive – option.

Further examples abound: poorly connected (or no) public transport alternatives leading to car dependency; a lack of green spaces due to urban development policies; no access to rural green spaces due to poor or inhibitive ‘right to roam’ policies; and so on. When choices such as greening homes, changing commuting behaviours, or buying greener products are outside of the choice set, they will logically not be chosen. If the current set of choices presents no way of realising one’s goals, no change in choice architecture will remove this barrier.

It is worth reflecting on the links between brown sludge and brown infrastructure. Recent debates within behavioural public policy have begun to encourage this (Chater and Loewenstein, 2022), and within the green nudging space, there is increasing recognition of the partnership between behavioural science and more traditional policy mechanisms (Nisa *et al.*, 2019; Gravert and Shreedhar, 2022). Within the administrative burden literature, it is common to acknowledge the importance of a variety of interventions to resolve challenges (Herd *et al.*, 2013; Moynihan *et al.*, 2015; Christensen *et al.*, 2019; Madsen *et al.*, 2020; Baekgaard and Tankink, 2022).

We have argued that brown sludge may exacerbate pre-existing economic barriers. For instance, where a person wishes to pursue an option but not because of economic barriers, any sludge which surrounds the options they *can* pursue is likely to be especially burdensome. Furthermore, uncertainty and search costs may be so substantial that individuals fail to perceive all their available options, experiencing brown sludge as if it were brown infrastructure. As previously discussed, emerging evidence shows that the propensity to avoid eco-information increases with the introduction of merely nominal information costs due to the tendency to exploit any moral wiggle room (Momsen and Ohndorf, 2020; 2022). When moral wiggle room interacts with additional costs constituting sludge from brown infrastructure, such as time costs, it may not be surprising that we fail to see enduring pro-environmental behaviour change. The relationship is just nuanced; and examining the barriers to green behaviours necessitates consideration of both.

As with brown sludge, brown infrastructure emerges from various places. Often, brown infrastructure is the default policy mindset. Because green policies are typically newer perspectives, they may come with less supporting evidence and induce less institutional confidence owing to a lack of experience (Mills and Whittle, 2023). e-Waste recycling in the UK is considered. UK local authorities provide waste collection and recycling to only a few types of waste – typically paper and plastic. Waste from electronics (e-waste) receives little or no public provision. This is despite the UK being the second largest producer of e-waste (Environmental Audit Committee, 2020). Recycling e-waste would induce typical recycling costs, such as collection costs. But e-waste requires different recycling processes compared to paper and plastic, inducing additional costs. Furthermore, common e-waste, such as batteries, smartphones, computer accessories, and computers themselves, are (relatively) new consumer goods and may not yet be cognizant to policymakers. The result is recycling provision that is more brown than green.

Brown infrastructure also comes from legacy decisions, a problem which also leads to sludge when administrative processes are just carried on, rather than scrutinised (Sunstein, 2022). For instance, an initial decision to prioritise driving over cycling adds to the infrastructural costs of prioritising cycling later. Norton

(2011) offers an interesting study in this area. They argue that the demise of electrified streetcars – once popular public transport systems in American cities – emerged from poor city and regulatory design. Cars were allowed on streetcar lines, causing traffic jams. Yet only streetcar providers had to bear the cost of road and track maintenance. As such, fares rose to cover these costs, while the service was declining in quality. This elevated the apparent benefits of car-ownership, causing people to adopt cars instead and shifting city planning priorities for decades towards individual vehicle ownership. Legacy decisions can make green policies look costlier and less convenient than brown infrastructure, further compounding the default mindset.

This is similar to what Rosenbloom *et al.* (2020) and others (e.g., Hickel and Kallis, 2020) argue in relation to the so-called carbon lock-in problem, where existing institutions and cultural patterns leave limited space for households to switch to alternatives. As they put it, carbon lock-in comes from ‘interconnected technologies, infrastructures, regulations, business models, and lifestyles’. As above, physical infrastructure may be dominated by roads. Taking the carbon lock-in perspective, one comes to see that even significant behavioural economic incentives may not be a solution to some problems of provision. For instance, carbon taxes may raise the cost of running a car, but pro-environmental alternatives will not be pursued if those alternatives still do not exist.

Societal impediments are important because they might prevent individuals from pursuing options they would like to. But availability *itself* is important in shaping individuals’ attitudes, beliefs, and preferences (Galbraith, 1977), which in turn feeds back into discussions of brown sludge and behavioural science (Fuller, 2020). Several studies show that the availability and proximity of green space determine green space usage (Maat and de Vries, 2006; Neuvonen *et al.*, 2007). The lack of access to nature can be profound for both pro-environmental motivation and behaviour. Soga *et al.* (2020) note that a lack of experiences in green space (and nature broadly) can lead to ‘biophobia’. This fear or avoidance of nature, in turn, leads to a lower willingness to undertake pro-environmental behaviours. Public transport is another worthwhile area to consider. Segregated cycle lanes and clearly painted cycle paths are an important determinant of bicycle usage (Doğru *et al.*, 2021). Adequate provision, rather than just information, is crucial for encouraging habitual alternative transport usage (Neoh *et al.*, 2017; Kristal and Whillians, 2020; Gravert and Collentine, 2021).

While not brown sludge, brown infrastructure is important to consider. From an environmental policy perspective, brown infrastructure cannot be overlooked, even when important choice-architectural solutions could also be pursued. From a behavioural policy perspective, brown infrastructure shapes human preferences, attitudes, and beliefs, and we could exacerbate some effects of brown sludge. Tackling brown infrastructure is not a matter of choice architecture (though behavioural science may play a role), but more often can be about assessing and expanding an individual’s choice set so they can pursue their own goals.

## Conclusion

Brown sludge contributes to the literature on behavioural climate policy by extending explanations for why people fail to pursue green behaviours, despite wanting to

(Carlsson *et al.*, 2021; van der Linden *et al.*, 2021; Gravert and Shreedhar, 2022). We argue several aspects of common barriers to green behaviour can be explained through brown sludge in terms of added transaction costs, such as search costs, time costs, and uncertainty costs.

This article also contributes to a growing body of literature which is critical in questioning the limits of behavioural science to affect substantial behavioural change (Loewenstein and Chater, 2017; Nisa *et al.*, 2019; Chater and Loewenstein, 2022; Mills and Whittle, 2023). While brown sludge can explain some barriers to green behaviour and points to some behavioural interventions to encourage pro-environmental behaviours, brown sludge is also limited as an explanation of some barriers. To account for this limitation, we also reflect on brown infrastructure, which describes barriers to green behaviours that do not arise from choice architecture.

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