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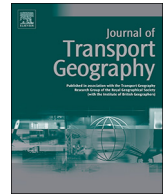
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Impacts of the built environment and travel behaviour on attitudes: Theories underpinning the reverse causality hypothesis

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ABSTRACT

The importance of attitudes in the relationship between travel behaviour (TB) and the built environment (BE) has been the subject of debate in the literature for about two decades. In line with the Theory of Planned Behaviour, attitudes – which affect behaviour – are generally assumed to be constant. However, it is plausible that attitudes can change, both directly, or indirectly, through the impact of the built environment on travel behaviour, a process which is referred to as reverse causality (RC). Based on literature from social psychology, this paper provides a conceptual model for the explanation of attitude changes. It also reviews the literature in the area of BE and TB concluding that two explanations dominate: a change in attitudes due to new experiences which can be underpinned by learning theories, and a change in attitudes due to mismatches between attitudes and behaviour which can be explained by cognitive dissonance theories. The literature also suggests a few additional explanations, while we also suggest explanations not provided in travel behaviour literature. Finally, we present an agenda for future research.

1. Introduction

For decades, researchers have been studying the influence of the built environment (BE) on travel behaviour (TB). Most of these studies have found an association between people's residential location and their travel mode choice. People living in low-density suburban neighbourhoods use the car for the lion's share of their trips, while residents in denser and more mixed neighbourhoods walk, cycle or use public transport more frequently. These differences can partly be explained by a high level of car accessibility and relatively long travel distances in suburban/rural areas, and relatively short travel distances and the presence of public transport services in more urban areas (for an overview, see [Ewing and Cervero, 2001, 2010](#)). These outcomes underpin spatial concepts such as compact urbanisation, transit-oriented development, new urbanism and smart growth. This direct relationship between BE and TB is depicted in [Fig. 1](#) with arrow (Abou-Zeid et al., 2012).

It is currently assumed that travel behaviour is guided by attitudes, especially since the publication of Ajzen's Theory of Planned Behaviour ([Ajzen, 1991](#)). There are numerous definitions of attitudes, and the formulations differ but content-wise they are quite similar, at least as

used in the debate on the BE and TB. Attitudes are usually defined as the degree to which the evaluation of a certain object, person or behaviour is favourable or unfavourable (for an overview of definitions of attitudes, see [Ajzen, 1991](#); [Eagly and Chaiken, 1993](#); [Gärling et al., 1998](#); [Van Acker et al., 2010](#)). The work of [Kitamura et al. \(1997\)](#) was one of the first and most cited papers to explicitly study attitudes in the context of the influence of the built environment on travel behaviour. Travel-related attitudes can relate, for instance, to mode-specific attitudes (e.g., a preference for using public transport) or travel-liking attitudes (e.g., the extent to which a person perceives travel time as wasted time). The majority of studies found that travel-related attitudes have an important effect on TB, such as the positive effects of mode-specific attitudes on the choice for that mode (e.g., [Beirão and Cabral, 2007](#); [Heinen et al., 2011](#)). Some studies even claim that attitudes have a stronger impact on TB than the BE does (e.g., [Bagley and Mokhtarian, 2002](#); [Handy et al., 2005](#); [Kitamura et al., 1997](#)).

Besides a direct effect of attitudes on TB ([Fig. 1](#), arrow 3), studies have also proposed indirect effects of attitudes on TB, through the BE ([Fig. 1](#), arrow 2). In this process, which is referred to as residential self-selection (RSS), a preference for a certain travel mode leads to people making choices for areas which allow them to travel in their preferred

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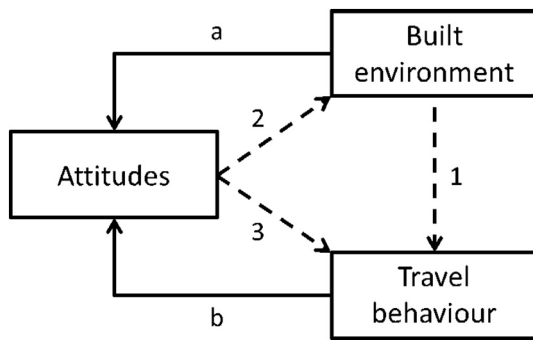


Fig. 1. Relationships between attitudes, the built environment and travel behaviour (solid lines indicate reverse causality) (based on Van de Coevering et al., 2016).

way. Consequently, the direct effect of the BE on TB might be overestimated as attitudes partly explain the impact of the BE on TB (for related debates, see Cao et al., 2009a,b; Chatman, 2009; Kroesen and Chorus, 2018; Naess, 2014). We refer to Cao et al. (2009a) for a review of empirical studies, and Mokhtarian and Cao (2008) for a review of methodologies. Although studies found strong effects for attitudes on TB, most of them still found significant effects of the BE on TB, independent of self-selection effects (e.g., Ewing and Cervero, 2010; Cao et al., 2009a).

Based on previous travel behaviour studies it can be argued that attitudes, BE and TB are interlinked as shown in Fig. 1. Attitudes affect TB both directly (arrow 3), and indirectly through the BE (arrows 2 and 1). However, it is possible that attitudes do not only affect, but are also affected by the BE and TB (Fig. 1, arrows a and b). Although long acknowledged as a hypothetical possibility (e.g., Handy et al., 2005; Kitamura et al., 1997; Naess, 2009), these attitude changes are often ignored in empirical travel behaviour studies, partly due to a lack of longitudinal data, making it impossible to measure the evolution of attitudes. Furthermore, attitude change has rarely been the focus of studies in this field, since influential theories, such as the Theory of Planned Behaviour, assume that attitudes remain constant. However, other psychological theories such as the Theory of Cognitive Dissonance (Festinger, 1957) and more recent empirical studies have focused on attitude change. In this study we refer to the effects of TB on attitudes, or the BE on attitudes as ‘reverse causality’ (RC). This study focuses on the direct and indirect impact of the BE as well as on direct attitude changes resulting from TB.

Part of the discussion on RC relates to issues of causalities (e.g., Cao et al., 2009b; Heinen et al., 2018), and the question of to what extent longitudinal studies adequately address the importance of residential self-selection when analysing the influence of the built environment on travel behaviour. Heinen et al. (2018) argue that existing studies do not take these elements into account, partly because several of the assumed conceptualisations do not fully capture self-selection effects. In this paper we do not further discuss the causal structures between BE, TB and attitudes, nor the question of whether and under which conditions attitudes change over time (not all empirical research found attitudes to change over time, despite changes in travel behaviour (e.g., Clark et al., 2016)). Rather, we make the assumption that RC is a plausible hypothesis. In this paper, we investigate the question of how RC processes can be explained, linking:

- (i) three clusters of processes leading to attitude changes, i.e. cognitive, behavioural and affective processes;
- (ii) ‘triggers’ that influence those processes; and
- (iii) ‘attitude changes’.

For this, we developed a conceptual model on attitude changes. We show that two explanations dominate: a change in attitudes due to new

experiences which can be underpinned by learning theories, and a change in attitudes due to inconsistencies between attitudes and behaviour which can be explained by cognitive dissonance theories. We consequently examine to what extent the RC-hypothesis has been tested empirically. Finally, we discuss how RC can best be investigated with respect to the impact of the built environment on travel behaviour. To the best of our knowledge, such a systematic discussion of the RC hypotheses and theories is not yet available.

From a transport-geographical perspective, RC is an important process: if attitudes are not included in studies on the impact of the BE on travel behaviour, RSS cannot be recognised and the role of the BE might be overestimated. On the other hand, not acknowledging that the BE itself can influence attitudes leads to an underestimation of the role of the BE. This understanding is also valuable for practice: a theoretical and empirical demonstration that travel attitudes effectively change as a result of changes in the BE, creates supports for innovative BE designs. However, this requires a better understanding of how these attitude changes occur.

This paper is organised as follows. Section 2 presents our conceptual model for attitude changes, and discusses the triggers and processes leading to attitude changes. Section 3 presents an overview of the literature on the reverse causality hypothesis. Section 4 finally summarises and discusses the main findings of our paper and presents avenues for future research in this area.

2. Psychological processes leading to changes in attitudes

2.1. Reverse causality

In this section, we develop hypotheses on RC. It is assumed that attitudes can change due to influences from TB and/or the BE. As explained above, the focus of this paper is not on the general impact of TB on attitudes, but on the impact of the BE on attitude change, either directly or via the impact of the BE on TB. In order to better understand the latter impact, we also make references to the more general travel behaviour literature on the impact of TB on attitudes.

Regarding the indirect effects via TB, studies have found that travel-related attitudes and mode choice are interdependent, and that attitudes both affect – and are affected by – mode choices (Dobson et al., 1978; Golob, 2001; Tardiff, 1977). Some studies even found stronger effects for the impact of travel behaviour on attitudes than vice versa (Golob, 2001; Kroesen et al., 2017; Reibstein et al., 1980). Reibstein et al. (1980), for instance, indicate that the frequency of bus use positively affects the attitude towards bus use. Other studies confirm this finding: a mode shift from car to public transport was accompanied by improved attitudes towards public transport (Abou-Zeid et al., 2012; Fujii and Kitamura, 2003; Fujii et al., 2001). According to De Vos et al. (2019), the effect of mode choice on attitudes towards that mode is indirect through satisfaction levels whilst using that mode. Based on this literature we conclude that a cyclical process between travel-related attitudes and mode choice is likely; a positive stance towards a certain mode can increase the use of that mode, while using that mode frequently might change the attitude towards that mode (Bohte et al., 2009; Van Acker et al., 2011).

It is also plausible that RC occurs because the BE directly influences attitudes. Although some studies suggest that the BE can impact people's travel attitudes, whether or not through travel patterns stimulated by the built environment (Cao et al., 2009b; Chatman, 2009; de Abreu e Silva, 2014; Ewing et al., 2016; Handy et al., 2005; Kitamura et al., 1997; Lin et al., 2017; Naess, 2009; Naess, 2014; Van Acker et al., 2014)), only a few have actually tested it. Bagley and Mokhtarian (2002) – using cross-sectional data from residents in the San Francisco Bay Area – found no significant effects for the impact of respondents' residential location on travel-related attitudes, while Van de Coevering et al. (2016) – using longitudinal data from Dutch residents – found that living far away from a railway station negatively affects attitudes

towards public transport use while positively affecting attitudes towards car use. Two studies focused on recently relocated residents. Both [De Vos et al. \(2018\)](#) – using quasi-longitudinal data from Ghent (Belgium) – and [Wang and Lin \(2019\)](#) – using panel data from Beijing (China) – found that attitudes towards the travel modes stimulated by the respondents' new neighbourhood significantly improved after the respondents moved.

2.2. A conceptual model for attitude changes

In this section we present our conceptual model for attitude changes. In contrast to the previous studies as mentioned above, we propose a more complex conceptualisation, as presented in [Fig. 2](#). Notice that this model is limited to attitude changes, and does not conceptualise behavioural changes. We derived our conceptual model analytically, inspired by literature.

2.2.1. Three clusters for attitude changes

Many studies consider attitudes to be stable constructs; partly inherited, and only subject to very slow change (e.g., [Tesser, 1993](#)). The commonly used Theory of Planned Behaviour ([Ajzen, 1991](#)), for instance, views behaviour as an outcome of attitudes, but does not consider changes in attitudes. However, theories have been developed that can help explain changes in attitudes. A first step in understanding why attitudes can change is to distinguish the processes that lead to attitude changes (arrows 4a, b, c) ([Eagly and Chaiken, 1993](#); [Triandis, 1971](#); [Zanna and Rempel, 1988](#)). [Eagly and Chaiken \(1993\)](#), for instance, suggest cognitive, behavioural and affective processes. We also adopt this classification, as it is helpful for understanding the reasons why attitudes change. To summarise, the cognitive cluster refers to people *knowing* something they did not know before, and consequently changing their attitudes. The behavioural cluster refers to people *doing* something. The affective cluster makes people *feel* something which leads to attitude changes. As we will explain below, these three clusters of processes are related and can be influenced by the same triggers.

2.2.2. Triggers

We assume that these processes change due to so-called 'triggers' (arrow 1a, b, c). We cluster triggers into three categories, the personal level, social level and the environmental context. The personal level refers to the actors own information and experiences. The social level refers to the influences from the actor's network, such as family, friends or colleagues. The third level, the environmental context, refers to all the other triggers, dominant subcategories being changes in the BE, and in the transport system (for example: changes in transport services, traffic congestion, traffic safety), and other societal changes (such as societal changes in norms and values, an economic recession, or levels of immigration).

Biographical key events, a category of triggers mentioned in the literature on attitude changes (see also below) can be personal, social, and environmental triggers. For example, the birth of a child can be seen as both a personal and a social trigger, as it affects the actor directly, but also indirectly through his or her network. A change in residential location is a biographical key event which leads to a change in the environmental context. Triggers are the reason why people change what they know, feel or do. They are 'external initiators of internal processes'¹ which lead to attitude change.

We developed our conceptual model primarily to explain why the BE can lead to attitude changes (directly or via TB). Related triggers can be placed in the category 'environmental'. A biographical key event like a change in job or residential location, can expose people to another type of residential or work area (for the importance of such events for attitude changes, see [Van der Waerden et al., 2003](#)). Also the BE

surroundings of a person can change, for instance when a new light rail station or shopping centre opens. However, our conceptual model is more general since it also contains non-BE related triggers. The trigger 'new information' can influence cognitive processes, for example if people become convinced of the negative environmental impact of car use (arrow 1a) (e.g., [Tertoolen et al., 1998](#)). Some triggers, social influence in particular, can also directly change behaviour (arrow 1c). For example, due to social influence people might decide, for health reasons, to walk short distances (instead of using the car). Non-BE related environmental triggers can originate from, for instance, the societal trend for healthy living. This may increase the importance of active modes, resulting in a change in mode-specific attitudes. Furthermore, changes in income – for example due to the general societal trend of a booming economy – can affect the travel options people can afford and their attitudes towards these options. For example, people may change their attitudes towards bigger cars once they can afford one themselves. These examples relate to the cognitive and behavioural cluster (arrows 1a and 1c). In addition, the affective cluster (arrow 1b) can be influenced by triggers. For example, the birth of a child might change attitudes towards environmental impacts in general and consequently of driving.

2.2.3. Relationships between clusters of processes

Unlike the conceptualisation of [Eagly and Chaiken \(1993\)](#), and in line with – amongst others – [Trafimow and Sheeran \(2004\)](#) we argue that relationships exist between the three clusters of processes. First, cognitive and behavioural processes can influence affective processes (arrow lines 3a, 3b), and can therefore indirectly affect attitude change. Cognitive processes refer to people knowing something they did not know before, which may influence their emotions and thus their affective processes (arrow 3a) (e.g., [Chatterjee and Scheiner, 2015](#); [Goetzke, 2008](#); [Heinen et al., 2013](#)). For example, people receiving new information about climate change (influencing cognitive processes) which may affect them emotionally (influencing affective processes). Processes in the behavioural cluster can also touch people emotionally (affective processes, arrow 3b) ([De Vos and Singleton, 2019](#)). For example, a person moves to bike-friendly neighbourhood, starts cycling and enjoys it, which is a change in behavioural processes which leads to related positive emotions. We also argue that the behavioural and cognitive cluster can mutually influence each other (arrows 2a, 2b). For example, information about climate change can influence cognitive processes, which can lead to more sustainable travel behaviour (updating behavioural processes, arrow 2a). On the other hand, experiences with public transport can influence behavioural processes and make people more aware of the real travel times and costs of that mode (arrow 2b).

2.2.4. Conflicts between clusters of processes

People may also experience conflicts between the three clusters of processes ([Trafimow and Sheeran, 2004](#)). For example, people might be aware that their driving behaviour is harmful to the environment (conflict between cognitive and behavioural processes) or they might like to drive fast, whilst knowing that this jeopardises safety (conflict between affective and cognitive processes). It should be noted that both the affective cluster and attitude change can impact the behavioural cluster (as indicated by dashed arrows 3c and 4d), since attitudes and the experience of activities can influence future choices ([Ajzen, 1991](#); [Kahneman et al., 1997](#)). However, as the focus of this paper is on the elements explaining attitude change we will not further discuss or analyse these two relations.

2.2.5. When do attitudes change?

Changes in attitudes are more likely to occur under specific conditions. We assume that attitude changes are more likely after certain life events have taken place (e.g., a residential relocation), after either very positive or very negative experiences, or when dissonances develop

¹ We thank one of the anonymous reviewers for suggesting this formulation.

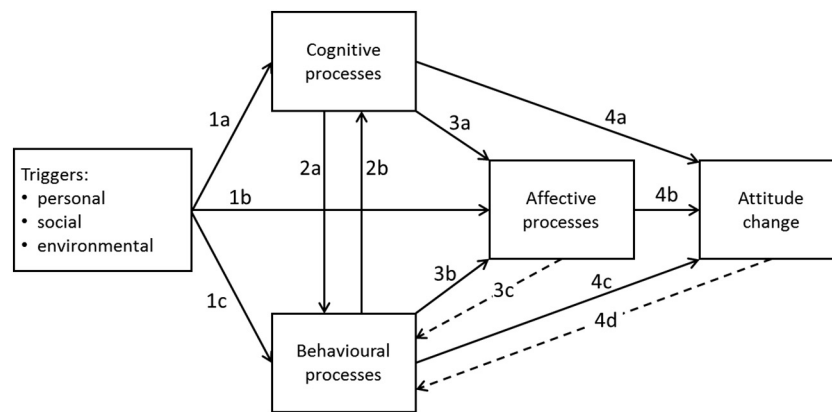


Fig. 2. a conceptual model for attitude changes.

between attitudes and behaviour. For instance, when people have just moved to a residential location which is not their preferred one, travel attitudes may change relatively fast due to (i) a new context leading to a reconsideration of travel choices, (ii) the development of dissonance between attitudes and BE, or (iii) possible positive experiences with travel modes stimulated by the new BE. However, after living in a neighbourhood for a while, it can be assumed that attitudes become more congruent with the BE and are less subject to change. This idea is in line with the study of De Vos et al. (2018) suggesting that residential dissonance might be a temporal situation that can fade away after a certain period of time. However, this hypothesis was only supported for suburban residents and cannot be generalised due to the exploratory character of their study.

Having explained the model in broad outline, we will now discuss the three clusters of processes in more detail.

2.3. Attitude change due to cognitive processes

The first cluster that leads to attitude change consists of cognitive processes, in which new information is gained about a certain object, behaviour or person. This information can be gained by direct experience, e.g., knowledge about the characteristics of a certain activity as a result of performing that activity. For instance, someone using certain public transport services for the first time might create a negative or positive attitude towards public transport because they (dis)like certain characteristics of the service. In other words, they gain knowledge about the chosen service by using it, which affects their attitude towards it. New information can also be gained indirectly, e.g., by reading articles, blogs, advertisements, or by talking to friends and family about that particular object (such as a travel mode). It might also be possible that – just like behaviour (Ajzen, 1991) – attitudes are affected by subjective norms, i.e. a (perceived) social influence to have a certain opinion about a specific attitude object. For example, employees will be more inclined to commute by bicycle if they notice that the employer appreciates this or if colleagues do the same (Heinen et al., 2013). Many studies also show that travel behaviour and social networks are related, i.e. people mostly attach importance to what others in their networks do. For example, Arentze and Timmermans (2008) propose a framework for the interactions between social networks, social interaction, and activity-travel behaviour. As an example of many empirical papers in this area, Siegel and Wang (2019) show that in some subcultures, millennials' travel behaviour is influenced by people in their social network. The impact of others can also play another role. Some studies indicate that if more people use a certain travel mode, this makes this mode more attractive for others (as a result of social spill-over effects) (Goetzke, 2008). Furthermore, travel behaviour is subject to social influences, and thereby influenced by the travel behaviour of family or friends, partly through socialisation processes in which individuals

learn skills, knowledge, and values according to their position in a group or society (Chatterjee and Scheiner, 2015).

In addition, it is also possible that people will – intentionally or not – look for new information to change their attitudes, so their attitudes better fit with their behaviour. A person being forced to travel with a certain travel mode might look for new, positive information for that mode, so that the attitudes towards that mode improve. However, we are not aware of any travel behaviour studies which analyse attitude change due to cognitive processes.

Learning theories explain how people learn in general. Many learning theories exist, but it is beyond the aim of this paper to review these theories from the perspective of attitude changes. We limit ourselves to Bloom's pyramid-shaped taxonomy of learning (Bloom, 1956), a taxonomy that inspired many others in their development of learning theories. Bloom distinguishes a hierarchy of multiple levels of learning. This theory allows us to explicitly distinguish the different ways of learning via knowledge and experiences. At the bottom level, the easiest ways of learning are via knowledge and comprehension, achieved through means such as reading newspapers or blogs, viewing graphics, or hearing information.

Higher levels are application, analysis, synthesis and evaluation, respectively. Experiences are a more active form of learning and in terms of Bloom's taxonomy are linked to 'application' or even higher levels in the pyramid. Via experiences, such as the use of a new travel mode, people update their knowledge base of this mode. They might remember the characteristics of travelling by public transport, for example, and via analysis and synthesis make the knowledge easily accessible for future travel decisions. Zigmont et al. (2011) explain that the learning processes that result from experience depend on the characteristics of the experiences, the persons, and the learning environment. Hence, there is not one way of learning via experience that applies to all contexts (learning environment) and to all people. To give an example of the learning context: travelling with others by train for the first time might make people aware of some of the characteristics of travelling by train, such as the availability of free wifi on the train, which they might not have known about had they travelled alone.

The literature on attitude change discussed in this paper does not provide the theoretical mechanisms, as explained by learning theories, of why the cognitive, behavioural or affective processes influence attitudes. Weinberger and Goetzke (2010) explicitly address learning as a mechanism in the context of car ownership, without referring to learning theory. They found that previous experience and learning was very important for car ownership. The BE can lead to attitude changes (RC) via cognitive processes, for example a person planning to move to another neighbourhood who reads about travel opportunities in the new neighbourhood and consequently changes their attitudes.

2.4. Attitude change due to behavioural processes

The impact of behavioural processes is linked to ‘doing’, and experiences are therefore required. The dominant reason why these processes change attitudes as found in the literature is that people align their attitudes with their behaviour. When behaviour and attitude do not match there is a tendency to adjust attitudes so that they correspond with prior behaviour. In addition, people may change their attitudes after experiencing certain behaviour, regardless of any aim to reduce dissonance between attitudes and behaviour.

The cognitive dissonance theory (Festinger, 1957) and Balance theory (Heider, 1958) indicate that people try to reduce a possible inconsistency between two or more attitudes, or between behaviour and the attitudes related to this behaviour. Such an inconsistency (or dissonance) can result in psychological discomfort or dissatisfaction. People might change their behaviour to reduce this unpleasant state of mind, or change their attitudes, restoring the balance between attitudes (and behaviour). People might (subconsciously) change their attitudes by linking positive elements to the chosen alternatives and negative elements to the non-chosen alternatives, in order to justify a decision (often referred to as choice-supportive bias or post-purchase rationalization). The self-perception theory (Bem, 1967) on the other hand, argues that people develop their attitudes by observing their own behaviour (mostly when no previous attitudes regarding the attitude object were present), and deducting what attitudes have led to it. While the first two theories indicate that attitude change is a result of the experience of (mainly negative) emotions, the latter theory indicates that people change attitudes independent of experienced mood. The above-mentioned theories contrast with theories indicating that behaviour is an outcome of attitudes (e.g., theory of planned behaviour (Ajzen, 1991)).

According to the cognitive dissonance theory (Festinger, 1957), behaviour will mainly affect attitudes when a dissonance between attitudes and behaviour occurs. In terms of travel behaviour, two different types of dissonance can be distinguished, i.e., travel dissonance and residential dissonance (De Vos and Singleton, 2019). Travel dissonance, for instance travel mode dissonance, refers to the situation in which the chosen travel mode is not the preferred one. Only a limited number of studies have focussed on travel mode dissonance. Tertoolen et al. (1998) found that providing information on the environmental impact of car use can result in a dissonance between the attitudes and behaviour of car users. Kroesen et al. (2017) found that people who do not travel with a favoured travel mode are more likely to change their attitudes than their behaviour, while De Vos (2018) found that travel mode dissonance negatively affects travel satisfaction. Furthermore, studies focusing on air travel often find that frequent flyers claim to be environmentally aware (Font and Hindley, 2017; Higham et al., 2014; Lassen, 2010; McDonald et al., 2015). In situations of travel dissonance it is plausible that satisfaction levels will be low and discomfort occurs. Changing behaviour is one way to try to reduce this dissonance and the accompanying discomfort, i.e. choosing another travel mode for future trips. However, when changing travel behaviour is not possible (e.g., due to budgetary or built environment constraints), people may change their attitudes in favour of the mode they are forced to use, so that there is less dissonance between their attitudes and behaviour. This is also in line with the Transaction Cost Theory (e.g., Williamson, 1981), which proposes that the term ‘costs’ does not only include monetary costs, but also non-monetary costs like time, effort, or discomfort. Such costs can be a barrier to changing travel mode, even when a change in BE makes a change in TB an interesting option. If people do not change their travel behaviour, despite attractive alternatives being available, then the likelihood of attitudes changing – due to a change in experience – decreases.

Another type of cognitive dissonance related to travel behaviour, is residential dissonance (Cao, 2015; Cho and Rodriguez, 2014; De Vos et al., 2012; Kamruzzaman et al., 2013; Schwanen and Mokhtarian,

2004, 2005). Residential dissonance occurs when people live in a neighbourhood which does not stimulate the use of a valued travel mode (e.g., a car-loving person living in a low-traffic city centre). Since the residential environment might force these people to travel in an undesired way (i.e., with an undesired travel mode) travel satisfaction might be negatively affected (De Vos et al., 2016). As a result, these people might consider relocating to a neighbourhood where travelling by their preferred mode(s) is easily accessible. However, as a residential relocation generally brings along considerable monetary as well as non-monetary costs, a change in attitudes seems to be a more obvious way to reduce the dissonance between travel attitudes and the chosen residential neighbourhood (De Vos et al., 2012). This is a very clear case of RC: the BE makes people change their attitudes towards travel modes to reduce the dissonance between attitudes and behaviour.

A distinction can be made between the effects of behaviour on attitudes in a stable situation and in an unstable situation. In a stable situation (e.g., people travelling by car for all their trips and residing in a certain neighbourhood for a certain number of years) it seems plausible to assume that the effect of behaviour on changes in attitudes will be less strong than when a certain context change occurs, for example a (forced) change in mode choice after residential relocation. Some studies found that attitudes towards public transport become more positive after increased usage, due to temporary changes in the road network (e.g., Fujii et al., 2001), or by providing habitual car drivers with a free bus ticket for a certain period of time (Abou-Zeid et al., 2012; Fujii and Kitamura, 2003). De Vos et al. (2018) and Wang and Lin (2019), on the other hand, indicate that travel attitudes change when people move to a different residential neighbourhood. It could potentially be argued that – just like travel behaviour (e.g., Verplanken et al., 2008) – travel attitudes are less likely to be changed in a stable context when compared with an unstable context. However, these studies could suffer from self-selection biases. People willing to participate in such studies are likely to be predisposed – or at least open-minded – towards changing their attitudes. Results from these studies can therefore probably not be generalised to the total population.

2.5. Attitude change due to affective processes

The third cluster of processes refers to affective processes, also labelled as emotional processes. In this case, attitudes change due to ‘feeling’: people change their attitudes based on negative or positive emotions towards a certain object or activity. As conceptualised in Fig. 2, emotions can be influenced directly by triggers, by cognitive or by behavioural processes. Just as behavioural intentions are affected by how negatively or positively people have experienced past behaviour (e.g., Kahneman et al., 1997; Russell and Lanus, 1984; Triandis, 1977), it is also possible that attitudes change due to the emotional experience of previous choices (e.g., Eagly and Chaiken, 1993; Zanna and Rempel, 1988). Positive emotions due to experienced activities, objects or services will positively influence the attitude towards the attitude object, while negative emotions due to experience will worsen people's stance towards the attitude object.

As made explicit above, the impact of emotions derived via experiences on attitudes can be underpinned by learning theories, classical conditioning and association. In terms of the taxonomy of Bloom the higher levels in the pyramid might affect people emotionally. The literature discussed in this section does not explicitly refer to learning theories. Satisfaction can even be regarded as the dominant force in attitude formation (Zajonc, 2000). Satisfaction with a certain choice or activity can influence the attitude towards that choice or activity through processes such as classical conditioning, in which a person is rewarded or punished each time an action is performed until the person associates the action with pleasure or distress (Clore and Schnall, 2005; Eagly and Chaiken, 1993).

In terms of the TB-BE interaction this means that satisfaction with travel, and satisfaction with the residential location will affect travel-

Table 1
processes and theories found in reverse causality literature.

	Source	Processes	Theories
1	Wang and Lin (2019)	Experience	Implicit: learning theories
2	De Vos et al. (2018)	Behavioural cluster: matching attitudes and behaviour	Cognitive dissonance reduction
3	Kroesen and Chorus (2018)	Experience	Implicit: learning theories
4	Lin et al. (2017)	Behavioural cluster: matching attitudes and behaviour	Cognitive dissonance reduction
5	Kroesen et al. (2017)	A bit implicit, but predominantly behavioural cluster: matching attitudes and behaviour	Cognitive dissonance reduction
6	Ewing et al. (2016)	Experiences	No explicit theory, implicitly: experiences/learning theories
7	Klinger and Lanzendorf (2016)	Behavioural cluster: justifications	cognitive dissonance theory
8	Yang et al. (2015)	Experiences.	No explicit underpinning. Implicit: learning theories
9	Van de Coevering et al. (2015)	Context change: biographical key events (e.g., birth of a child, change of jobs) – more open mind	Implicit: learning theories
10	Dill et al. (2015)	Experiences/exposure	No explicit underpinning. Implicit: learning theories
11	Van Acker et al. (2014)	Behavioural cluster: matching attitudes and behaviour	No explicit underpinning. Implicit: learning theories
12	Chorus and Kroesen (2014)	Experiences/exposure	Learning theories
13	Spears et al. (2013)	Impact of BE on TPB, including attitudes and perceived behavioural control	Cognitive dissonance reduction, implicitly: self-perception theory
14	Bohte et al. (2009)	Experience	Perception–Intention–Adaptation (PIA) theoretical framework. Builds upon TPB.
15	Naess (2009)	Experiences	No explicit underpinnings. Implicit: Learning theories
16	Chatman (2009)	Experiences	Cognitive dissonance reduction
17	Schwanen and Mokhtarian (2007)	Behavioural processes	Not explicit, implicit: learning theories
18	Bagley and Mokhtarian (2002)	Not explicit, likely: experiences	Experience/learning theories
		Experiences	Cognitive dissonance reduction
			Not explicit, implicit: learning theories
			Cognitive Balance; mutual dependence between attitudes and behaviour

related attitudes. For travel behaviour, we mainly see strong potential effects from satisfaction with the use of a certain mode on attitudes towards that mode. Furthermore, it is also possible that, for instance, negatively perceived trips with long durations will result in a negative stance towards travelling in general (e.g., feeling that travel time is wasted time). However, the evaluation of a certain activity (and the possible effects on attitude change) might not be equal to the mean of all the feelings experienced during that specific time frame. People tend to remember the most intense feelings during – and the feelings near the end of – a certain activity (i.e., peak-end rule) (Fredrickson and Kahneman, 1993; Kahneman et al., 1993). As a result, critical incidents during travel (e.g., car accidents, extreme weather conditions during active travel, substantial public transport delays), can negatively impact attitudes towards the mode used (Van der Waerden et al., 2003). Furthermore, it is also possible that residential satisfaction affects travel-related attitudes. People not living in a neighbourhood stimulating the use of (one of) their preferred travel mode(s), might not be satisfied with their residential neighbourhood, as the physical characteristics of the neighbourhood might constrain the use of certain modes (De Vos et al., 2016). For instance, a person living in a suburban-style neighbourhood but who likes to walk and cycle, might be dissatisfied with his/her neighbourhood as it limits walking and cycling trips due to long average distances. The land use characteristics might force this person to travel with undesired motorised travel modes, resulting in negative travel experiences (a typical case of RC) and a preference for living in a more urban-type neighbourhood stimulating active travel. It has to be noted that – although some studies have analysed the effect of attitudes on travel satisfaction (Abou-Zeid et al., 2012; De Vos et al., 2016; Reibstein et al., 1980; St-Louis et al., 2014) – we only found one travel behaviour study showing that travel satisfaction has a positive effect on the attitudes towards the mode used (i.e., De Vos et al., 2019). It is likely that an attitude towards a certain

travel mode will affect satisfaction levels when using that mode, but also that satisfaction levels with multiple trips using a certain mode influence the attitude towards that mode, especially when a favoured mode is experienced negatively, or vice versa (De Vos, 2019). However, more (preferably longitudinal) studies on the link between travel attitudes and satisfaction are needed.

3. An overview of literature

In the prior sections, references were given to the appropriate literature. In this section we explore the literature on the interaction between the BE and TB more systematically for explanations on attitude changes related to the BE directly or via TB, using the clusters of processes and theories above. The aim is to find out to what extent the explanations we proposed above can be found in the literature, indicating confirmation of our assumptions, as well as whether additional explanations are provided by this literature. Finally, any explanations not found could provide interesting avenues for future research.

Ideally, we would not only review the processes and theories but also the triggers and all the conceptualised relationships provided in Fig. 2. However, as most papers only make the processes and sometimes the theories explicit, we have limited the review to these aspects. A possible explanation for not explicitly referring to the complex causal structure for attitude change might be the cross-sectional empirical focus of most papers. Because we position our paper in the debate on the relationships between travel behaviour, the BE, and attitudes, our literature review is limited to that area.

3.1. Approach

A search in Scopus on “travel behaviour” (OR “travel behavior”) AND “attitudes” AND “land use” (OR “built environment”) – final

search 9-10-2018 – resulted in 108 hits. We systematically searched for the term ‘attitud*’ (attitude, attitudes, attitudinal) in the papers, looking for sections discussing explanations for the reverse causality hypothesis. From the 108 papers found, 18 provided an explanation of the RC-hypothesis. Unlike what is usual in literature studies, we did not apply forward and backward snowballing (citations in and to the papers we found) because the initial search saturated quickly with respect to explanations for the reverse causality hypothesis. We therefore concluded that it was unlikely that snowballing would reveal more insights.

Table 1 gives an overview of the selected studies and the processes and theories found in the papers. We have labelled the processes and theories according to the discussion in Section 2 above. We first explain how we linked the theories to the studies reviewed. Cognitive dissonance theory is generally explicitly referred to by the authors of the papers, so this theoretical explanation could be easily assessed. Learning theories were not explicitly referred to, but implicitly it is clear that if people change their attitudes based on experiences (directly, or via one or multiple of the three clusters of processes – see Fig. 2), they must have learned from the new experiences, so we assume that learning theories provide the basis for attitude change. Chorus and Kroesen (2014) explicitly refer to two other theories and we list this in the table.

Consequently, we explain how we linked the processes to the studies reviewed. Because the authors that refer to cognitive dissonance theory make clear that a dissonance between attitudes and behaviour exists, we use the label ‘behavioural processes’ in Table 1. Papers referring to experiences generally do not make the related processes explicit. As conceptualised in Fig. 2, experiences can have an influence on all three clusters of processes, so we do not score processes in Table 1, but only indicate that experiences are the main trigger for attitude changes.

3.2. Results

Table 1 shows that two processes dominate. First, people change their attitudes after exposure to new experiences. These experiences can have an impact on all three clusters, but the literature generally does not clearly indicate how experiences lead to attitude changes or explicitly refer to theories explaining attitude change. Second, people change attitudes to reduce a mismatch between behaviour and attitudes, in line with Cognitive Dissonance theory. In this situation, the behavioural cluster triggers attitude change. Thirteen studies can – implicitly or explicitly – be positioned in the first cluster, nine in the second cluster. Note that some of the papers provide processes in both clusters. Still, the literature provides only limited support for our conceptual model, leaving many avenues for future research as will be discussed in Section 4.

For the underpinning of attitude changes we only found one theory, or more explicitly, one theoretical framework, in addition to those presented in Section 2: a framework based on the Theory of Planned Behaviour and the related Perception-Intention-Adaptation framework as proposed by Spears et al. (2013). Their framework (Spears et al., 2013: 41) “accounts for the contribution of both built environment and socio-psychological factors, and incorporates an expanded version of the theory of planned behaviour”. This possible theoretical underpinning of attitude change deserves more attention in future research.

4. Discussion and conclusion

Although most transport studies focus on the effects of attitudes on people's residential location choice and travel behaviour (referred to as residential self-selection), the focus of this paper is on the reverse effects of BE and TB on attitudes (referred to as reverse causality). We discuss, based on the existing literature, the triggers and clusters of processes leading to attitude change, and related theories. Based on psychological literature, attitudes can change through cognitive processes (‘knowing’), behavioural processes (‘doing’) and affective

processes (‘feeling’). We propose a new conceptual model explaining attitude changes based on these processes as well as the triggers influencing these processes, such as experiences and gaining new information. Our model is a first proposal to conceptualise why attitudes change. We realise it can be discussed, especially from a long-term perspective. In the long term changes in the three clusters could impact the exposure to triggers. For example, if a person's attitude has changed (due to changes in any of the three clusters), that person may not only change their behaviour, but may also be more open to receiving specific information (a feedback to ‘triggers’). We hope our conceptualisation fuels a debate on the complex mechanisms that induce attitude changes.

A search in the BE-TB literature indicates that there are two dominant explanations for changes in travel attitudes resulting from the BE directly or via TB (adaptations): Cognitive Dissonance reduction due to a mismatch between behaviour and attitudes, and experience/learning. Other explanations found in the literature relate to context changes, such as biographical key events (e.g., birth of a child, change of jobs), and explanations related to the Theory of Planned Behaviour and the related Perception-Intention-Adaptation framework.

Since we assume that the BE and TB will actually change attitudes towards travel, it is important to focus on the potential implications for the BE-TB debate. Just as not considering attitudes might result in an over- or underestimation of the effect of the BE on TB (Chatman, 2009; Kroesen and Chorus, 2018; Naess, 2014), not taking into account the effects of BE and TB on attitudes might result in a distorted view of the relationship between BE and TB. It might be possible, for instance, that the effect of the BE on TB is partially indirect through changes in attitudes. A move to an urban neighbourhood with good public transport services, for instance, might result in an improvement in a person's attitudes towards public transport, leading to more frequent use of public transport. To summarise, when analysing the relationships between attitudes, BE and TB, studies should no longer only take into account three potential effects (from attitudes and of BE on TB, and of attitudes on BE), but five, including the effects of BE and TB on attitudes. Of course, the reverse effects complicate the measurement of the links between attitudes, BE and TB. In order to measure causal relationships, longitudinal approaches (using panel data with multiple waves) seem most appropriate. However, due to the complex nature of the links between attitudes, BE and TB, qualitative data might also provide researchers with valuable insights. In this sense, in-depth interviews or focus groups (of e.g., recently relocated residents) might be valuable.

Finally, we suggest four avenues for future research. A first cluster of research relates to exploring the reasons for attitude changes, including the processes and triggers leading to attitude change as well as the complex causal structure as visualised in Fig. 2. Future research could explore whether there are ways in which attitudes can change additional to those set out in Fig. 2, and whether other theories can explain these attitude changes (see Section 3). We think that qualitative research is an interesting first step. In-depth interviews, for instance of people who have recently moved to a new type of residential area might provide valuable insights. Focus group meetings are another option, perhaps even a better option, because people might not be fully aware of their changes in their attitudes and the causes of these changes. Interaction with others might make them more aware (but might also result in a social desirability bias).

Second, we suggest quantitative methodologies, such as (cross-lagged) Structural Equations Modelling (SEM), possibly by using (multiple wave) smartphone surveys (e.g., Friman et al., 2017). Longitudinal approaches can help to understand the causal order of the interactions between attitudes and behaviour. In (at least) two waves both attitudes and behaviour are measured, and attitudes and behaviour in wave 1 can each influence both attitudes and behaviour in wave 2. In other words, these models can measure attitude and behavioural changes and their mutual influences. In addition, the correlations between attitudes and behaviour at both moments can be

estimated (see, for example, Kroesen et al., 2017). The first wave can be before a move to another type of residential area, the second wave can be some time after the move. Although we do not know how fast attitudes change following exposure to a new built environment, we assume that it might take some time to let people experience the new neighbourhood and the new levels of access to new destinations and travel options, before attitudes change.

Third, we feel that the evolution of attitudes over time for specific groups of people under specific conditions is a promising topic. Which changes occur for which segment of the population, when, and under which conditions? This is a challenging topic, but would enable better understanding of reversed causality. An appropriate method to study heterogeneity amongst individuals is Latent Class Analyses (LCA), in which unmeasured class membership is identified.

Fourth, we argue that it would be interesting to study the impact of information and communication technologies (ICT) on attitude changes. We speculate that these technologies have accelerated the speed of attitude changes, for example through smartphone applications. Previously, the process of acquiring knowledge and gaining experience was a gradual process. Nowadays, travellers can easily and immediately obtain almost complete information about transport options. This makes it plausible that attitudes will also change faster, and perhaps also more positively, because fewer mistakes are made and the period of uncertainty is shorter. A final topic for future research could be the impact of social influence on travel behaviour, maybe even residential choice, and consequently attitude change. To the best of our knowledge, the literature on social networks, social interaction and social influence has not studied this topic in the context of BE and attitudes, and the BE-attitudes literature has largely ignored the social influence literature. For example, it could be assumed that in cycling- and pedestrian-friendly neighbourhoods with young families near primary schools, chauffeuring children to school by car is considered socially unacceptable. In most parts of the US, on the other hand, it might be possible that people have the opposite opinion. They might find it socially unacceptable to let children walk or bike to school unescorted.

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