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Cross-sectional illusions: what we have learned about the attitude-behaviour relationship and its policy implications

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ABSTRACT

We describe and challenge long-standing assumptions in transport research about the direction and strength of the relationship between attitudes and behaviour. Economic and social science theories suggest a one-way effect from attitudes (interchangeably perceptions or motives) to behaviour. Drawing on a synthesis of empirical studies focused on car use and ownership, we show that this view is simplistic. Most research tests this relationship through cross-sectional data and reports medium to large effects from attitude to behaviour (behavioural intention). However, in modern (travel) behavioural modelling, emerging (longitudinal) panel models reveal that: (i) the attitude-behaviour relationship is bidirectional, (ii) the strength of the real effects is weaker than what is suggested by cross-sectional studies, (iii) attitudes are more a function of behaviours, not the other way around, and (iv) behaviours are more a function of past behaviours than of deliberate planning; contrary to the assumptions of the theory of planned behaviour. From a policy perspective, expecting to change (travel) behaviour solely by changing attitudes, often referred to as soft or pull measures, may be overly optimistic. We advise researchers to be cautious when using cross-sectional data to inform policy decisions. Directions for future research are also discussed.

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Cross-sectional data; panel data; attitude; behaviour; habit; transport policy

1. Introduction

Economic and psychological theories suggest a unidirectional relationship between attitudes and behaviour. Economic theories, particularly extensions of random utility maximisation that incorporate latent psychological variables (Ben-Akiva et al., 2002), and psychological models such as the theory of planned behavior (TPB) (Ajzen, 1991), suggest that individuals' attitudes (also perceptions and motivations) guide their behavioural choices or intentions. According to this perspective, attitudes can function as relatively stable cognitive elements in the short term, while remaining open to change through new experiences or interventions. In both cases, they shape how individuals form intentions and ultimately determine their actions. However, this assumption has

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been criticised both outside and within these disciplines (Kent, 2022; Schwanen & Lucas, 2011; Shove, 2010; Watson, 2012). These scholars have argued that the relationship between attitude and behaviour is complex, yet they also acknowledge that it remains a powerful factor in policy and practice. Examining these critiques within the field is particularly relevant, as transport research has often adopted these theories to explain travel behaviour. In transport policy, the attitude–behaviour relationship has attracted much attention. Cars, as the dominant mode in many cities, are at the centre of heated debates: some value them for their convenience, speed, flexibility, while others see them as a major cause of congestion and emissions. This has led researchers to ask whether soft measures such as nudging and attitudinal interventions can reduce car use/ownership, or whether push policies such as congestion charging are needed. The TPB has often been used to frame this debate, with many studies linking attitudes to behaviour and encouraging policymakers to favour soft measures. Yet the TPB has also faced criticism for oversimplifying decision-making and overstating the power of attitudes (Schwanen & Lucas, 2011; Shove, 2010). This makes it even more important to reassess the attitude–behaviour link in the context of car consumption.

Empirical research on attitude-behaviour relationships in the transport domain has largely been conducted using cross-sectional data, which captures a single snapshot of individuals' attitudes and behaviours (or intention to conduct a specific behaviour) at a specific point in time (Soza-Parra & Cats, 2024). Studies based on such data usually report moderate to strong correlations between attitudes and behaviour, reinforcing the established notion that modifying attitudes/perceptions can effectively lead to behavioural change (see Mokhtarian, 2024 for a review). This assumption underlies a wide range of policy interventions, including pro-environmental campaigns promoting climate-friendly lifestyles, efforts to change the perceived image of cars, and transport policies encouraging car use reduction. However, an emerging body of research questions the strength and directionality of the attitude-behaviour link theoretically (Chorus & Kroesen, 2014; De Vos, 2022) or when examined longitudinally (Kroesen et al., 2017; Mehdizadeh & Anable, 2025; Mehdizadeh & Kroesen, 2025; Thøgersen, 2006). A significant limitation of cross-sectional data is that they do not allow for conclusions about within-person variations and primarily capture between-person changes (Chorus & Kroesen, 2014). Unlike cross-sectional studies, which may overestimate the impact of attitudes due to simultaneity biases or social desirability effects, panel studies suggest a more dynamic and reciprocal relationship (Chorus & Kroesen, 2014; Dobson et al., 1978; Reibstein et al., 1980; Tardiff, 1977; Thøgersen, 2006). Travel attitudes can be also, to some extent, endogenous with respect to the travel behaviour itself, making it difficult to establish clear causal relationships between the two. This bidirectional influence complicates efforts to determine whether attitudes drive behaviour or vice versa, highlighting the challenge of drawing definitive (causal) inferences via cross-sectional design (Chorus & Kroesen, 2014). In addition, behaviours may not only be a consequence of attitudes but can also play a significant role in shaping them over time (Hsiao, 2007). For instance, repeated engagement in a (travel) behaviour may lead to attitude adjustments through mechanisms such as cognitive dissonance resolution (De Vos, 2018; De Vos et al., 2022; De Vos & Singleton, 2020; Festinger, 1957) or habit formation (Schwanen et al., 2012; Verplanken & Aarts, 1999).

Drawing on the core elements of a good conceptual synthesis outlined by De Vos and El-Geneidy (2022), this conceptual review critically examines the relationship between

attitudes and behaviour in the context of car use/ownership.[1] By integrating findings from both cross-sectional and longitudinal studies, the review explores the dynamic interplay between attitudes (perceptions/motives) and travel behaviour. Car use and ownership have long been central issues in transport policy, often debated due to their environmental, social, and economic implications (Anable, 2005; Cremer-Schulte et al., 2024; Soza-Parra & Cats, 2024; Toy et al., 2025; Van Eenoo, 2025). While objective factors such as infrastructure and costs play a significant role, subjective factors, particularly (un)favourable attitudes towards cars, have gained increasing attention as potential drivers of car use or as behaviour/intention (Soza-Parra & Cats, 2024). It has been argued that understanding the attitude-behaviour relationship is essential for developing effective policies that not only respond to existing levels of car use or ownership but also guide more sustainable travel choices (De Vos, 2022; De Vos et al., 2025; Mokhtarian, 2024).

The present study explores the extent to which attitudes drive behaviour, whether behaviours can shape attitudes in return, and how methodological choices influence our understanding of this relationship. By doing so, this study aims to give a more realistic picture of this theoretical framework that accounts for bidirectional and dynamic interactions between attitudes and behaviours, with implications for both research design and policy interventions. Of note, the focus of this conceptual review is specifically on the relationship between these two elements: attitude and behaviour. The role of other elements, such as the built environment, residential location, travel satisfaction, social norm, and perceived accessibility, is beyond the scope of this study.

It is also important to distinguish between (cross-sectional) studies that measure behavioural intentions and those that rely on revealed behaviour as outcome variables. While both are often grouped under the umbrella of "behavior", this conflation can hide important theoretical and empirical differences. Drawing from the TPB (Ajzen, 1991), it is established that attitudes influence intentions, and intentions, in turn, are what lead to actual behaviour. In this line, an "intention-behavior gap" has been also reported in various domains, including transport, where individuals' stated intentions do not always fully translate into revealed behaviours (Bamberg et al., 2003; Sheeran, 2002). Thus, studies that rely solely on intention as a proxy for behaviour may report stronger attitude-behaviour effects than those examining revealed behaviour, given the closer psychological proximity between attitudes and intentions. Therefore, when reviewing the literature on attitude-behaviour relationships, we also specify whether the outcome variable reflects revealed behaviour or merely the intention to act. At the same time, for the sake of parsimony and readability, we occasionally use the term "attitude–behavior" as a general label in this study that encompasses both intention-based and behaviour-based outcomes, while acknowledging the theoretical and empirical distinctions between them.

2. Method

This review aims to synthesise existing empirical studies that examine the relationship between attitudes and behaviour in the context of car use and ownership. The primary focus is on the directionality and magnitude of these relationships, comparing findings from cross-sectional and longitudinal studies to identify overarching patterns. The selection of studies for this review is based on a previously published systematic review that explored attitude (personal motives)-behaviour relationships in the topic of car use and

ownership (see Soza-Parra & Cats, 2024). However, while the original review focused on broader themes, it did not specifically target the directionality and strength of the attitude-behaviour link, which is the core aim of this review. Therefore, the initial pool of studies was re-evaluated and filtered to ensure relevance to this specific research objective. To refine the selection, the following inclusion criteria were applied: (i) the study must be empirical and quantitative, using statistical models to estimate the relationship between car attitudes and car behaviour, and (ii) the study must report the standardised effects between attitudes (i.e. car specific attitudes not general attitudes) and behaviour. Given their prevalence in the literature, the majority of the selected papers from this pool are cross-sectional, with the exception of one longitudinal study. However, we conducted a targeted, systematic search for panel studies that examine the attitude–behaviour relationship in the context of car use or ownership.[2] After reading the titles and abstracts of papers (and the full text when the title and abstract were not informative) and applying our inclusion criteria, meaning that (i) the study needed to be an empirical and quantitative academic paper using longitudinal or panel data and models, (ii) it measured car attitudes and car use/ownership, (iii) it reported significant standardised effects between car attitude and car use/ownership, and (iv) it reported direct cross-lagged effects between car attitude and car use or ownership rather than other effects (e.g. effects from attitudes to latent classes of behaviours extracted from latent class models or latent transition models), five panel papers were selected for this review.[3]

A total of 54 studies were initially identified from the systematic review conducted by Soza-Parra and Cats (2024).[4] These studies were systematically re-screened to extract only those that met the inclusion criteria outlined above. Specifically, studies that employed quantitative modelling techniques and explicitly tested the relationship between car attitudes and behaviour/intention (car use or ownership) were retained. After applying the inclusion criteria, the final sample was narrowed down to 20 studies. Among these 20 studies, only one study had used a panel model. To increase the number of studies based on panel models, employing abovementioned systematic search, four more panel models which had similarly tested attitude-behaviour relationships but were not in the pool of Soza-Parra and Cats (2024), were added. In total, 24[5] studies were used for the review.

Regarding the analysis, the absolute standardised effects between attitude and intention/behaviour were extracted from the selected studies. In cross-sectional studies, intention or behaviour is typically measured, but not both often; therefore, we specify which outcome was used. In contrast, panel models consistently incorporated behaviour as the outcome variable. The reported values (effect sizes) represent the average standardised effects for the paths attitude ⇨ intention, attitude ⇨ behaviour, behaviour ⇨ attitude, or intention ⇨ behaviour (when tested), based on the absolute values from studies examining car attitudes (or motives and perceptions) and car use or ownership. In a few studies, attitudes were measured across multiple dimensions (e.g. instrumental, symbolic, environmental), and the reported averages were derived from the absolute values of these effects. Notably, only statistically significant effects were included. Additionally, the standardised stability effects (i.e. the autoregressive effect) from cross-lagged panel models in longitudinal studies were considered for the attitude ⇨ attitude and behaviour ⇨ behaviour paths.

When comparing effect sizes from panel studies (e.g. cross-lagged panel effects) with those from cross-sectional studies, it is important to recognise that they are estimated

differently (Orth et al., 2024). In cross-lagged panel models, the effect of a predictor on an outcome is estimated while controlling for the autoregressive effect of the outcome itself. For example, the cross-lagged effect of attitude on behaviour controls for past behaviour, which has already been influenced by past attitudes. As a result, cross-lagged effects are often smaller in numerical values than corresponding effects in cross-sectional studies. However, valid comparisons across study types are possible when appropriate benchmarks for small, medium, and large effect sizes are applied. To aid interpretation, a recent meta-analysis in psychology provides benchmarks for cross-lagged effects: 25th percentile = 0.03 (small effect), 50th percentile = 0.07 (medium), and 75th percentile = 0.12 (large) (Orth et al., 2024). Gignac and Szodorai (2016) suggest the corresponding benchmarks for effect sizes in cross-sectional studies in psychology: 25th percentile, r = 0.10 (small); 50th percentile, r = 0.20 (medium); and 75th percentile, r = 0.30 (large). These established benchmarks allow for meaningful comparison across study types. In the analysis of effect sizes, only statistically significant effects are included. However, non-significant effect sizes can also be informative, particularly in understanding the full distribution of effects and the potential reduction of the attitude–behaviour relationship. However, some studies do not report non-significant coefficients or full model results. This is a well-documented issue in meta-analytic research and is often attributed to selective reporting practices and publication bias, where non-significant results are less likely to be published or fully reported (Page et al., 2019). Therefore, to ensure a fair analysis, we only consider statistically significant effects. Since only statistically significant effects are included in the review, the effect of the attitude–behaviour link may be even smaller than the review finds, as all non-significant relationships are omitted.

3. Results and synthesis of findings

Of these 24 studies, 17 (71%) were cross-sectional, examining attitude-behaviour (intention) relationships at a single time point (Abrahamse et al., 2009; Bamberg & Schmidt, 2003; Belgiawan et al., 2014; Belgiawan et al., 2016; Belgiawan et al., 2017; Bergstad et al., 2011; Choocharukul et al., 2008; Donald et al., 2014; Ikezoe et al., 2021; Lois & López-Sáez, 2009; Nilsson & Küller, 2000; Scheiner & Holz-Rau, 2007; Sigurdardottir et al., 2013; Thøgersen et al., 2021; van Acker et al., 2014; Verma et al., 2016; Zhu et al., 2012). Two studies used a cross-sectional design with the instrumental variable (IV) method to address bidirectionality, applying the two-stage least squares (2SLS) approach to mitigate endogeneity bias (Moody & Zhao, 2019; Moody & Zhao, 2020). This bias is a common limitation in standard statistical models based on cross-sectional data, which cannot fully capture bidirectional effects. The remaining five studies (21%) employed longitudinal or panel designs, allowing for the analysis of temporal (bidirectional) dynamics or within-person variations of the attitude-behaviour relationship across multiple time points (Faber et al., 2024; Kroesen & Chorus, 2018; Kroesen et al., 2017; Mehdizadeh & Anable, 2025; Mehdizadeh & Kroesen, 2025). Detailed information about the studies, such as study design, effect sizes for different paths, and the nature of the outcome measures, is presented in Table 1. Details on the source of effect sizes for each study are provided in the supplementary material file.

Table 1. Detailed information about the selected studies.

Id	Authors	Year	Type of design	Study focus	Attitude ⇨ Behavior	Attitude ⇨ Intention	Behavior ⇨ Attitude	Intention ⇨ Behavior	Attitude ⇨ Attitude	Behavior ⇨ Behavior	Nature of outcome
1	Nilsson & Küller	2000	Cross-sectional	Car use	0.46	n.a	n.a	n.a	n.a	n.a	Behavior
2	Bamberg & Schmidt	2003	Cross-sectional	Car use	n.a	0.32	n.a	0.60	n.a	n.a	Intention
3	Scheiner & Holz-Rau	2007	Cross-sectional	Car ownership and use	0.12	n.a	n.a	n.a	n.a	n.a	Behavior
4	Choocharukul et al.	2008	Cross-sectional	Car use	n.a	0.37	n.a	n.a	n.a	n.a	Intention
5	Abrahamse et al.	2009	Cross-sectional	Car use	0.27	n.a	n.a	n.a	n.a	n.a	Behavior
6	Lois & López-Sáez	2009	Cross-sectional	Car use	0.34	n.a	n.a	n.a	n.a	n.a	Behavior
7	Bergstad et al.	2011	Cross-sectional	Car use	0.13	n.a	n.a	n.a	n.a	n.a	Behavior
8	Zhu et al.	2012	Cross-sectional	Car ownership	n.a	0.17	n.a	n.a	n.a	n.a	Intention
9	Sigurdardottir et al.	2013	Cross-sectional	Car ownership	n.a	0.75	n.a	n.a	n.a	n.a	Intention
10	Belgiawan et al.	2014	Cross-sectional	Car ownership	n.a	0.24	n.a	n.a	n.a	n.a	Intention
11	Donald et al.	2014	Cross-sectional	Car use	n.a	0.24	n.a	0.75	n.a	n.a	Intention
12	Van Acker et al.	2014	Cross-sectional	Car ownership	0.14	n.a	0.01	n.a	n.a	n.a	Behavior
13	Belgiawan et al.	2016	Cross-sectional	Car ownership	0.27	n.a	n.a	n.a	n.a	n.a	Behavior
14	Verma et al.	2016	Cross-sectional	Car ownership	n.a	0.12	n.a	n.a	n.a	n.a	Intention
15	Belgiawan et al.	2017	Cross-sectional	Car ownership	n.a	0.23	n.a	n.a	n.a	n.a	Intention
16	Kroesen et al.	2017	Panel	Car use	0.05	n.a	0.09	n.a	0.78	0.81	Behavior
17	Kroesen & Chorus	2018	Panel	Car use	0.05	n.a	0.07	n.a	0.64	0.76	Behavior
18	Moody & Zhao	2019	Cross-sectional with IV	Car ownership	0.66	n.a	0.05	n.a	n.a	n.a	Behavior
19	Moody & Zhao	2020	Cross-sectional with IV	Car ownership and use	0.79	n.a	0.68	n.a	n.a	n.a	Behavior
20	Ikezoe et al.	2021	Cross-sectional	Car ownership	0.25	n.a	n.a	n.a	n.a	n.a	Behavior
21	Thøgersen et al.	2021	Cross-sectional	Car ownership and use	0.16	n.a	n.a	n.a	n.a	n.a	Behavior
22	Faber et al	2024	Panel	Car use	0.14	n.a	0.03	n.a	0.28	0.59	Behavior
23	Mehdizadeh and Kroesen	2025	Panel	Car use	0.03	n.a	0.06	n.a	0.34	0.65	Behavior
24	Mehdizadeh & Anable	2025	Panel	Car ownership and use	0.05	n.a	0.1	n.a	0.40	0.47	Behavior

3.1. General insights

The forest plot in Figure 1 illustrates the standardised effect sizes for different paths across different study designs. For clarity, this section reports aggregated results, pooling car use and car ownership studies (i.e. when effects from studies on car use and car ownership are combined); Section 3.2 follows the same approach and then examines the results separately. Among cross-sectional studies, the attitude ⇨ intention effect sizes ranged from 0.12 to 0.75, whereas the attitude ⇨ behaviour effect sizes ranged from 0.12 to 0.46. On average, the effect was stronger for attitude ⇨ intention (0.30) than for attitude ⇨ behaviour (0.23). These findings reinforce the conventional assumption that attitudes shape behavioural intention and behaviour in a unidirectional manner. In a cross-sectional study, van Acker et al. (2014) examined the effect of behaviour on attitude as well. Their findings showed that car ownership (availability) had a minimal effect on car-related attitudes (effect size = 0.01), whereas attitudes had a stronger effect on behaviour, with an effect size of 0.16.

In two cross-sectional studies using the IV method, which can reveal bidirectional effects at a single point in time, the strength of the relationship between attitude and behaviour was

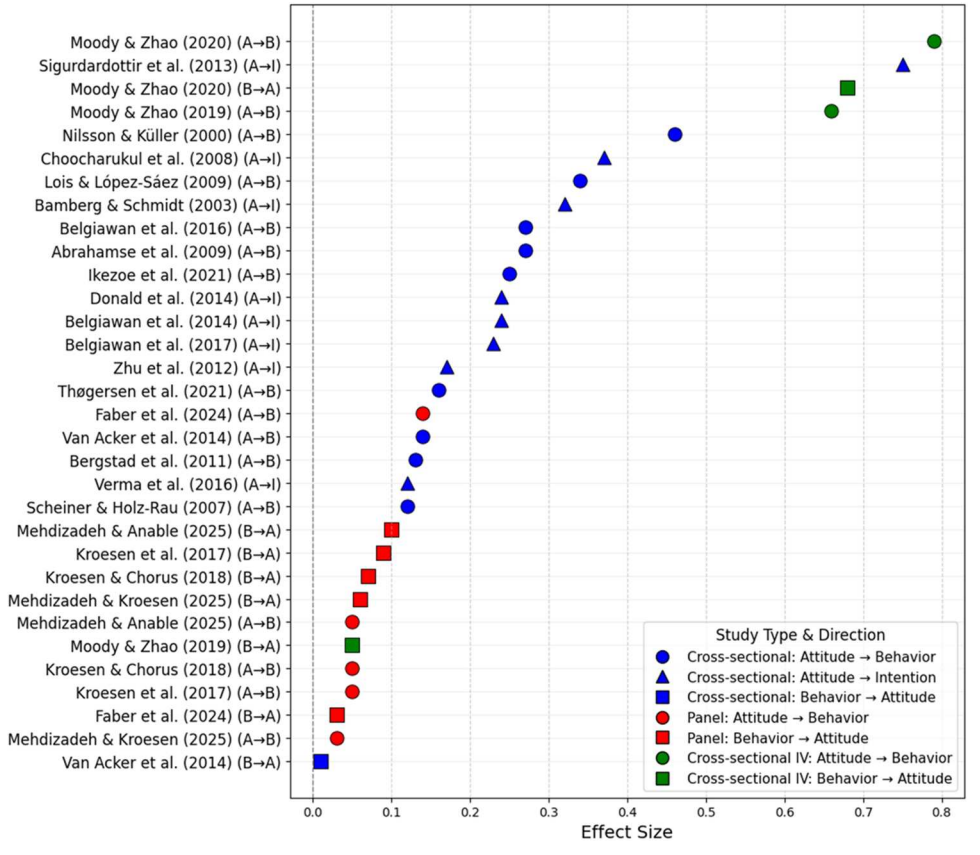

Figure 1. Forest plot of (standardised) effect sizes of the attitude-behaviour (intention) or behaviour-attitude in different study types.

Note: A: Attitude; B: Behavior; I: Intention.

notably high. However, the studies still reported that the effect of attitude on behaviour (0.66 and 0.79) was larger than the reverse, consistent with main assumptions from other cross-sectional findings. Of note, IV methods do not directly capture temporal changes, meaning they infer bidirectionality rather than observing it over time. Since both studies using IVs report exceptionally large effect sizes, we treat them as outliers and exclude them from the main analysis (effect sizes). Panel models are generally more reliable for assessing bidirectionality because they observe actual changes over time rather than inferring relationships from a single time point. In the five panel studies, the estimated standardised effects of attitudes on behaviour were significantly weaker. Note that, to facilitate a fair comparison between cross-sectional and cross-lagged effect sizes, we restate the effect size thresholds applied in this study (see Methods). Cross-sectional effect sizes are classified as small ($r = 0.10$), medium ($r = 0.20$), and large ($r = 0.30$), whereas panel effect sizes are classified as small (0.03), medium (0.07), and large (0.12). On average, the standardised effects for attitude ⇨ behaviour in panel studies was around 0.06, (< 0.07, i.e. below the medium effect size threshold) ranging from only between 0.03 and 0.14, weaker than those reported in cross-sectional studies (the attitude ⇨ behaviour effect size in cross-sectional studies was 0.23 (> 0.20), indicating a medium-to-large effect). These findings suggest that the true effect of attitudes on behaviour is likely overestimated in cross-sectional research, possibly due to methodological limitations such as the temporal proximity of measurement points and the lack of consideration for within-person changes.

While cross-sectional studies predominantly assume a unidirectional effect from attitudes to behaviour, the longitudinal (panel) studies indicate a bidirectional relationship. In all five panel studies, behaviour was also found to influence attitudes over time, with behaviour ⇨ attitude effects being of comparable or even greater magnitude than attitude ⇨ behaviour effects. Across panel studies, on average, the standardised effect of behaviour ⇨ attitude was about 0.07 ranging from betwen 0.03 and 0.10, suggesting that behaviours reshape attitudes over time, albeit with a medium effect size according to cross-lagged effect size benchmarks. Of note, the average effect of attitude ⇨ behaviour in panel studies with only using two waves (Kroesen & Chorus, 2018; Kroesen et al., 2017; Mehdizadeh & Anable, 2025; Mehdizadeh & Kroesen, 2025) is weaker than a panel study with multi waves. In a multi-waves panel model, the longitudinal relationship between attitude and behaviour shifted slightly, with attitudes exerting a greater influence on behaviour (Faber et al., 2024). Despite this change, the relationship was still bidirectional (Faber et al., 2024). It is important to note that this latter finding is based on a single study, which limits the ability to draw definitive conclusions about the effects observed in short-term versus long-term panel data (i.e. two-wave versus multi-wave panel). In general, these findings challenge the long-standing assumption and suggest that (i) real-world behaviours can also play a role in shaping individual attitudes over time, rather than attitudes solely dictating behaviours, and (ii) the true relationships between attitude and behaviours from panel models are weaker than what we see from cross-sectional study designs.

3.2. More detailed insights

Figure 2 summarises how attitude and intention/behaviour actually affect each other cross-sectionally (excluding cross-sectional design with IV method) and longitudinally.

Arrow thickness in Figure 2 is normalised to established, study-design–specific effect size benchmarks (see Method), reflecting effect size magnitude rather than raw numerical values shown in Figure 1, to enable fair visual comparison across cross-sectional and panel studies. The average effects of attitude on intention and behaviour, and vice versa, shown in Figure 1 were accordingly categorised as negligible, small–medium, medium, medium–large, large, or very large, and represented by proportionally scaled arrows in Figure 2. The values for behaviour-to-behaviour and attitude-to-attitude effects are drawn from stability estimates reported in longitudinal studies (i.e. cross-lagged panel models).

A key insight that emerged from our analysis concerns the distinction between behavioural intentions and revealed behaviours, a topic long emphasised in the literature (Ajzen, 1991; Sheeran, 2002). Among the 24 studies reviewed, 16 used revealed behavioural data as the outcome measure, while 8 used intentions. This distinction was especially relevant within the 17 cross-sectional studies: 9 measured revealed behaviour, while 8 focused on intention. However, all five panel studies employ revealed behaviour without including intention in the models.[6] According to the TPB (Ajzen, 1991), attitudes influence behaviour indirectly through intentions. Cross-sectional studies that use intention as a behavioural proxy may therefore overestimate the strength of the attitude–behaviour link. Our distinction between intention and behaviour offers some support for this concern. Among cross-sectional studies, the average effect size for attitude ⇨ intention was 0.30, while for attitude ⇨ behaviour it was 0.23. Although this difference suggests that attitudes are more closely associated with intentions than with revealed behaviours, it is important to note that the difference is modest. Moreover, there is considerable variability across studies; in some cases, the attitude ⇨ behaviour effect size in one study exceeds the attitude ⇨ intention effect reported in another. This variability may partly stem from differences in how attitudes and behaviours are operationalised across studies. According to the TPB (Ajzen, 1991), the strength of the attitude–behaviour link

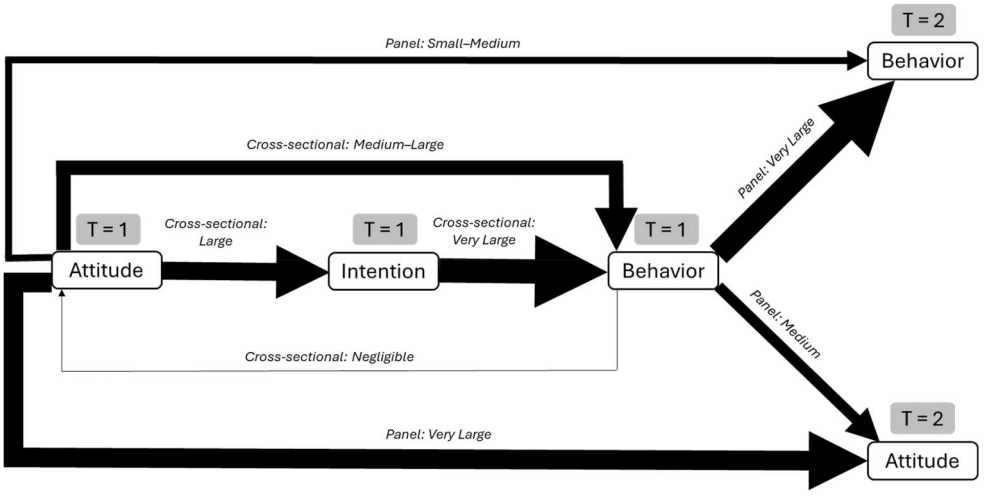

Figure 2. Schematic illustration of the attitude-(intention) behaviour relationship (arrow thickness normalised to design-specific effect size benchmarks).

can depend on the degree of correspondence between the measured attitude and the specific behaviour in question. Although we only included effect sizes derived from car-specific attitudes toward car use or ownership in our pool of studies, there is still no universal consistency in how these attitudes are defined or measured. Some measures of car attitude are formulated in ways that closely resemble behaviour, whereas others capture more abstract evaluative or affective dimensions. When this principle of compatibility is not followed, effect sizes are likely to be weaker. It is possible that some of the variation observed in our review reflects inconsistencies in measurement specificity, with studies that more closely align attitudes and behaviours showing stronger associations. Thus, the relationship is not clear-cut, and caution is warranted in making strong claims based solely on these average values. Still, the broader pattern aligns with our overarching conclusion: the effects of attitudes on revealed behaviour tend to be weaker than the effect of attitude on intention in cross-sectional research. This supports the idea that studies measuring intentions may report inflated associations due to cognitive proximity between variables, rather than capturing real-world behavioural dynamics. Furthermore, our longitudinal panel studies consistently reveal weaker, bidirectional effects between attitudes and behaviour, challenging not only the assumptions of cross-sectional models but also aspects of the TPB. These findings suggest that changes in attitudes alone may not strongly drive behavioural or intention change, particularly in the presence of strong habits or structural constraints, consistent with the TPB's recognition of the (possible) direct role of perceived behavioural control in affecting behaviour. Moreover, behaviour may, over time, influence attitudes at least as much as the reverse. Ultimately, this strengthens the case for moving beyond static frameworks and toward dynamic, panel-based models that better account for the temporal, reciprocal, and within-person changes.

Only two cross-sectional studies in our sample reported an effect from intention to behaviour, yielding a notably high average standardised effect size of 0.67. This aligns with the TPB, which posits intention as the most immediate predictor of behaviour (Ajzen, 1991). However, the scarcity of studies ($n = 2$) and their reliance on cross-sectional designs, which are known to inflate effect sizes due to common method bias and shared measurement context, calls for caution in interpreting these results. More importantly, none of the longitudinal (panel) studies in our sample tested the intention ⇨ behaviour link directly. This is surprising, since intention plays a central role in TPB. If intention is truly the key link between attitudes and behaviour, the lack of long-term evidence makes it hard to trust the assumed cause-and-effect relationship. Overall, our findings support a larger point: while cross-sectional studies may align with theory, they probably overstate how strongly attitudes and intentions predict behaviour. Without tracking people over time, claims about how intentions lead to behaviour remain weak.

Another key finding from the panel studies was the strong consistency (stability) in behaviour over time. The influence of past behaviour on future behaviour was found to be much stronger than the influence of attitudes on behaviours (Kroesen & Chorus, 2018; Kroesen et al., 2017; Mehdizadeh & Anable, 2025; Mehdizadeh & Kroesen, 2025; Thøgersen, 2006). On average, stability effects for past behaviour predicting future behaviour were about 0.60 ranged from 0.47 to 0.81, indicating a high level of behavioural consistency over time. In contrast, the effect of attitudes on future behaviour remained

weaker, reinforcing the notion that (travel) behaviour has been more a function of past behaviour than of deliberate, planned action, contrary to the assumptions of the TPB. This suggests that interventions aiming to change behaviour may need to focus on disrupting existing behaviours rather than simply altering attitudes. Moreover, attitudes also show a degree of stability over time, however, their stability is weaker (on average around 0.55) compared to that of behaviour. In sum, cross-sectional studies, which dominate this field of research, generally report a moderate to strong unidirectional effect from attitude to behaviour (or intention). However, longitudinal analyses reveal a different dynamic, incorporating both stability (consistency) effects and cross-lagged effects. In general, panel models show that past behaviour strongly influences current behaviour. Moreover, there is a bidirectional relationship between attitude and behaviour, with behaviour exerting a somewhat greater effect on attitude over time than the reverse. Nevertheless, these bidirectional (cross-lagged panel) effects remain weaker than what cross-sectional studies typically suggest.

It is important to distinguish car ownership from car use behaviour. Car use may reflect more frequent behaviour, whereas car ownership may represent a more deliberate, investment-oriented decision, as highlighted in dual-process models (Ouellette & Wood, 1998; Stern, 2000; Thøgersen et al., 2021). Since our panel studies did not include any that exclusively examined car ownership, a separate comparison of ownership versus car use between cross-sectional and panel designs did not make sense. However, such a separation is possible within cross-sectional studies, as our pool includes both exclusive car use and exclusive car ownership papers (see Table 1). Our separated analysis of cross-sectional studies by ownership and use (not shown in Figure 2 for the sake of parsimony) indicates that (i) intentions are again more strongly influenced by attitudes than actual behaviours, (ii) the pattern of effects[7] for ownership versus use is broadly consistent with the aggregated results (i.e. where car ownership and use are lumped together in Figure 2). This suggests that, at least in cross-sectional research in our pool, combining ownership and use does not substantially change the observed relationships, and (iii) interestingly, when exclusively comparing the attitude-behaviour effect for car use between cross-sectional and panel studies, it further supports our conclusion that this effect is more strongly overestimated in cross-sectional studies than in panel studies. Future panel research should separately track ownership and use to better capture the differential cognitive and habitual processes underlying these decisions. Another issue with car ownership studies is that they often do not distinguish consistently between conventional vehicles and newer technologies, such as electric vehicles. Research on innovation adoption suggests that consumer decision-making differs for new versus well-established products, with novel technologies typically influenced by higher perceived risks, learning effects, and social factors. Consequently, the attitude-behaviour relationships observed for car ownership may vary depending on whether the vehicle is traditional or alternative-fuel, particularly in contexts where households have installed private charging infrastructure.

One might ask what role habits have played in previous (cross-sectional) studies. Although we did not directly compare the relative contributions of habits and attitudes in predicting behaviour, the autoregressive effects observed in the panel models (i.e. the stability or consistency of behaviour from one time point to the next) may partly reflect habitual processes. This implies that part of the observed effect of past behaviour

may operate through habit-like mechanisms. It is important to note, however, that past behaviour captures not only habit but also other factors that influenced behaviour previously. This distinction is important for interpreting autoregressive effects, as these effects should not be equated solely with habit. In this context, behaviour refers to the observable action at time point T, whereas habit denotes the automaticity, repetition, and cue-dependence underlying that action (Verplanken & Aarts, 1999). There has been debate over whether travel behaviour is primarily habit-driven or the result of deliberate planning in the literature. Some researchers argue that it is largely shaped by habits (Gärling et al., 2001; Verplanken et al., 1997), while others emphasise the role of deliberate decision-making (Ajzen, 1991; Ajzen & Fishbein, 1980) or a combination of both (Verplanken et al., 1994). Several cross-sectional studies have also included direct measures of habit as predictors of travel behaviour (not limited to car ownership or use) (see Gärling & Axhausen, 2003 for a review). A few of these studies, particularly those examining public transport use with cross-sectional data, suggest that both habit and deliberate planning significantly influence behaviour, with deliberate planning sometimes having a slightly greater effect than habit (Nordfjærn et al., 2014; Şimşekoğlu et al., 2015). Of note, the effect of habit likely varies by which mode people travel. Different types of travel behaviour may involve habit to varying degrees depending on how frequently the behaviour is performed. For example, some studies examine habitual public transport use, which may occur daily, while others focus on car choice decisions, which may be made less frequently. If frequency differs across these behaviours, this could partly explain why habit and behavioural consistency appear to play a stronger role in some contexts than others.

In a seminal cross-sectional empirical study in the context of car choice behaviour, Verplanken et al. (1994) reported that when car choice habit is strong, the attitude–behaviour relation is weak, whereas when habit is weak, the attitude–behaviour relation is strong. However, it should be noted that for some individuals, particularly those living in areas with limited access to public transport or other alternatives, car use may not reflect a freely made choice but rather a constrained one. In such contexts, the notion of "choice" is affected by structural limitations, making it important to critically reflect on what constitutes a "free" choice in travel behaviour. Bamberg et al. (2003) conducted a longitudinal study to examine the impact of introducing a prepaid bus ticket on college students' use of bus. Their findings suggest that travel mode decisions are primarily based on deliberate reasoning and can be influenced by interventions that modify individuals' attitudes, perceived social norms, and perceived behavioural control. They also observed that previous travel behaviour predicts future behaviour only when contextual factors remain stable. Although the study by Bamberg et al. (2003) utilised longitudinal data, it did not assess cross-lagged effects between attitudes and behaviour over time. Instead, the analysis focused on the cross-sectional relationship between attitudes and behaviour (or intentions) at each wave, which may account for the strong attitude–behaviour associations reported (Bamberg et al., 2003). However, when synthesising the relative effect of attitudes and habits on travel behaviours, Gärling and Axhausen (2003) highlight the important role of habits, a conclusion also largely based on cross-sectional research or experiments. Therefore, past research addressing this debate, which has relied on habit and attitude measures in cross-sectional data, has produced contradictory and conflicting results. In line with the trend of effect sizes illustrated in Figure 2, we believe that more

panel study designs and (cross-lagged) panel modelling approaches are needed to support the notion that travel behaviour may be more a function of past (or habitual) behaviour than of deliberate action.

Why is a panel data/model superior to cross-sectional data/model when studying the relationship between behavioural consistency (habits), attitudes, and behaviour? And why should we stop evaluating their relative effect using only cross-sectional data? The answer lies in what panel models, particularly (random intercept) cross-lagged panel models ((RI-)CLPM), allow us to uncover that cross-sectional approaches cannot. Cross-sectional data provide a snapshot at one point in time, which can reveal correlations but offers no insight into direction or temporal dynamics (or within-person changes over time) (Chorus & Kroesen, 2014). We cannot tell if attitudes influence behaviour or if behaviour reinforces attitudes. In contrast, (RI-)CLPM uses repeated measures over time to examine how one variable (such as attitude) at an earlier time point (e.g. wave 1) predicts another variable (such as behaviour) at a later time (e.g. wave 2; a year later), while controlling for prior levels of both (Finkel, 1995). This structure allows researchers to identify the direction of effect, explore reciprocal relationships, and measure stability versus change. In the context of behaviour research, (RI-)CLPM helps distinguish true change from stable individual differences, offering a much clearer understanding of whether and how attitudes or past behaviours (and habits) lead to (current) behavioural outcomes. For researchers and policy-makers seeking to influence behaviour over time, this makes panel models not just useful, but essential.

From a policy perspective, the findings challenge the long-standing assumption that changing attitudes will automatically lead to behavioural change. Given the weak and bidirectional nature of attitude-behaviour relationships observed in panel studies, expecting policies to drive behavioural change solely through attitude shifts may be overly optimistic. Moreover, since behaviour appears to be more a function of past behaviours, policies should focus on altering structural conditions, incentives, and habitual disruptions rather than relying on attitudinal campaigns alone. The London 2012 Olympics provide a good example of the gap between stated travel attitudes or intentions and actual behaviour change. To reduce pressure on the transport system during the Games, Transport for London encouraged commuters to reduce, re-time, re-route, or re-mode their travel (Parkes et al., 2016). More than half of participants (54%) made at least one change during the event, but only 6% continued those changes afterward. Notably, many who had no prior intention to change still modified their behaviour temporarily. This suggests that external disruptions can prompt short-term change even without internal motivation. However, lasting habit change is unlikely without consistent push measures. The study by Parkes et al. (2016) highlights the limitations of relying on attitude alone to predict behaviour and underscores the need for interventions that address both structural conditions and psychological factors to achieve sustained change. Additionally, the marked contrast between cross-sectional and longitudinal findings raises concerns about the validity of policy recommendations based on cross-sectional studies. Thus, researchers should be cautious when using cross-sectional data to inform policy decisions and instead prioritise longitudinal approaches to capture the true (causal) dynamics between attitudes and behaviour.

4. Conclusion

This conceptual review challenges the long-standing assumption that attitudes strongly dictate behaviour, as often suggested by cross-sectional studies in the transport domain. By analysing both cross-sectional and longitudinal research in the context of car use/ownership, it is evident that the attitude-behaviour relationship is bidirectional, but its real strength is weaker than previously assumed/reported in cross-sectional studies. Longitudinal evidence suggests that behaviours, such as car use, have a stronger influence on car attitudes than the other way around. More importantly, consistency in behaviour plays a dominant role over deliberate decision-making when it comes to travel behaviour. These findings carry significant implications for both policy and behavioural modelling. Policies that rely solely on changing attitudes, often referred to as "soft" or "pull" measures, such as awareness campaigns or incentives to promote sustainable travel, may be insufficient to drive meaningful shifts in behaviour. If the real effects between attitude-behaviour is weak and behaviour influences attitudes more than attitudes affect behaviour, then interventions should prioritise direct behavioural changes rather than expecting attitude shifts to lead to action. To effectively reduce car consumption, policymakers may need to implement stronger "push" measures, such as restricting car access/ownership in urban areas, implementing congestion pricing, or reducing parking availability. These more radical policies can directly change habitual behaviours, which in turn may gradually reshape attitudes away from car dependency. Recent studies highlight the potential for implementing more radical transport measures in the transition toward sustainable transport systems (Ballo et al., 2023; Mehdizadeh et al., 2024; van Wee et al., 2023). When combined with our finding that behaviour can influence attitudes over time, this helps to explain phenomena such as rising levels of public support following the implementation of push policies such as congestion charging. For example, once people experience such measures, they may realise the impact is less negative than anticipated, leading to a shift in attitude (e.g. "It was not as bad as I thought"). Thus, a combination of restrictive policies and structural changes in transport systems may be necessary to achieve long-term behavioural shifts toward sustainability.

4.1. Future research directions

Future research on attitude–behaviour dynamics in transportation would benefit from addressing the following directions.

- **Extend analyses beyond the car to other travel modes**

  Future research could investigate how the directionality and strength of the attitude–behaviour relationship vary across different travel modes. In the current study, the focus was on cars; however, other modes such as bicycles and public transport might show similar or different patterns. For example, in a recent study using panel data, Egner et al. (2024) show bidirectionality between cycling attitude and cycling in Norway, highlighting that attitude influences behaviour more than the reverse. Other older studies such as Tardiff (1977), Dobson et al. (1978), and Reibstein et al. (1980), focusing on public transport, also focused on reciprocal effects between bus use and attitudes (using cross-sectional data). Extending future analyses across different modes or even comparing attitude–behaviour dynamics in the transport domain with those in other fields can be interesting.

- **Investigate the time sensitivity of attitude–behavior relationships**

  In future longitudinal panel studies, the time sensitivity of the attitude–behaviour relationship should be investigated further. According to cognitive dissonance theory, it might take years for the dissonance between attitude and behaviour to be minimised. Most current panel models use one- or two-year gaps between waves, while longer intervals, for example, five years between waves, might change the direction and strength of the effects between attitudes and behaviours. This can be insightful, as it shows when and how attitudes can really affect behaviours or vice versa.
- **Incorporate intentions and broader psychological elements into (cyclical) panel models**

  In order to better validate or challenge theoretical frameworks such as TPB, it would be useful if panel models also incorporated intention in addition to revealed behaviour in the structure of (RI-)CLPMs. Current panel models only use revealed behaviour when testing the role of attitudes, while in TPB or cross-sectional SEMs, intention is often used as the mediator. New theoretical models combining a variety of approaches show the existence of a cyclical model (De Vos et al., 2022) where different psychological elements can mediate or moderate the relationship between attitude and behaviour. The directionality of chain links between behaviour, satisfaction, attitudes, desire, intention, and other constructs such as habits, subjective norms, and perceived needs should be explored in future panel models.
- **Develop transport-specific benchmarks for longitudinal (panel) effect sizes**

  To facilitate meaningful comparisons between cross-sectional studies and panel models, valid benchmarks are needed within the transport research field. Because effect sizes for cross-lagged effects are estimated differently from coefficients in cross-sectional models, establishing such benchmarks is essential. Cross-lagged effects also tend to be smaller than their cross-sectional counterparts. Given that the number of longitudinal studies in transport research remains limited compared with other fields, such as psychology, we adopted benchmarks from psychology. In this study, we identified only five panel studies, which may increase sensitivity to idiosyncratic characteristics of individual studies. Additional panel studies are needed to establish more robust effect size benchmarks. Future transport research should also aim to develop field-specific guidelines for interpreting cross-lagged effect sizes. For instance, using a representative sample of studies published in the transport literature, the 25th, 50th, and 75th percentiles of the observed distribution could correspond to small, medium, and large effects, respectively.
- **Apply longitudinal approaches to policy perceptions and spillover effects.**

  In line with our study, longitudinal data and models can also be used to explore the directionality of effects between perceptions such as perceived fairness of controversial car-centric policies and acceptance or support behaviours before and after implementation. This line of inquiry may also intersect with election geography. Recent studies suggest that voting for certain political parties could serve as a proxy for transport-related attitudes (Furlong et al., 2025; Marquet et al., 2024). Additionally, panel data can be employed to investigate positive or negative spillover effects across domains of pro-environmental behaviour, for example, how purchasing or driving an electric vehicle may influence air travel behaviour and vice versa. These applications extend the utility of longitudinal approaches and offer avenues for future research.

Notes

1. Conceptually, car use may reflect more routine behaviour, whereas car ownership may represent a more deliberate, investment-oriented decision. Accordingly, this study examines the effects of car-related attitudes on car use and car ownership separately, in addition to reporting aggregated effects (i.e., when effects from studies on car use and car ownership are combined due to the limited number of panel studies; see Section 3.2).
2. E.g., ("car use" OR "car ownership" OR "car usage") AND ("attitude" OR "perception" OR "motive") AND ("cross-lagged")
3. Note that the following papers (with panel design) seem to be also relevant to our study, but they do not meet our all-inclusion criteria. For example, in Bamberg et al. (2003)'s study, even though they used two-wave panel data/models, they did not test cross-lagged effects between A and B over time, i.e., A1 → B2 or B1 → A2 (see Bamberg et al. (2003), Figure 2, page 182). So, this study does not meet one of our inclusion criteria. In Kalter et al. (2021) (see Kalter et al. (2021), Section 4.3 or Table 6) and Tao, Y. (2024), they test the directionality of effects between preference and behaviour not between attitude and behaviour. Kalter et al. (2020) and Haustein and Kroesen (2022) conducted panel studies using latent transition models to examine car attitudes and car use or ownership. While these studies categorised participants into different profiles, they did not explore the directional relationship or report direct effect sizes between attitudes and behaviours. In van de Coevering et al. (2016; Van De Coevering et al., 2021), the primary focus of these studies is not on the direct attitude–behaviour link but rather on broader constructs such as built environment effects, residential self-selection, or reverse causality.
4. The papers are provided by Soza-Parra and Cats (2024) in the following supplementary material file's link: https://www.tandfonline.com/action/downloadSupplement?doi=10.1080%2F01441647.2023.2278445&file=ttrv_a_2278445_sm2347.docx
5. 19 cross-sectional papers + 5 panel papers. Please note that within the Soza-Parra and Cats (2024) pool and other sources related to longitudinal studies, we identified several relevant attitude–behaviour studies. However, we excluded them from the final analysis because they did not meet all our inclusion criteria, particularly the requirement for reported effect sizes between attitudes and behaviours. For instance, among the cross-sectional studies, a well-known example is Anable (2005), which uses a segmentation approach to cluster individuals based on their attitudes and behaviours. However, due to the study's design, it was not possible to extract effect sizes specifically representing the relationship between attitudes and behaviours. Similarly, examples of longitudinal studies have been discussed earlier.
6. To enable comparison between cross-sectional and panel studies, one might expect that only the attitude ⇨ behaviour paths should be compared across study types. However, as shown in Figure 2 and discussed later in the text, the average effect sizes for both attitude ⇨ intention and attitude ⇨ behaviour in cross-sectional studies exceed 0.20 and are relatively similar in magnitude. Hence, both paths are retained in the presented illustration.
7. Car Attitude ⇨ "Car Ownership Intention" is 0.30; Car Attitude ⇨ "Actual Car Ownership" is 0.22; Car Attitude ⇨ "Car Use Intention" is 0.31; Car Attitude ⇨ "Actual Car Use" is 0.30.

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