review

How cities can apply behavioral science to promote public transportation use

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abstract

In this review, we present and critically evaluate evidence regarding how policymakers can apply behavioral science–based strategies to encourage the use of public transportation. After briefly introducing the theoretical background, we describe selected rigorously studied interventions informed by behavioral insights. We organize the interventions into three overarching groups: (a) communication-based approaches (information provision, goal setting and plan formation, and message framing), (b) bias-busting approaches (strategies that can counter negative perceptions of public transportation, break habits by timing interventions strategically, overcome anticipated dislike of social interactions on public transportation, and tap into emotional influences on decisionmaking), and (c) technology-based approaches (feedback and gamification). On the basis of the reviewed findings, we identify the interventions that seem most promising for increasing public transportation use.

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Core Findings

What is the issue?
Increasing public transport use is an important policy method for decreasing carbon emissions and combating climate change. However, interventions designed to do so may not always work in practice. A review of different interventions yields a framework of (a) *communication-based* approaches, (b) *bias-busting* approaches, and (c) *technology-based* approaches that are all worth considering.

How can you act?
Selected recommendations include:
1) Using multiple transport intervention strategies to have a better chance at being effective
2) Designing interventions that convey information emphasizing the intrinsic reasons for using public transportation and elements that will promote habit formation

Who should take the lead?
Researchers and policymakers in transportation

Before the COVID-19 pandemic, the transportation sector accounted for 23% of global energy-related carbon dioxide emissions, and these emissions were climbing.[1] It was clear that use of public transport was critical for limiting carbon emissions: It saved the United States roughly 4.2 billion gallons of gasoline each year.[2] But there was room for improvement, given that 88% of Americans still owned a car.[3] The pandemic has temporarily depressed ridership, but once public transport becomes safe again, policymakers concerned about global climate change and sustainability will need to use every tool possible to raise the ridership numbers.

This task will not be easy. Policy change occurs slowly, particularly in the transport sector. As Greg Marsden and Iain Docherty have noted, this slowness is related to at least two factors.[4] One is the length of the planning cycle for new investments in transportation—the "carrots" of new infrastructure that may induce individuals to use public transportation more often.[5] A second is that politicians may be reluctant to enact policy measures that could be perceived as "sticks,"[6] such as measures seen as threatening individual autonomy.[7] (One recent review of alternative transport policy measures explains when and why carrots may be effective.[8])

What is more, people's patterns of transportation use are notoriously difficult to change, in part because the patterns are often central to individuals' lifestyle and identity and can influence feelings of well-being.[9] The ways individuals get around also tend to be governed by deeply ingrained habits. Therefore, even when technological advancements and infrastructure investments have made public transportation more attractive and accessible, massive changes in human behavior will still be needed to ensure that much more of the American population transitions to environmentally friendly public transport.[10,11]

By applying insights from behavioral science, policymakers can create effective interventions to promote the use of public transportation. In the pages that follow, we briefly look at theories that may help explain people's transportation choices, and we describe a framework and a methodology we have developed for evaluating relevant studies. Then we review the strongest research having implications for interventions and, on the basis of that research, offer policy recommendations.

Insights From Behavioral Science Theory

A number of behavioral theories offer guidance for altering the transportation decisions people make.[12–17] Some view behavior change as resulting from internal factors (such as values, attitudes, and personal norms), whereas others view change as a function of external factors (such as social norms and financial incentives). Still others consider change to be the result of a combination of internal and external influences.

Rational choice theory,[12] which has been studied extensively, posits that people make logical decisions based on the goal of maximizing their best interests.[18] This theory has been refuted by a growing body of research examining decisions in a variety of domains, including transportation,[19,20] although one of its implications—that people are more likely to choose an option when they are given an incentive to do so—can be used to help prompt a switch from cars to public transportation in some contexts.[21]

Other behavioral theories—going by such names as *prospect theory*, *theory of planned behavior*, and *habit formation theory*—provide more nuanced insights.[13–17] They are used to more accurately understand and predict the hidden influences on human behavior, being based on the assumption that individuals are influenced not only by logic but also by other conscious thought processes, unconscious processes, and small situational cues. One central notion of these theories is *bounded rationality*,[12] the idea that individuals' decisions are restricted by the limited willpower, time, and energy people have to devote to thinking choices through. Bounded rationality can introduce systematic biases into people's decisionmaking, as will be seen later in the article. By explicitly incorporating ways

to overcome travelers' cognitive limitations and harness their behavioral biases, policymakers should be able to create more effective behavior change initiatives. (See note A for more information on bounded rationality.)

Overview of Research Into Changing Transit Behavior

In recent years, a growing number of experiments have tested behavioral interventions for changing people's travel behavior. However, attempts to synthesize the findings have come to conflicting conclusions. Several literature reviews (also known as *narrative reviews*)[22–24] and meta-analyses (which combine data from multiple related studies)[25–27] have concluded that these behavioral science–based interventions are generally effective at motivating car users to change their travel mode. However, a more recent systematic review and meta-analysis focusing on studies that included control groups found no significant effect on the proportion of journeys made using alternative modes of transport.[28] Further, few of the experiments cited in the literature reviews and none of the meta-analyses focused exclusively on inducing travelers to switch from cars to public transportation, and so the potential and limitations of behavioral science–based interventions for increasing public transportation are not yet well established.[29]

To help fill this knowledge gap, in our review, we highlight research that applies behavioral science to specifically promote a switch from driving private vehicles to using public transportation. As we noted earlier, our goal is to help policymakers and the practitioners who run or are otherwise involved with transportation systems to design more effective, evidence-based transport policies and programs. Our review, it should be said, is not meant to be exhaustive. Rather, we present an overview and critical evaluation of intervention approaches that have successfully changed behavior. We selected studies for inclusion if they pertained specifically to promoting a switch from car driving to using public transportation and incorporated behavioral science insights (as opposed to solely traditional policy tools such as direct incentives and regulations). When it was possible, we preferred studies that were rigorous and well controlled. As much as we could, we concentrated on gold-standard studies—namely, randomized controlled trials that had large numbers of participants who were followed longitudinally (that is, the participants were assessed at multiple time points). We chose to highlight a handful of high-quality studies in each category rather than all possible examples so that readers could learn the details of the procedures and the studies' limitations. (Readers may refer to a 2015 article by Marta Garcia-Sierra and her colleagues[30] for a review of empirical evidence on behavioral biases in general travel choices and the implications of those biases for transport policy.) We acknowledge that people can reduce their use of cars in ways other than riding buses or trains, such as by ridesharing, but those other options are outside the scope of our article.

A Framework for Behavioral Interventions

We postulate that all behavioral science interventions to increase the use of public transit fall into three broad categories: *communication-based approaches*, *bias-busting approaches*, and *technology-based approaches*. In this review, we highlight eight key interventions that fit into one or another of these categories (see Table 1). These eight stood out to us as the most promising actions when we closely examined Eric Adjei and Roger Behrens' 2012 review of theories related to experiments conducted with the aim of decreasing demand for single-occupancy car use[31] and Garcia-Sierra and colleagues' 2015 review of behavioral economics concepts and insights related to travel behavior.[30] Behavioral economics, as many readers may know, stands in contrast to classical economics in considering the psychological and social factors that influence decisionmaking and often lead people to make choices that differ from those a purely rational actor would make.

We present field studies supporting each of the eight main intervention approaches. Three of these approaches are based on communication:

Table 1. Examples of behavioral intervention studies & their action implications

Strategy and source	N	Design	Outcome	Key details of intervention	Main findings	Action implications
Communication-based approaches						
Information provision						
Brög & Schädler (1999)[34]	NA	Nonrandom control group; pre–post test	Self-reported proportion of travel on public transportation (according to a travel diary)	1. Information about public transportation alternatives 2. No information (control)	Public transportation use increased from 53% to 64% among those informed about public transportation alternatives; no change in control group.	• Provide informative brochures about public transportation services, schedules, and fares. • If possible, provide tailored information, specific to citizens' local public transportation needs and available services. • Combine the provision of information with one or more of the other intervention approaches.
Beale & Bonsall (2007)[37]	71	Randomized controlled trial	Self-reported bus use	1. Marketing material designed to correct common misperceptions of the bus services 2. Marketing material plus free bus ticket 3. Control	After six months, 62% of participants in the information only and information plus free ticket groups reported taking the bus, compared with 47% in the control group.	
Bamberg (2013)[40]	NA	Randomized controlled trial	Self-reported proportion of trips by car	1. Tailored travel information 2. Standardized travel information 3. Control	Medium (d=−0.54) decrease in car use in the tailored information condition, and a small (d=−0.17) decrease in the standardized information condition.	
Goal setting and plan formation						
Fujii & Taniguchi (2005)[42]	292	Two intervention groups; no control group; nonrandom	Self-reported proportion of trips by car (travel diary)	1. Tailored information and advice on reducing car use 2. Planning group (asked to make behavioral plans for methods to reduce car use)	28% reduction in total trip duration; 12% reduction in car-use days by the planning group. No significant changes in the advice group.	• Ask citizens to set goals for the percentage they would like to increase their public transportation use. • Encourage and support citizens in developing a detailed behavioral plan to achieve the goal.
Taniguchi & Fujii (2007)[44]	495	Nonrandom control group; pre–post test	Self-reported frequency of bus use	1. General information on how to use bus services, two free bus tickets, and a request to form behavioral plan 2. Control	Proportion of participants in the experimental group using the bus (38%) was more than double that in the control group (18%).	
Message framing						
Kormos et al. (2015)[47]	78	Randomized controlled trial	Self-reported proportion of trips by car (travel diary)	1. Low social norm information (underreporting others' ability to switch to sustainable transportation) 2. High social norm (overreporting others' behavior) 3. Control	Participants in the high social norm condition decreased commuting-related private vehicle use by five times, compared with their baseline.	• Use dynamic social norm messages emphasizing positive trends in others' behavior regarding public transportation.

Strategy and source	N	Design	Outcome	Key details of intervention	Main findings	Action implications
Bias-busting approaches						
Countering negative views of public transportation						
Pedersen et al. (2012)[56]	42	Randomized controlled trial	Predicted satisfaction with public transportation	Defocusing: Participants listed up to 10 daily activities and the amount of time allocated to each activity	Significant increase in car users' predicted satisfaction with public transportation.	• Reduce perceived waiting time and combat the perception of unreliability by giving real-time arrival (wait time) information to users. • Counter the waiting time paradox and ambiguity aversion by providing accurate waiting times in a mobile app. • Use a defocusing technique in which participants list daily activities, as well as the amount of time they usually allocate to each activity. This exercise counters the focusing illusion (the tendency to focus on a few negative aspects of public transit rather than putting the commute in the context of a full day's activities).
Watkins et al. (2011)[54]	655	Two groups; nonrandom	Self-reported perceived wait times of transit riders (survey) Actual wait times of transit riders	Perceived and actual wait times for riders with and without access to real-time information for commuters arriving at Seattle-area bus stops; measures based on observations and surveys of researchers	Perceived wait times of transit riders was greater than actual measured wait times for riders without real-time information (but not for riders using real-time information). The addition of real-time information decreased perceived wait time by 0.7 min (about 13%). Real-time information users reported average wait times (7.5 minutes) that were 30% lower than those reported by riders using traditional arrival information (9.9 minutes).	
Breaking habits						
Fujii et al. (2001)[68]	335	Pre–post test; no control group	Self-reported frequency of public transportation use	Took advantage of an eight-day freeway closure (for maintenance)	Public transportation use by commuting drivers increased from 9% to 20%.	• Leverage structural changes like temporary road closures and withdrawing parking spaces. • Offer financial incentives, like free travel cards or congestion charging. • Ask citizens to think through their various commuting options. • Use timely interventions; the best time is right after an individual has moved or started a new job.
Bamberg (2006)[71]	169	Randomized controlled trial	Self-reported proportion of car and public transportation (mobility diary)	Newly relocated residents received a free bus ticket (for one day) plus personalized information and map about bus services	Public transportation use increased from 18% to 47% among newly relocated residents.	
Fujii & Kitamura (2003)[63]	43	Randomized controlled trial	Self-reported frequency of bus use	Free bus ticket (for one month) and bus route map provided to student car drivers	Bus use frequency increased by 126% from baseline in the experimental group during the free month and by 20% one month after the free ticket expired.	

(continued)

Table 1. Examples of behavioral intervention studies & their action implications (*continued*)

Strategy and source	N	Design	Outcome	Key details of intervention	Main findings	Action implications
Bias-busting approaches (*continued*)						
Overcoming anticipated dislike of social interactions on public transportation						
Epley & Schroeder (2014)[78]	118	Randomized controlled trial	Perceptions of commuting experience	Train commuters asked to (a) speak with a nearby stranger, (b) focus on solitude, or (c) commute as normal	Commuters reported a more positive experience on public transportation when they connected with other commuters versus when they did not.	• Try physical changes in design that encourage conversations on public transportation.
Tapping into emotional influences on decisionmaking						
Pedersen et al. (2011)[83]	106	Randomized controlled trial	Current and predicted satisfaction with public transportation (self-reported via survey before, during, and after the test period)	1. Free 30-day public transportation pass and signed a commitment to use public transportation 2. Control	Experimental group satisfaction ratings at the end of the period were significantly higher than their initial satisfaction ratings as well as control group ratings.	• Expose citizens to the experience of public transportation to (ideally) improve their attitudes toward it.
Technology-based approaches						
Feedback and gamification						
Taniguchi et al. (2003)[97]	599	Pre–post test; no control group	Self-reported proportion of car and public transportation (travel diary)	Maintain travel diary, then receive seven-day feedback summarizing travel diary	Proportion of trips taken by family car decreased by 5%. Proportion of trips by public transportation increased by 4%.	• Push for the integration of feedback and gamification functionality into commuters' current routines (such as in popular apps).
Kazhamiakin et al. (2015)[95]	36 overall (20 completed all phases)	Within-participant comparison across three phases; no control group	Selection of sustainable routes via mobile app (Viaggia Rovereto)	Mobile app to log trips; sustainability features and gamification added to app during each subsequent two-week phase	Sustainable route choice significantly increased from 42.7% to 60.6% with the addition of gamification.	

Note. NA = not available. Pre–post tests compare the same group before and after an intervention. Measures such as Cohen's *d* reflect the size of the observed effects: values of 0.2, 0.5, and 0.8 typically indicate small, medium, and large effect sizes, respectively. Superscript numbers identify each source's location in the reference list.

(a) information provision, (b) goal setting and plan formation,[32] and (c) message framing.[14,15] Four of the intervention approaches revolve around what we call "bias busting." They are meant to counter (d) misplaced negative perceptions of public transportation,[12,13,18] (e) the selection of transportation modes out of habit,[17] (f) the conviction that public transportation will entail unwanted social interactions,[33] and (g) emotions that cloud decisionmaking about whether to drive or take public transport. Interventions targeted to emotions have not been well studied to date, but the literature suggests they could be important to include.[30] The final intervention approach fits into the technology-based category and involves (h) the use of feedback and gamification.

Communication-Based Approaches

Information Provision. The most common intervention for steering commuters toward public transportation is the public awareness campaign, which is undertaken on the assumption that commuters lack sufficient knowledge of their transportation options and that providing such information will alter their behavior. Indeed, some studies show that when lack of knowledge is a barrier to action, information provision can be helpful. For example, an intervention in Leipzig-Grünau, Germany, resulted in a statistically significant increase in public transportation use from 53% to 64% among those informed about public transportation alternatives (for instance, via brochures and maps) as part of the IndiMark program—which was implemented in various European countries and based on a targeted marketing approach with customized travel information. People who received no information showed no change in behavior.[34]

Travelers' perceptions of the quality of public transportation services often contradict objective reality.[35] Therefore, when accurate information is provided, travelers may find public transportation more attractive because their misperceptions have been corrected.[36] Researchers conducted a randomized controlled trial to explore whether inaccurate negative public perceptions about bus travel could be improved through informational material. The British researchers found that providing accurate information did promote bus use among habitual bus users and those with preexisting positive attitudes toward bus use, although it caused a significant decrease among already infrequent users and those negatively disposed toward bus use.[37]

"perceptions of the quality of public transportation services often contradict objective reality"

In line with the findings from Germany mentioned earlier, some researchers have argued that information about alternative travel modes must be customized to the individual to optimally promote behavior change;[38,39] such personalization can minimize the cognitive energy a person must expend in formulating new plans. For example, compared with a control group, participants in one study chose public transportation significantly more frequently after receiving a personalized travel information package, whereas the same was not true for participants who received a standardized information package of public transportation brochures.[40] This study had some limitations. Notably, participants were randomized to conditions but baseline data were unavailable; thus, the possibility of preexisting baseline differences cannot be excluded.

Overall, the effectiveness of providing information to change car drivers' travel choices seems limited. A review by Caspar G. Chorus and his colleagues of relevant studies conducted over 15 years found the evidence to be mixed.[41] Therefore, the overall effects of information provision remain uncertain. However, this type of intervention has the benefit of being politically uncontroversial and thus may be best applied in conjunction with another intervention, thereby increasing the likelihood of a positive effect.

Goal Setting & Plan Formation. Another information-based approach to switching peoples' choice of transportation uses techniques that harness their ability to change behavior voluntarily.[38,39] Sebastian Bamberg, Satoshi Fujii, Margareta Friman, and Tommy Gärling have proposed a theoretical framework for transportation behavior change, the first two stages of which are setting a change goal and forming a plan to achieve the goal.[38] Research in Japan has shown, for example, that public transportation use increased 76% for a travel feedback program that specifically requested that participants set goals (that is, participants chose the percentage by which they wanted to increase their public transportation use), versus only 25% among those not asked to set a goal.[27] Similar findings were obtained in another study by some of the same authors.[42]

Researchers have further argued that—beyond merely setting a goal—commuters must make a detailed plan for achieving the goal.[43] A meta-analysis of 14 travel management programs found, for instance, that in 11 interventions in which participants were asked to form a plan to use their cars less, the participants reduced their car use.[27] In a study using a controlled pre–post test design, in which behavior before an intervention was compared with behavior after it, researchers in Japan found a significant increase in the self-reported bus use of participants in their experimental group, who received general information on how to use bus services as well as two free bus tickets and formed a plan to increase their bus use.[44] One month later, the proportion of participants in the experimental group who reported using the bus (38%) was more than double that in the control group (18%). A limitation of this study, however, is that the control group was not randomly assigned.

The advantage of using goal setting and plan formation is that such interventions are generally well studied and seemingly effective. However, the key disadvantage is that these interventions require self-directed behavior and therefore work only on those who are already motivated to change. Consequently, they are not easily implemented with people who do not wish to alter their behavior. In addition, these interventions can take time to execute, and they may not be politically desirable if they are perceived as an infringement on individual autonomy. Last, as is true of the experiment described in the previous paragraph, these interventions tend to use a pre–post design without random assignment to groups; this feature decreases their validity for drawing causal inferences.

Message Framing. Framing involves rearranging words and concepts within a message in specific ways to encourage a particular change in decisions or attitudes without altering the greater meaning of the message. Framing is also meant to elicit behavior without limiting the recipients' freedom of choice. For instance, a message may be framed in a way that nudges employees to sign up for a discounted train pass as a default while still allowing them to opt out of the program if they desire. Message-framing strategies are helpful primarily in situations in which decisionmakers base their choices at least partly on messages they read.

In 2013, researchers found that when they described two modes of transportation according to the modes' carbon dioxide emissions, using loss framing rather than gain framing of the same data increased the likelihood that people would be more inclined to favor the lower emitter. For example, participants who read a loss-framed message were told that one mode of transportation emitted 2,900 more grams of carbon dioxide than the other on a five-mile trip (and so was worse for the environment), whereas participants who read a gain-framed message were told that the second mode emitted 2,900 fewer grams than the first (and so was better for the environment).[45] Conversely, another study showed that a benefit-framed message tested in a lab setting was more effective for increasing intentions to use green transportation modes than was a loss-framed message.[46] Thus, to date, findings related to loss–gain framing—while promising—have been somewhat contradictory.

Other message-framing studies have examined the influence of social norms on changes in travel behavior. For instance, at the University of

Victoria, British Columbia, Canada, researchers used a monthlong randomized controlled field experiment to evaluate how different descriptive social norms—descriptions of how other people typically behave—affected the willingness of faculty, staff, and student participants to reduce their private vehicle use.[47] Participants who received personalized e-mail messages that overestimated the true social norms for the use of sustainable transportation increased their own use of sustainable transportation (including public transportation, carpooling, and cycling) for commuting by approximately five times. However, this study used deception—it included statements that either under- or overestimated true social norms—to demonstrate a causal effect, which is not ethically defensible in public policy.

A less controversial approach would be to highlight an accurate *dynamic norm* (that is, a norm that is changing) by citing, for example, positive trends in behavior change among commuters. In a 14-week intervention experiment in Germany, investigators found that presenting a dynamic norm ("More and more customers are switching from to-go-cups to a sustainable alternative. Be part of this movement and choose a reusable mug") was effective at encouraging sustainable behavior.[48] The message increased the use of reusable alternatives by 17.3%.

Bias-Busting Approaches

Countering Negative Views of Public Transportation. Several different biases—systematic deviations from some benchmark of rationality—can come into play when people decide how they will travel from here to there. As a result of bounded rationality, people who are pressed for time or face multiple demands on their cognitive powers, as is common, often rely on *heuristics*; these simplified decisionmaking rules can lead to biases that can influence travel mode choice.[30,49] For example, the *immediacy effect,* also known as *hyperbolic discounting,* can come into play: This is the tendency for people to view immediate rewards as being more valuable than future rewards of equal or greater objective value. This view, in turn, can lead individuals to focus on the short-term benefits of car driving rather than the potential longer term financial and environmental benefits of using public transportation. The *car effect bias* causes car users to unreasonably interpret or discount information about travel options, dismissing alternatives and reinforcing their own driving decisions and habits. *Loss aversion* leads people to resist losing even small amounts of time by using public transportation.[30]

A few other biases that affect transportation behavior have been successfully targeted by interventions. People who are accustomed to driving can become frustrated and overestimate waiting time when using public transportation. This frustration leads to the *waiting time paradox*, wherein individuals tend to perceive their wait time as being longer than it is.[50] Additionally, *ambiguity aversion* suggests that the uncertainty surrounding travel time is more unattractive to travelers than are longer travel times themselves.[51–53] Both the waiting time paradox and ambiguity aversion can be neutralized by providing real-time arrival information for public transportation options, such as through mobile apps and signage on public transit.

One study involving commuters who were waiting for buses in Seattle found that those who used real-time travel apps had significantly lower actual and perceived wait times, presumably because they were able to plan their commutes more precisely.[54] That said, the researchers observed and surveyed only commuters who were willing to stop and talk to them on the bus platform. As such, the researchers could not control for self-selection bias; preexisting differences in mood, stress level, patience, or sociability could have affected results. Additional experimental research, ideally using randomization, is needed. It appears, however, that reducing perceived wait times could increase public transportation ridership.[55]

Another cognitive bias that can cause travelers to shy away from public transportation is the *focusing illusion*,[56] in which people concentrate on the details of a particular, or focal, event and attribute more importance and impact to those details than they actually have in reality. For example, travelers may perceive switching

"habits can sometimes prevent people from making rational choices"

to public transportation as unsatisfying because they focus on negative aspects of such a change without recognizing how little those aspects actually matter in the context of their day. This bias can be combated fairly effectively using a *self-relevant defocusing technique,* in which travelers are reminded of the minimal role that their commute plays in their overall day. In a study conducted in Sweden, for example, participants listed up to 10 of their daily activities (which usually included commuting), along with the amount of time they generally allocated to each of those activities. This simple intervention was conducted before they took a survey about their predicted satisfaction with public transportation. Presumably by revealing that public transportation was a less important part of their day than the participants would otherwise assume, the list making significantly increased the group's predicted satisfaction ratings compared with the ratings of a randomized control group. (A generic defocusing technique, which consisted of the same exercise but used a preset list of activities instead of a list generated by the participants themselves, was not effective.) Thus, reminding travelers of the minimal role their commute plays in the grand scheme of their day can counteract the focusing illusion to potentially improve attitudes and behavior involving public transportation.[56]

These biases can be further classified according to whether they (a) have been demonstrated to influence attitudes toward public transportation and have an associated intervention that has been tested (as is the case for the waiting time paradox), (b) have been demonstrated to have an effect on attitudes about transportation but have no potential intervention associated with them (as is true of the car effect bias), or (c) have not yet been documented to have an effect on transportation behavior and therefore have not been subject to an intervention (as with the immediacy effect).

The strategies discussed in this section seem worthy of both implementation and further exploration. For example, the outcomes for many of the interventions that have been tested consisted of measured attitudes toward using public transportation rather than changes in behavior. Although attitudes can indeed inform behavior, to better understand the effectiveness of an intervention, investigators need to track how these strategies influence actions.

Breaking Habits. As automatic behaviors that require minimal cognitive processing and deliberation,[57] habits can sometimes prevent people from making rational choices.[17] Of course, they can be helpful shortcuts that allow commuters to conserve brain power, saving them from having to think through the same travel problems repeatedly.[58] However, they can also pose a significant barrier to changing transportation choices. If a decision to drive to work is made when commuting starts, the driving habit may then be automatically reapplied each day without being reassessed to determine whether it is the best choice. Interventions implemented to break a travel habit should aim not only to curtail the less preferred behavior but to establish a new, more environmentally sustainable habit in its place. The strength of a travel habit, which can be measured by variability in transport choices, can predict how resistant travelers will be to an intervention meant to increase their use of public transportation.[59]

Three elements are involved in the creation of habits: repetition of the behavior, associated context cues, and rewards.[60] Financial incentives, such as free travel cards or congestion charging, can promote new habits effectively.[61–63] A review of qualitative (nonstatistical) research has found that reduced-fare promotions can successfully encourage car users to try public transportation services.[64] However, such external rewards have the potential to overshadow intrinsic motivation for using public transportation by making people feel like they have the right to pollute the environment as long as they are paying for

it. This tendency can make behavior return to baseline levels once the incentive is removed.[65]

Studies using behavioral interventions that specifically target commuting habits have had some success at increasing public transportation use. One such approach involves *vigilant monitoring*, which is the conscious override of automatic inclinations; this monitoring is difficult to sustain but can be helpful when paired with the other strategies.[60] For example, participants in two studies in Sweden were made to think through their various commuting options (such as by keeping a written travel diary that documented how they chose to get to work each day). In both studies, participants who had a strong car-driving habit reduced their use of the car.[66,67] By deliberately considering their choice of transportation, participants were able to change their driving habits.

Once a new habit is formed, however, the old one can still be triggered by cues from the environment that are associated with that behavior, such as passing familiar car routes people are used to following. It is therefore important to neutralize these context cues. One way to break the hold of cues on habits is to add friction to the undesired behaviors and remove friction from desired ones, so the impulse to indulge a habit is more difficult to act on even when cues are encountered. In the case of the car-driving habit, changes in the environment (also known as *environmental reengineering*)—such as temporary road closures[68] and withdrawn parking spaces[69]—can prompt people to rethink their commuting habits and increase their use of public transportation. These times may be the ideal moments for a messaging or a targeted-information campaign.

Changes in the choice context can also facilitate the breaking of habits.[70] For instance, the best time to implement an intervention (such as the provision of information about local public transportation) is right after an individual has moved to a new home or started a new job—times when habits are weak or not yet formed.[4] One randomized controlled trial began six weeks after participants had moved to Stuttgart, Germany. An intervention combined capitalizing on a change in context with the provision of customized information (about public transportation in the area) and a financial incentive (a free one-day travel pass). Six weeks after the intervention, public transportation use in the experimental group had dramatically increased from 18% to 47%, whereas a control group of recently relocated participants showed a much smaller increase (rising from 18% to 25%). The intervention was particularly effective among those who reported a strong intention to reduce car use. A couple of weaknesses of the study, acknowledged by the authors, were a lack of long-term follow-up and a lack of direct analysis of the effect of relocation, which would have required a comparison with an intervention group already living in Stuttgart.[71]

Existing research on changing habits to increase public transport use has some limitations. Many studies lack longitudinal follow-up as well as participant masking—that is, the participants know the general goal of the intervention. When the purpose of an intervention is known, a conscious or subconscious desire to please the researchers may affect participants' behavior while they are being monitored but not necessarily afterward. Despite these limitations, it seems that disruptive events—such as the lifting of stay-at-home orders related to the COVID-19 pandemic—can be leveraged to encourage new habits and thus effect behavior change. However, one key disadvantage of the interventions described in this section is that they are somewhat difficult to implement and so are perhaps best paired with another intervention approach, such as offering free passes.

Overcoming Anticipated Dislike of Social Interactions on Public Transportation. Satisfaction with one's work commute contributes to overall life happiness.[72] Bus commuters tend to be the least satisfied of all commuters,[73,74] although bus riding, like other means of public transportation, offers an opportunity that riders have deemed a top factor in satisfaction with their trips: talking to others during the ride.[75] Those who socialize as part of their commute tend to feel more positive about their journey.[75,76] Individuals

report increased positive affect even when they have forced themselves to act extraverted in response to a researcher's request.[77] Therefore, it is possible that public transportation companies could increase commuters' satisfaction and, in turn, ridership levels by encouraging interactions and extraversion on buses and trains.

One randomized controlled intervention, reported in an article published in 2014, demonstrated commuters' satisfaction with social interactions on public transportation.[78] Commuters in Illinois who were asked to speak to a stranger during their trip had a much more positive commuting experience than were those asked to "keep to yourself and enjoy your solitude." This pattern is the opposite of what commuters in a parallel experiment by the same authors predicted would occur.[78]

A primary hurdle to acting on the finding from Illinois and promoting social interaction among commuters is that, as the experiment involving predicted feelings showed, commuters tend to believe that solitude is preferable to social interaction. To reap the benefits of social interactions, they would first need to be convinced to give public transportation a try. Once they did, though, they might be prodded to socialize more if transportation authorities applied such strategies as making physical alterations that encouraged conversation, such as installing chairs that face each other in pods.

Tapping Into Emotional Influences on Decisions. No studies have examined interventions aimed at altering emotions in a way that will prompt people to choose public transportation, but affective influences on transit choices have been found to rival the influence of practical considerations.[79]

Obstacles to using public transportation include the positive feelings of freedom, independence, comfort, and apparent control that people ascribe to the experience of driving a car.[80–82] Making decisions using shortcuts based on their current emotions—that is, by relying on the *affect heuristic*—people may choose, for instance, to commute by car rather than via public transportation because driving makes them feel good.

Research has shown that a variety of emotions come into play when transportation decisions are made. For instance, individuals are not good at *affective forecasting*, or estimating the future impact a particular event will have on them and their emotions. This forecasting difficulty can stem from the *intensity bias*, in which people overestimate how intensely they will be affected by an event, or from the *duration bias*, in which individuals overestimate how long they will be affected by something. In the public transportation realm, commuters may overestimate how unsatisfied they would be if they shifted from driving to using public transportation.

A randomized controlled trial has demonstrated that exposing people to public transportation can improve the accuracy of their forecasts about how they will feel about a given form of transport. Participants in an intervention in Sweden were given a 30-day public transportation pass and signed a contract to use public transportation as their main travel mode to and from work for that period. They were surveyed before, during, and after the test period for their current satisfaction and predicted future satisfaction with public transportation. Their ratings at the end of the period were significantly higher than their initial satisfaction ratings and higher than the ratings of participants in the control group.[83]

Much as negative feelings toward public transportation can undermine its use, negative feelings about one's choice of less green forms of transport—such as guilt, shame, or disappointment—can lead to the increased use of public transportation.[84–86] Although it is difficult to ethically harness these feelings in an intervention, policymakers could attempt to activate the psychological mechanisms that lead to them, such as the senses of responsibility and moral obligation that are elicited by reminders of an individual's personal norms[87,88] or pro-environmental values.[89,90]

Some positive feelings about cars are reinforced, if not manufactured, by the advertising

industry. Legislators can potentially combat the industry's messages by taxing "dirty" advertising (that is, ads promoting vehicles that pollute the environment) and subsidizing "clean" advertising (for example, ads promoting public transportation).[91,92]

Technology-Based Approaches: Feedback & Gamification

Feedback through web-based apps can change transportation behavior.[93] Feedback typically works by providing a mild form of reward or punishment, which can facilitate goal-directed behavior; at times, it can consist simply of information that is useful in assessing one's progress toward a goal. Feedback can, therefore, be used as the basis for other interventions that amplify its effects, such as gamification—the application of game-design elements in nongame contexts to make behavior change fun.[94] For example, smartphone apps such as Viaggia Rovereto have reduced car use among commuters by 13% while simultaneously increasing biking, walking, and use of public transportation through such gamification features as earning points, badges, and free bikeshare memberships.[95] Although using apps that provide feedback could be considered a type of communication-based intervention, we view apps as being a distinct, separate category because they are typically more interactive than the communication-based approaches we described earlier and are meant for ongoing use rather than being focused on one moment in time.

In one review, researchers examined studies of 10 apps meant to promote the use of sustainable transportation and found that most of the apps used the strategies of personalization, feedback (self-monitoring), and information provision.[93] Only three of the studies measured actual changes in behavior, though. The three apps appeared promising, but the studies included no control groups, used relatively small samples, and relied on short time frames (less than nine weeks).

Experiments conducted in Japan before smartphone feedback and gamification apps came into wide use demonstrated one way to leverage feedback to increase public transportation use.[96] Researchers asked participants to complete daily diaries of their transportation use.[42,97] The investigators analyzed and repackaged that information for participants as three-day or seven-day personalized travel summaries, including details of where they went, how they got there, and how they could increase their use of public transportation. With these summaries, the researchers were attempting to change behavior by leveraging insights from psychological studies that indicated such information would lead to behavior change by increasing the perception of self-efficacy, eliciting thoughts of how to implement intentions, and activating personal norms (such as the belief that the individual is the kind of person who wants to protect the environment). The intervention reduced family car use by an average of 15%,[42,97] with a 4% increase in the proportion of trips by public transportation,[42] as compared with a control group that was not chosen randomly. In 2012, this type of diary-feedback procedure was tested with a dedicated app over a three-week period, and researchers discovered that a small number of frequent commuters significantly increased their walking and cycling (although not public transportation use) while also decreasing their driving by a statistically significant amount.[98] This small intervention trial did not include a control group.

Although both feedback and gamification approaches hold promise for affecting public transportation decisions, they have not been well evaluated to date. None of the app or simple feedback interventions mentioned in this section were tested in randomized controlled trials. The app studies also had a relatively small number of participants (for instance, several included only 15 or 20 participants).[96] However, the evaluations used strong outcome measures (for instance, data obtained from travel diaries filled out in real time) from actual commuters. Thus, if a larger and better controlled intervention could be designed, the results might be replicated. That said, perhaps the greatest barrier to the large-scale implementation of these strategies is the requirement that participants actively opt in and take actions they would not normally do, such as filling out diaries. Anything that requires effort can deter a change

23%

Transportation's share of global energy-related CO_2 emissions

88%

Americans who own a car

42b

Gallons of gasoline saved each year through public transport use

"even interventions with small effects can add up to a large influence on emissions"

in behavior and may cause selection biases in the research.

A simpler and more effective approach, therefore, may be to integrate feedback and gamification functionality into commuters' current routines rather than asking them to complete daily diaries or download new apps. For example, if travel feedback or gamification modules could be integrated into Google Maps and Apple Maps, they would affect a large number of commuters who already use those programs. Policymakers may consider advancing proposals that encourage the introduction of gamification functions.

Discussion

Main Findings

Transportation is a difficult domain in which to effect behavior change. Yet the research we describe in this article indicates that behavioral science–based interventions have the potential to increase public transportation use. Given transportation's high impact on greenhouse gas emissions, even interventions with small effects can add up to a large influence on emissions.

Policymakers and practitioners have various options at their disposal to encourage public transportation use. Pricing approaches, such as free bus passes, have shown success, although such fiscal measures risk crowding out travelers' intrinsic motivation to take public transit,[99] so the effects may be short-lived. Information provision through public awareness campaigns—which have long been a mainstay policy measure—can be a reasonably priced way to help correct inaccurate perceptions about transit services, but assessments of their effectiveness have produced inconsistent results. As such, we do not recommend launching an information provision campaign without also implementing one or more additional strategies that can capitalize on it. Alternative policy options and programs that leverage the behavioral insights and the three categories of interventions—specifically, communication-based approaches, bias-busting approaches, and technology-based approaches—described in this article may increase the effectiveness of traditional measures.

Advice for Policymakers & Practitioners

Given the scarcity of rigorous behavioral research on how to increase the use of public transportation and the limitations of the intervention strategies reviewed above, what should policymakers and practitioners do? As a general rule, programs that use multiple strategies have a better chance at being effective than do single-strategy programs. In particular, programs that provide free public transportation passes (incentives) and customized schedules and maps (tailored information), use effective message framing, and are delivered at times when habits are likely to be reconsidered (such as during life changes or road closures) are more likely to succeed than programs that lack these features. The odds of maintaining a new transportation habit increase if the programs also include both information that emphasizes the intrinsic reasons for using public transportation (health, happiness, and the like) and elements that will promote habit formation (that is, repetition of the behavior, cues that trigger a desire to use public transportation, or rewards for taking the train or bus).

However, this plan of action may not be feasible for all policymakers or practitioners. For example, budget-constrained programs may not have the resources to provide free transit passes or to send individually tailored messages, maps, and schedules to customers. Some programs may not have access to information about customers' recent life transitions (such as moving or taking on a new job), or they may target residents who are not necessarily undergoing a life transition.

We recommend that when policymakers design a behaviorally informed public transportation promotion strategy, they first take stock of any available resources and information and,

if possible, undertake preliminary research, such as examining existing data and reports and conducting surveys, interviews, and focus groups. Once these preliminary steps are complete, program designers can select a strategy that best suits their target population and situation. For example, if a program designer is interested in boosting transit use among potential riders and preliminary research finds that such travelers have misperceptions about the comfort or convenience of bus rides, then providing information directly to these individuals (for instance, through mail or social media) may be an effective strategy.[37]

Direct delivery of information can be augmented by applying behavioral insights derived from research into message framing or overcoming biases in decisionmaking. For example, using public advertising to encourage potential riders to defocus (that is, to think about how they actually spend their time during the day) can remind travelers of the minimal role their commute plays in the grand scheme of their workday, which can counteract the focusing illusion, thereby improving attitudes and ideally behavior involving public transportation. Correcting waiting time misperceptions can also increase perceived satisfaction with public transportation when people choose to use it. If a preintervention review of commuting trends reveals that a number of commuters are already switching to public transportation, then policymakers might want to consider delivering messages that are framed to highlight that change (that is, they may want to call attention to the *dynamic norm*).[48] Another possibility would be to explore ways to partner with motor vehicle bureaus to identify and send targeted messaging to those who have recently relocated to an area, so as to harness the effects of changed choice contexts.[71]

Alternatively, when preliminary research indicates that some residents are already interested in commuting via public transportation, policymakers could target those residents with interventions that encourage goal setting and plan formation. This approach essentially plucks low-hanging fruit for increasing transit use. Asking already engaged residents to make a plan (in person, by mail, by social media, or through another method) can help them fulfill their goal of using public transit more often, as Fujii and Taniguchi have demonstrated.[42] Asking for a public commitment can further increase the likelihood of success. Table 2 provides guidance on when to consider the interventions described in Table 1, according to the policymakers' goals and target populations. We

Table 2. Considerations for selecting an intervention approach

Project or target population characteristic	Recommended intervention
If knowledge about public transportation services is a barrier, or if misperceptions exist . . .	provide information (or combine information provision with another intervention approach).
If your target population already wants to change . . .	use goal setting and plan formation.
If you have an opportunity to present communications directly to people who travel in personal vehicles . . .	use message framing.
If you want to use a light touch . . .	provide real-time arrival information, or use message framing to remind travelers of the minimal role their commute plays in their day.
If you have the ability to change design elements of public transportation . . .	increase social interactions on public transportation.
If you are able to target travelers who have recently experienced a major life event (such as a move or a job change) . . .	take advantage of the timing to break old habits.
If you are planning a marketing campaign or a free trial . . .	tap into the emotional influences on decisions.
If you have access to personal travel data and a method of direct communication with travelers . . .	give feedback and gamify the intervention.

encourage policymakers to combine solutions to best address their specific situation.

Limitations & Future Research

Experiments conducted to study behavioral science–based interventions for increasing public transportation use are a relatively new and growing phenomenon. Syntheses of their findings have led to contradictory conclusions. As we mentioned earlier, multiple narrative reviews[22–24] and meta-analyses[25–27] have concluded that behavioral interventions can motivate car users to switch travel modes, whereas a more recent systematic review and meta-analysis examining the efficacy of behavioral interventions studied in controlled trials found no significant effect on the proportion of trips made via alternative modes of transport.[28] What is more, none of the meta-analyses conducted so far have focused exclusively on public transportation. As a result, the true potentials and limitations of behavioral interventions for increasing public transportation are not yet established conclusively.[29] More studies focused on ways to increase use of public transportation could help to resolve the contradictions.

From a methodological perspective, many studies of interventions would be improved by using a randomized controlled design, which could more convincingly demonstrate effectiveness, prove causality, and eliminate confounding factors. They would also benefit from the inclusion of measures that would help to assess whether any observed behavior change could be attributed to a change in the suspected underlying mechanism, as well as from decreased reliance on self-report measures,[100] which are less accurate than objective observations. Researchers conducting future studies should also aim to include longitudinal components that cover one or more years; none of the interventions surveyed followed participants for as long as two years, and very few followed them for even one year. Additionally, exploring potential contextual differences in the effectiveness of various intervention approaches may allow for more refined and tailored applications of the interventions. For example, a free public transportation trial was effective at the Massachusetts Institute of Technology but ineffective when implemented in Switzerland, possibly because of differences in sociodemographic factors and population attitudes.[101] Last, a major challenge to translating research insights into policy is that some of the interventions may be difficult to carry out at the scale that would be needed. Overcoming these hurdles will depend on the creativity of future researchers and practitioners.

Several experiments generated promising results but warrant replication after design improvements. For instance, collecting baseline data would strengthen findings that public transportation use increased after people received a customized travel information intervention but not after they received standardized information.[40] In addition, research on travel apps that provide real-time information about waiting times[54] and on delivering information to newly relocated commuters [71] could benefit from randomizing participants into intervention and control groups and keeping participants in the dark as to whether they are receiving an intervention. Similarly, of the few mobile apps meant to influence transportation choices that have been studied, none were assessed in randomized controlled trials and none had large samples.[93] Results from interventions using gain-[46] or loss-oriented[45] message framing have been contradictory; further studies are needed before a conclusion can be reached. Another study found success when messages were framed in a way that exaggerated the state of social norms,[47] but such exaggerations could not ethically be used by policymakers. Policymakers could, however, highlight true changing trends (that is, dynamic norms) in others' travel behavior. If future researchers made some key improvements to the designs of past studies, they would make important contributions to the field.

Some potential interventions suggested by behavioral science research have not yet been studied but seem worth examining, ideally using randomized controlled trials. In particular, several biases relevant to public transportation[30,49]—such as the immediacy effect, the car effect bias, and loss aversion—have yet to be targeted in any kind of study. Moreover,

the effects of biases such as the waiting time paradox, ambiguity aversion, and the focusing illusion have been assessed only through attitude changes rather than through the more direct measure of behavior change. Further, because commuters' satisfaction grows with any activity that makes them think their commutes offer benefits aside from simply getting to work,[102] framing a message to emphasize that commuting by public transit frees up time for other things might help elicit behavior change. In addition, as previously mentioned, travelers' emotions can influence their transport choices. For example, negative emotions (such as guilt over polluting the atmosphere) may lead to increased use of public transit,[84–86] but this line of research has not been pursued much, probably because it not ethical to try to induce negative emotions in study participants. Creative researchers, policymakers, and practitioners may, however, be able to ethically apply a similar mechanism through the activation of personal norms[87,88] (such as "I am a person who tries to behave in a socially conscious way") or proenvironmental values.[89,90]

Conducting academic studies of various interventions is not the only way to fill gaps in the research: Policymakers and practitioners can also contribute by using existing research to inform policy decisions. Documenting the successes and failures of such behavioral policy initiatives can supply data needed to provide the grounds for further study. In this way, policymakers can enrich the literature while simultaneously enacting real-world change.

Conclusions

The COVID-19 pandemic led to a dramatic decline in public transportation use. Policymakers will need to use every tool available to increase ridership once doing so is safe and to achieve a broader transition toward public transportation use. In this effort, innovative behavioral science–based policies that go beyond public awareness campaigns to include other communication-based approaches, bias-busting approaches, and technology-based approaches can potentially complement more traditional policies. The application of behavioral science to public transportation policy is a relatively new concept and, as we have noted, faces some challenges. But it holds considerable promise for effecting meaningful change in society's use of public transportation. We hope this article will motivate and enable policymakers and practitioners to explore ways to merge behavioral science with rigorous evaluation and thus more effectively encourage the use of public transportation.

end note

A. For a more detailed review of the implications of bounded rationality and social preferences for travel policy, see reference 10. For an article with a focus on behavioral economics and its implications for transport, see reference 103.

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