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Beyond the limits of memory? The reliability of retrospective data in travel research

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ABSTRACT

In the last decades, an emerging research interest has developed for long-term, individual travel patterns. Retrospective methods as one approach to investigate long-term behaviour on the personal level are being applied more often in travel research. Although biases and errors in retrieval are well known in cognitive psychology and memory research, they are hardly discussed in travel research. This paper focuses on three research questions: (1) What insights into the quality of retrospective methods are provided by memory research, what are its strengths and weaknesses? (2) What can we derive from the theory for the empirical work and the design of surveys? (3) What results can we transfer to the application of retrospective methods in travel research? Firstly, this paper provides an overview of the most important recall traps, such as omission, incorrect numerical and biased retrieval. As memory research has shown, various techniques can support retrieval and response behaviour regarding past behaviour, for example, the choice of event type, memory characteristics and recall aids, such as temporal and thematic landmarks, help improve accuracy. Furthermore, the design of a retrospective survey plays an important role, for example by building up an internal and thematic framework in respondents. The use of retrospective methods in travel research is categorized in the application fields of life events, changes in travel patterns, social networks and travel distances, mobility socialization, travel attitudes and needs and mobility practices. Along these categories, this paper discusses the potential, risks and opportunities to improve the use of retrospective data in travel research.

1. Introduction

In recent decades, an emerging interest has developed regarding individual travel behaviour from a life-course perspective. At first, the life-course perspective was used to explore long-term travel decisions (Mortimer & Shanahan, 2003); later on, short-term travel decisions, for example daily travel mode decisions, also became a focus (Scheiner & Holz-Rau, 2013). In this context, the mobility biographies approach (Lanzendorf, 2003; Scheiner, 2007) links single events to different dimensions, such as the life-style, accessibility and mobility domain. In this way, the mobility biographies approach considers the birth of a child, as a window of change for daily habits, for example, and related changed patterns in travel behaviour. A growing number of studies takes this approach in order to investigate stable travel patterns over long periods and their interruptions (Beige & Axhausen, 2012; Müggenburg et al., 2015; Rau & Manton, 2016). When investigating long-term behaviour, panel and retrospective methods are applied. Panel studies investigate individuals at various points in time. With retrospective surveys, participants answer questions just once, while simultaneously reporting about a single event (cross-sectional retrospective survey) or a longer period (long-term retrospective survey) in the past. In quantitative approaches, research is carried out using questionnaires, either as lists or tables, calendar instruments or open items (see Section 4 on survey design and Section 5 on their application in travel research). Qualitative approaches use biographical interviews,

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sometimes with the visual support of calendars. Qualitative approaches sometimes make use of photographs and other personal material as support for retrieval.

Retrospective methods are a promising approach due to their numerous advantages concerning (i) economic and (ii) methodological aspects. (i) Contrary to panel studies, respondents answer the questionnaire just once and no regular contact maintenance is necessary. This saves resources both for participants and researchers, which has a positive effect on motivation and cost efficacy. It further opens up resources for larger samples. In addition, timely analysis of data is possible, as it is not necessary to wait for further data acquisition. This aspect is especially relevant for transfer into practice. (ii) While panel mortality is a widely discussed challenge faced by panel studies, in retrospective surveys there is no need to fear systematic bias of the sample as a result of drop-outs due to its single data acquisition. Thus, dealing with missing values is easier. Retrospective methods can cover a longer period in comparison to panel design. While panel studies also track changes over time, they face higher risks of inconsistency and sometimes discontinuity (Solga, 2001).

On the other hand, the literature discusses certain disadvantages of retrospective methods. Methodological aspects in particular are the focus of criticism. When evaluating retrospective data according to the quality criteria of quantitative research (Moosbrugger & Kelava, 2007), the criterion of reliability is most notable: recalling detailed information of past years later seems rather difficult. Besides the ability to remember, another important aspect is accuracy: do respondents remember the past correctly? Did the event in question really happen at the indicated point in time or a few months or years earlier or later? Would the respondent give the same answer if he or she were asked a second time? Large samples may correct unsystematic errors, but systematic distortions limit data quality immensely. Regarding economic aspects, the literature discusses the higher motivation needed due to the higher burden on cognitive resources while answering a complex survey. This in turn may also have negative effects on data accuracy.

Cognitive psychology and memory research provide profound insights into retrieval strategies and biases. Despite the growing number of studies in transport research, methodological reflections on retrospective methods considering the foundations of memory research have found little attention in travel literature. Results from other disciplines have great potential to improve the use of retrospective methods to investigate individual travel behaviour. The aim of this paper was to review findings from cognitive psychology and memory research and discuss the transfer of their use to travel research. Thus, it is rooted in an individualist approach. Nevertheless, it discusses links to collective approaches. The paper addresses the following three questions:

(I) What insights on the quality of retrospective methods are provided by memory research, what are its strengths and weaknesses?
(II) What can we derive from the theory for the empirical work and the design of surveys?
(III) What can we transfer to retrospective methods in travel research: what can retrospective methods in travel research achieve, what do they fail to achieve?

The methodical approach was a systematic literature review of published academic work on autobiographical memory, retrieval processes and retrospective methods. Important studies were identified in various disciplines, mainly memory research, cognitive psychology and transport studies, in order to combine different insights. Literature research started with well-known standard textbooks in psychology and sub-disciplines concerning the human brain, learning and memory. Next, the author used library catalogues, subject-specific reference works and subject-oriented library websites and databanks, such as PsycARTICLES, PsycINFO, PSYNDEXplus, PubMed, Sciencedirect, SpringerLink, Web of Science, Wiley Online Library and wiso Sozialwissenschaften. Key words were ‘accuracy’, ‘autobiographic’, ‘biography’, ‘forgetting’, ‘long-term’, ‘memory’, ‘reliability’, ‘remember’, ‘reminiscence’, ‘retrieval’ and ‘retrospective’ in various combinations. Only academic journals and books and, in exceptional cases, reports published by prestigious academic institutions were considered.

The paper is organized as follows: Firstly, it provides an overview of the theoretical foundations of memory (Section 2) and traps in recall from memory research and cognitive psychology (Section 3). Then, it summarizes the recent state-of-the-art strategies to improve retrieval of memories (Section 4). In a next step, these results are transferred to travel research (Section 5). Finally, conclusions (Section 6) were drawn on the ongoing challenges faced by this method.

2. The functioning of memory: Theoretical foundations

When discussing retrospective methods and autobiographical memory, we first need to take a closer look at the theoretical foundations and briefly summarize recent knowledge about what memory is, how it works and why human beings need to remember. This furthers understanding of the obstacles encountered while retrieving memories and helps to derive strategies to support accurate recall.

2.1. What is memory?

Memory is divided into short-term memory and long-term memory. While short-term memory refers to immediate information, long-term memory refers to what is commonly understood as ‘memory’ and to information that we can recall with some effort (Sudman et al., 1996). Long-term memory includes a declarative part (knowing facts) and a procedural part (knowing how to do things). The declarative part summarizes episodic memory, which refers to personal experiences, and semantic memory, which refers to individual knowledge of facts (Tulving, 1972). Both interact with each other rather than working separately. Semantic memory also encompasses scripts, which are abstracted from repeated experiences.

Autobiographical memory is part of long-term memory. Cognitive psychologists disagree about what exactly comprises

autobiographical memory (Greenberg & Rubin, 2003). Definitions range from an autobiographical memory that encompasses daily activities (Neisser, 1995) to only critical life events with high emotional content (Bluck & Habermas, 2000). Further discussions deal with the individual as the subject or object of memory: defining autobiographical memory as experiences an individual had is identical to episodic memory; on the other hand, also considering memories of things referring to a person, such as date of birth, involves an overlap with semantic memory (Spada, 2006). Thus, both have autobiographical dimensions. Consequently, autobiographical memory is not a distinctive cognitive system, but refers to all memory systems concerning the self (Conway, 2005).

Brewer (1986) divides autobiographical memories along two dimensions: type of event (specific and general or repeated events) and type of memory (vivid imagination or abstract knowledge) (see Table 1).

Another approach was developed by Belli (1998), who distinguishes between three types of autobiographical memories that he describes not as a unit as such but as a network of different loosely connected memories (Conway, 1996). There are 'extended events', 'summarized events' and 'specific events' that focus on higher-level events, a collection of several similar events and a single event, respectively (Barsalou, 1988; Belli, 1998, p. 385). Both approaches show that memories are stored with different amounts of detail (Berntsen & Rubin, 2002), reaching a peak with so-called flashbulb memories where an event is vividly imagined and almost becomes a repeated experience (Brown & Kulik, 1977).

Based on these different levels of specificity, Conway and Pleydell-Pearce (2000) developed a structural model of autobiographical memory and distinguished between life-time periods, general events and event-specific knowledge, which are connected in a causal and temporal way and are organized hierarchically. Lifetime periods consist of thematic and temporal knowledge of a phase in life, such as "when I was at school", "working for company x" or "when the children were young". General events are more specific and heterogeneous and include repeated and single events. Finally, event-specific knowledge is very vivid and image-rich.

Lastly, recent approaches take a step further and define life scripts or life story schemes, which encompass life-time periods according to Conway and Pleydell-Pearce. They assume that individuals consider memories in the broader context of their entire life, establishing thematic, temporal and causal coherence (Kirkegaard et al., 2008). They define life scripts as "normative expectations within a given culture to the patterns of individual life courses, such as the developmental changes that are expected to take place at various points in life and the different life phases that people are expected to live through at different ages" (Berntsen & Rubin, 2002, p. 640). This approach primarily provides a contribution towards explaining why people retrieve selective events in a certain way. This preference of coherence instead of correspondence can cause severe bias and errors in retrieval (Bluck, 2003; Conway et al., 2004; Glasner, 2011). Social and cultural science also define memory in a more collective sense. Many of these approaches rely on the work of Maurice Halbwachs (1985), who defines memory according to the following criteria: (1) reconstruction, which means that people reconstruct the past during retrieval depending on their actual reference frames, (2) interaction, by which he means that individual retrieval is collective remembering due to social frames and (3) functionality, which serves for social orientation (knowing where you come from). Harald Welzer (2008) combines aspects of psychological and sociological memory theories and therefore individual and societal processes. At the same time, he points out that the scientific investigation of these theories clearly reach its limit due to the complexity of the interaction of individual and collective processes. These aspects already give a hint of the function of autobiographical memory and its prioritizing of memories on their way to long-term memory.

2.2. How does memory work?

When asked about events in the past, this starts a searching process for memories. In addition to retrieval, two further phases are responsible for the transfer of short- to long-term memory: encoding and storage (Myers, 2014). Sudman et al. (1996) refer to memory as a large storehouse of information with different file drawers, which are organized with different labels. In order to store knowledge in this complex system, the first step is to understand information. Therefore, encoding requires attention. Consequently, experiences, which are new, rare or associated with emotions and are highly relevant to the individual, get more attention and may be more frequently saved. Next, labelling of information happens (storage). When retrieving information, a similar process to that of answering a question starts: the individual needs to generate a search request that matches his or her labels in memory. Thus, the wording of a question is relevant.

Apart from the differences in degree of detail, another important aspect is the choice of detail, which is picked out of the memory during retrieval. Recent studies assume that episodic memories are not saved as perfect, precisely defined facts, but are instead reconstructed from the autobiographical knowledge base during retrieval (Conway, 1996; Conway and Pleydell-Pearce, 2000; Holland & Kensinger, 2010). This so-called constructivist approach (see also Section 2.1.) to autobiographical retrieval assumes that repeated reports of events will result in different stories influenced by the person's emotions and motivations (Conway, 1996).

Table 1
Categorization of autobiographical memories according to Brewer (1986) based on Spada (2006).

	Specific event	General/repeated event
Reliving in imagination	Personal memory, e.g. first day of school	Generic personal memory; e.g. memory of maths lessons (nonspecific)
Abstract knowledge without sensory perception	Autobiographical fact, e.g. knowledge of driving license	Self-schema, e.g. knowledge of low budget during studies

2.3. Why do we remember?

So, why is it important to store this amount of information about our past? Bluck et al. (2005) assume that autobiographical memory has three functions for human life: self, social, and directive. The self-function is responsible for continuous self-perception over time and is therefore involved in personality development. The social function encompasses sharing memories and better empathy with others and thus aims to achieve social bonding. The directive part helps in solving problems, making decisions and planning for the future.

In summary, we learn from these different approaches that different types of memories exist, which are stored with different amounts of detail and that they are not stored separately but embedded in further information and, finally, can change during recall due to construction processes. The following section deals with the risks of memory distortions of both episodic and semantic memory and shows how we can make use of these attributes.

3. Retrieval of autobiographical memories: The ravages of time

Dealing with data in empirical quantitative research, researchers assume that measurements consist of observed or reported behaviour or thoughts and measurement error (Field, 2009). Besides other elements, such as social desirability, the measurement error includes incorrect retrieval (Groves, 1996). Researchers discuss different quality criteria to keep measurement error to a minimum, such as reliability and validity (Field, 2009). In the context of retrospective methods, discussions focus on reliability.

In order to explain the decrease in correctly recalled autobiographical events in more distant past, different restrictions ('forget', see Section 3.1.) and misrepresentations of memory ('bias', see Sections 3.2 and 3.3) are discussed in the literature (Behrens & Del Mistro, 2008; Klein & Fischer-Kerli, 2000; Myers, 2014; Schwarz, 2007). The following sections present a summary.

3.1. Omission

A failed retrieval process results in the inability to recall memories. Schacter (1999) found three processes to be responsible for the inability to retrieve information: (i) transience (forgetting), (ii) lack of focus and (iii) blocking. *Forgetting* (i) happens, for example, when trying to remember details after a long time. Francis Galton first performed experiments concerning the ability of recall in order to examine the reliability of memories (Galton, 1880). He found that autobiographical memories have a similar curve of forgetting as the classical curves of Ebbinghaus (1966), who used a nonsense row of syllables as material to remember: with increasing temporal distance, the number of recalled memories decreases (Oberauer et al., 2006). The difference, however, is that the curve is flatter, descends more slowly and shows a higher frequency of memories between the ages of 20 and 30. Forgetting occurs due to various causes: insufficient encoding due to limited processing capacity, futile consolidation or an inability to keep memories available with

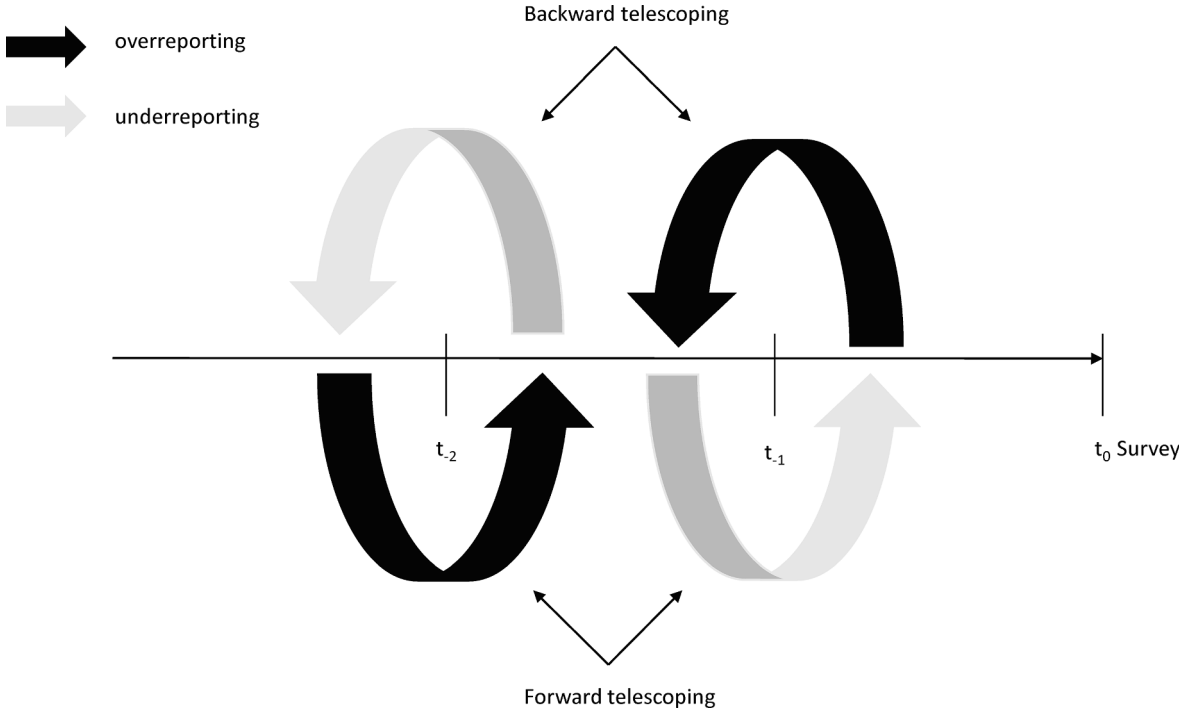

Fig. 1. Forward and backward telescoping. Source: own presentation based on Glasner, 2011.

strategies like rehearsal and a lack of retrieval strategies (Sudman et al., 1996). Motivational factors form the basis of all these causes. Schacter also attributes the second process *lack of focus* (ii) to motivational reasons, as participants do not optimize their retrieval due to either a lack of motivation or an inability or unwillingness to use global estimation strategies. This is called 'satisficing' (Krosnick, 1991; Krosnick & Alwin, 1987). *Blocking* (iii) refers to a process in which the individual is only temporarily unable to retrieve the information immediately, but is aware of this memory block and knows that the information will be accessible later. In everyday situations, we know the phenomenon, when someone is not able to recall a piece of information ("It is on the tip of my tongue") (Brown, 1991; Brown & McNeill, 1966).

3.2. Incorrect numerical estimation

3.2.1. Telescoping

Just a few memories are stored in memory with exact dates (Friedman, 1993). These are mainly experiences which are highly significant and regularly rehearsed (e.g. date of birth, date of marriage, see Section 2.2). The majority of autobiographical memories are not time-stamped and therefore individuals need to reconstruct them. Thus, accessing the number of years associated with events may be difficult. Studies show that the memory of annual figures of autobiographical events requires a more complex memory performance than for other characteristics of memories. This memory may, therefore, be re-derived separately from the remembered event (Klein and Fischer-Kerli, 2000; Wagenaar, 1986), as this factual knowledge is usually accompanied less by emotion and with no representation of lively, detailed illustration (Reimer, 2001). Consequently, incorrect retrieval to reconstructed dates occurs more frequently than forgetting.

Such errors in reconstructed temporal classification are referred to as telescopic effects in which an experience is classified either earlier (backward telescoping) or later (forward telescoping) than it actually occurred. The likelihood of telescoping increases with time (both right arrows in Fig. 1 are less likely). Most events are estimated as occurring later than was actually the case (Janssen, Chessa, & Murre, 2006). However, this telescoping seems to happen mainly while remembering shorter periods of less than one year (Reimer, 2001). There are hints that especially salient events are associated with forward telescoping (Loftus & Marburger, 1983; Neter & Waksberg, 1964; Tourangeau et al., 2004).

Symmetric distortions caused by telescoping are controversially discussed (Reimer, 2001). In this context, Bradburn et al. (Bradburn et al., 1994) raise the question of whether telescoping is not a biased representation of memory, but rather can be traced back to the greater variance in the subjectively estimated dates of remote events. Their hypothesis is supported by the finding that an increase in rounding to prototypical units occurs with greater uncertainty. The way of asking may cause asymmetric effects of telescoping: surveys for example often ask for "the × last months or years" (then $t_0 = t_{-1}$). Consequently, with this formulation, forward telescoping only shows overreporting, while backward telescoping only indicates underreporting (Glasner, 2011). Thus, carefully chosen time references are mandatory, as the indication of specific external (historic) events or reference to formulations like "the last six months" may in themselves have an impact on the response of the participants (see Sections 4.1.4 and 4.2.4) (Schwarz, 2007).

3.2.2. Scale effects

Scale effects describe systematic errors in dating depending on the type of time scale presented in, for example, months or years (Friedman & Wilkins, 1985). Various studies found that respondents can recall the month of fragmentary memories quite accurately, while they are often unsure about the year (Auriat, 1993; Friedman & Wilkins, 1985). Explanations include orientation provided by seasonal phenomena (e.g. temperature, light, etc.) or temporal associations with significant regularly occurring events such as birthdays during the time reconstruction process (Glasner, 2011). This does not seem to be a general pattern, but depends on the type of event (Auriat, 1993): depending on the temporal reference system respondents use, they remember the year of experience more accurately than the months. This is the case when respondents know at which age or year they experienced the event and reconstruct other parts (e.g. childbirth). Consequently, this effect depends on the representation of the event in memory and its way of retrieval (Reimer, 2001).

3.2.3. Rounding

When asked for the number or period of behaviours, respondents often tend to estimate their answer, which often results in rounding (Becker & Diop-Sidibé, 2003; Huttenlocher et al., 1990). Possible explanations are difficult questions, such as asking for a long reference period and less salient events, a satisficing strategy and ignorance of the necessity for accurate answers in surveys (Glasner, 2011).

3.3. Biased retrieval

3.3.1. Emotions and memory

The context in which we experienced an event can serve as a cue for recall (Godden & Baddeley, 1975; Myers, 2014). Various studies support the important role of emotions in memory retrieval, which make it vulnerable to biases at the same time (Buchanan, 2007; Holland & Kensinger, 2010). In this context, recent literature hypothesizes that during retrieval, emotional memories are reconstructed instead of being static, clearly defined facts (Holland & Kensinger, 2010). As we have seen in theoretical foundations (Section 2.2), we remember memories with high emotional involvement better than events accompanied by personal distance (Berntsen & Rubin, 2002; Talarico et al., 2004). This emotional influence extends from encoding and storage to retrieval. Closely related to context is the mental and emotional state during retrieval, which can have an effect on memory as well: emotions can also

work as triggers (Fiedler et al., 2001). *Mood congruency* (i) highlights certain details of experiences in all stages and determines what information enters memory and is available for retrieval. Respondents remember events better that match their current mood and the context while answering a survey. Thus, in terms of selective retrieval, the influence of the individual's concrete context, such as present needs, emotions and mood, should not be underestimated.

(ii) At this point, it is important to remember that individuals aspire to pleasant experiences and avoid painful and aversive experiences (Grawe, 2004). As autobiographical memory supports the planning of future behaviour (Wirtz, Kruger et al., 2003), it draws attention to especially positive emotions which influence the memory process (Talarico et al., 2004). As a consequence, selective forgetting occurs and *unpleasant* events fall into oblivion faster (DePrince et al., 2012). Furthermore, positive events are more rich in sensory detail from a retrospective perspective (Comblain et al., 2005; D'Argembeau et al., 2003). (iii) Finally, *individual characteristics*, such as personality, cultural values and age (Holland & Kensinger, 2010), have an influence on the content of memories. Personality influences the selection of memories (Safer & Keuler, 2002): extrovert individuals retrospectively remember more positive effects than they reported daily in a panel survey. The opposite was found for persons with high scores on neuroticism who remember more negative feelings than they actually experienced (Barrett, 1997). Furthermore, having high self-esteem leads to more positive memories while low self-esteem results in more negative memories (Christensen et al., 2003). Next, cultural values bias memory reconstruction for emotional contents. It seems to be easier to remember emotions that are valued in a culture (Tsai et al., 2006), irrespective of daily reporting (Scollon et al., 2009). In this context, Robinson et al. (1998) observed gender differences in retrospective reports of emotions rather than in current momentary reports. Finally, age plays a role in retrieval as well: older individuals tend to forget negative events or negative feelings (Berntsen & Rubin, 2002) and reconstruct the past in general as well as negative events more positively than they actually were (Comblain et al., 2005; Kennedy et al., 2004). Older adults remember a higher number of memories between the ages of 10 and 30 years. This is known as the reminiscence bump (Rubin, 2002; Rubin et al., 1986).

3.3.2. Serial-position effect and scripts

Further distortions are miscalculations of order and time in serial-position effect: individuals particularly remember those events better which happen for the first time (primacy effect) or lately (recency effect). In this context, researchers should consider how long it has been since the events in question took place or at least the age of the participants.

The human brain works in networks and scripts which are "conceptual representations of stereotyped event sequences" (Abelson, 1981, p. 715). These scripts contain different information about actions in regularly occurring events and their order. This knowledge provides orientation by predicting occurrences and fills in memory gaps (Abbott et al., 1985). While trying to remember similar repeated events, such as visiting a restaurant or using public transport, general scripts might be activated, interfere with each other and blend together. Similar experiences might interfere with each other in proactive (disruptive effect of prior learning on the reproduction of new information) and retroactive (disruptive effect of newly learned information on reproduction of older information) interferences (Myers, 2014). The recall of repeated events might lead to the retrieval of a schematic memory consisting of a mixture of those events (Sudman et al., 1996).

3.3.3. Construction and post-rationalization

In retrospect, individuals may explain their past behaviour using reasons that were not available at the time of the event, but that are consistent with their current self-image. This is called interpretation and construction effects or *post-rationalization* (Behrens & Del Mistro, 2008). The reason for this effect is that the function of memory is, among other things, to guarantee a coherent picture of oneself (see Section 2.3).

As we have seen in the theoretical foundations (Section 2.1), there is an overlap between semantic memory and episodic memory, when scripts are deduced from repeated experiences. When retrieving memories there is the risk that this conjunction may also have an effect in the other direction: scripts may serve as a general frame, which is filled in by vivid, but incorrect constructed memories.

3.3.4. Self-presentation

Social desirability (Edwards, 1957) as self-deception or impression management (Helmes & Holden, 2003) has an influence in general on response behaviour. Individuals tend to present themselves in a way that corresponds to the expected social or individual norm. In retrospective surveys, explanations of past behaviour or choice of memories may thus be distorted according to recently changed attitudes or norms in the sense of social desirability.

The following section presents strategies and appropriate fields of application in order to further the development of an adequate study design.

4. The art of asking: How can we improve the quality of retrospective data?

Even though memory performance depends on various processes, such as storage and retrieval of memories (see Section 2.2), researchers can only try to support retrieval as encoding is beyond anyone's control in retrospective surveys. Based on insights from cognitive psychology, various aided recall techniques have been developed to improve retrospective data quality and handle problems of retrieval errors and biases. These will be presented in the following two categories: content of questions (1) and survey design (2).

4.1. Content of questions

4.1.1. Characteristics of events

When assessing the data quality of studies, researchers should have in mind the following positive event characteristics: events which are experienced for the first time or are still in process are remembered particularly well. The same is true for events with high relevance to the individual. Additionally to their individual importance, the rehearsal of them due to regularly retelling leads to a higher ability to remember. The high density of remembered events between the ages of 10 and 30 for older adults gives a hint of this assumption.

The duration and frequency of events have an influence on the ability of retrieval: the shorter the duration of an event, the greater is the probability it will be forgotten. Such events are seldom intertwined with other important aspects of life that could facilitate retrieval. If events occur repeatedly, it is even harder to pick certain sequences out of the general scheme. Thus, habits (e.g. daily commute trip to work) are at risk of interference with activated scripts (e.g. process of commuting, such as travel mode, connection) that interfere with correct retrieval (e.g. certain aspects of commuting on a certain day).

Consequently, while aiming to capture accurate data, it is helpful to consider mainly events with the following characteristics if it is compatible with the research interest: rare, long-lasting events with severe consequences and high emotional and cognitive involvement (Oberauer et al., 2006; Thompson et al., 1996). Potential risks are the individually experienced frequencies and perception of events.

Furthermore, providing recall aids can also increase data quality. Klein and Fischer-Kerli (2000) showed that the characteristics of items influence data quality far more than the qualities of participants. This finding underlines the potential of well-designed surveys and emphasizes the responsibility of empirical social research for the development of retrospective instruments for life history data. In the following, a number of aspects are discussed that are worth considering during questionnaire development due to their potential for facilitating retrieval.

4.1.2. Cued retrieval

Cued retrieval supports the individual process of remembering through certain triggers: asking for landmarks or landmark events describes the retrieval of additional events, in which the individual participated, which are key to the individual and structure their life stories (Shum, 1998). Landmarks, whether personal or even indications of an external event, such as a volcanic eruption, seem to reduce the telescoping effect (Loftus & Marburger, 1983). Such cues or landmark events can be additional memories from other people, such as close relatives as well (Wagenaar, 1986). Belgian research supports the hypothesis of a retrieval strategy being more accurate if various events are obtained simultaneously (Auriat, 1993). Asking explicitly about certain life events or personal landmarks, such as residential relocations, childbirth, marriage or separation, may facilitate the retrieval process in comparison to open questions (Dehmel & Wittchen, 1984). However, when providing external or personal landmarks, researchers should be careful of potential risks: as events have different relevance in different cultures, there are potential restrictions to this approach related to the quality criterion of cultural fairness. Even within the same culture, individuals may perceive events as being of varying significance. Close relatives may verify the dates of personal landmarks. Memories triggered in response to a question depend on the cues given in the questionnaire. Consequently, these cues should be as specific as possible and precise in formulation in order to avoid distortion. A combination of cued (provision of additional information to support retrieval) and non-cued retrieval (questions without further information, association or trigger) should be avoided due to systematic distortions in response behaviour.

Generally, directly retrieved dates are more accurate than constructed ones, which in turn are better than guessed dates (Burt, 1992; Glasner, 2011). Thus, interviewees should preferably ask for direct retrieval and only provide aided recall techniques if individuals cannot recall dates directly.

4.1.3. Support of different retrieval strategies making use of temporal, thematic and semantic associations

We have seen that there is a risk that the context of memories may interfere with actual context (see Section 3.3.1.), but on the other hand researchers may make good use of this phenomenon: recalling not only the event as such but the whole context often leads to more detailed memories. This can be utilized especially in interviews. In quantitative retrospective data acquisition, thematic blocks of related items may have a similar effect. Instead of a calendar a subjective temporal frame can be used and may help to decrease omission. Three different strategies make use of these associations in a temporal, thematic or semantic way: (i) parallel retrieval, (ii) sequencing and (iii) top-down retrieval. Parallel retrieval (Belli, 1998) is a strategy that evokes the recall of events with a content association (e.g. “when my daughter was born, we lived in X and I took a break from my job as Y”) instead of a partial biography (e.g. work biography). (ii) Sequencing (Belli, 1998), on the other hand, asks for events in chronological order within a theme. This could facilitate retrieval because related events in different partial biographies only need to be remembered once (e.g. all residential relocations of a certain period in chronological order). This contributes to responsibility in dealing with a participant’s resources. (iii) Finally, top-down retrieval relates to Conway’s model (see theoretical foundations of memory 2.1.) and describes the process of deriving hierarchical information from long-term memory from lifetime periods to specific knowledge (e.g. retrieval of context, such as workplaces to enhance retrieval of work hours, see Section 2.1. for explanation of terms). According to Belli, individuals use this strategy to recall isolated events with no direct interconnection. Researchers can try to activate this strategy during their survey. To date, there is no systematic research to compare the efficacy of these strategies.

4.1.4. Reduction of telescoping by the length of reference period

Memories of dates are rather unreliable. Respondents are often uncertain about dates and tend to overreport events in a certain

reference period (Sudman et al., 1996). The extent of this telescoping effect (see Section 3.2.1) depends on the length of period and formulation of time indication (Section 4.2.4. will come back to these impacts on survey design) (Neter & Waksberg, 1964). Dex (1995) assumes that the longer the reference period and the longer ago the events occurred then the lower the accuracy of data is. Wagenaar (1986) found that dates referring to the end of periods are a poor cue. When asking for memories, it is important to consider phases (e.g. one year) rather than specific points in time. The choice of an appropriate length of reference period depends on various factors: shortening the reference period, e.g. asking for events during one month last year, simplifies answers (Lugtig et al., 2016). On the other hand, researchers should bear in mind that very short time periods (e.g. one week) enhance the relative telescope effect, as small absolute errors result in large overstatements (Sudman et al., 1996). Furthermore, asking for a shorter period may enhance the motivation to fill in all types of events, as more events require greater efforts for retrieval (Blair & Burton, 1987; Tourangeau et al., 2004). This may result in a more intensive reconstruction of time, context and related events. Neter and Waksberg (1964) developed a technique, bounded recall, to reduce the uncertainty of temporal memory (see Section 3.2.) and consequently telescoping (see Section 3.2.1). Respondents answer the same questions in successive interviews with changed temporal references. Firstly, they provide information, for example, about the "last six months". In the next interview they specify the same events, but this time with reference to the period between the first and second interviews. In addition, researchers remind them of the events they mentioned in their first interview. Studies found forward telescoping in the first interview, while the telescoping effect in the second interview was reduced (Sudman et al., 1996). This also particularly reduces omission of less salient events (Tourangeau et al., 2004). The disadvantages are the higher costs caused by the need for a number of interviews and dependence on the repeated willingness of participants. However, first results show that this technique may work even within the same survey (Sudman et al., 1984).

4.2. Survey design

4.2.1. Order of items

Memory is organized in networks (Myers, 2014; Spada, 2006), referred to in the literature as schemes or scripts. Asking about a life event activates other related events and congruent characteristics, facilitating access. When trying to recall specific but maybe subjectively less important events that occurred a long time ago, more important events serve as anchor points that enable coherent structures and recall to memory of less significant events (Brückner, 1990; van der Vaart & Glasner, 2010). Consequently, the thematic organization of items may facilitate access to autobiographical memory. Research supports this hypothesis, as studies show that respondents tend to consult content associations rather than temporal ones (Burt et al., 2003; Spada, 2006). Events described often occur in propinquity, which calls for their use as landmarks and a simultaneous query in order to construct a temporal reference system (Dex, 1995; Robinson, 1986). Solga (2001) identifies the first hints of a reliable order to recall someone's life course as starting with residence and family (parents, siblings), continuing with school, training and work, and finishing with partnership and parenting.

4.2.2. Open questions vs. multiple choice?

As recognition is easier than reproduction (Dehmel & Wittchen, 1984), using a choice of categories as answers may facilitate retrieval (e.g. specify examples for life events such as childbirth, marriage, etc.). In general, researchers should specify questions as much as possible in order to make it easier for respondents to answer (e.g. asking about means of transport used for commuting instead of travel behaviour in general) (Sudman et al., 1996). Questions should be clear and simple and include homogeneous content (e.g. presenting explicit activities instead of asking "what have you done?") and define terms clearly but not exhaustively (Reimer, 2001). However, the advantage of open questions is the avoidance of suggestions. The decision on type of question therefore depends on the research interest.

4.2.3. Repetition and scope of questions

Another strategy to enhance data accuracy is item repetition: Loftus et al. (Loftus, Klinger et al., 1990) asked participants twice about the same kind of events. The second time they shortened the reference period from six to two months. This resulted in less overreporting. Another option is to use several, slightly different questions for one event in the past. A technique that makes use of repeated retrieval is the 'cognitive interview' developed for forensic interviews. Interviewees ask individuals to put themselves back in the context of what happened, report all details, even if they seem irrelevant, describe the event from different points of view and finally describe what happened in reverse chronological order. Using all strategies results in more accurate data (Reimer, 2001).

With regard to the scope of questions, dividing a question into smaller units helps the participant to find an answer by using different accesses to the information required. Thus, instead of asking "How often did you use the car last month?", one could ask about car use on the way to work, for leisure trips, shopping expeditions and weekend trips in the past month. The level of specificity of questions should be adjusted to the targeted information level (Glasner, 2011).

4.2.4. Formulation of reference period

The formulations "last year", "since 03.03.", "since childbirth" "the last 12 months" may all indicate the same reference period but result in different answers (Reimer, 2001). The formulation "last year" for example is misleading (last 12 months or last calendar year). Thus, it is essential to clearly define a period. Furthermore, public events, such as a volcanic eruption, seem to reduce telescoping (see Section 3.2.1) in comparison to formulations, such as "the last year" or "since 03.03.". However, even public events may of course be subject to distortions, such as telescoping (Auriat, 1996).

Table 2
Application of retrospective methods in travel research.

Authors	Design		Place and time	N	Object of research
Behrens & Del Mistro, 2008	Paper-pencil survey (2005), PACI (2006)	List, open	Cape Town; 2005, 2006	40 (2005) 250 (2006)	Travel behaviour (commuting), behaviour change, accessibility (route)
Beige and Axhausen, 2008, 2012, 2017	Paper-pencil (by mail)	Calendar	Zürich; 1985–2004 (in 2005)	1166	Life events (residential relocation, employment/ education), vehicle ownership / availability, season tickets
Bonham and Wilson, 2012	In-depth interviews	diary entries, video	Adelaide; life-course	49	Bicycling experiences of women through life-course
Chatterjee et al., 2013	In-depth interviews, surveys	Calendar	England; 3 years before interview (in 2010)	144	Life events (household composition, employment), travel behaviour (cycling)
Delbosc & Nakanishi, 2017	In-depth interviews	Open, timeline	Australian millennials (Sydney, Melbourne, Canberra), life course	55	Travel behaviour (recent, future), accessibility/ residential location, prospective study
Mobility Biographies project (DFG)*	Paper-pencil survey	List	3 generations; life course (in 2007–2016)	4620	Life events, accessibility, socialization, travel behaviour (education, commuting), vehicle ownership
Greene & Rau, 2008	2 Interviews, diary, graph	Timeline	Ireland life-course (in 2013–2014)	18	Mobility practice careers
Jones et al., 2014	Biographical interviews	Calendar	Bristol; life course	33	Travel behaviour (walking, cycling)
Klöckner, 2005	Online questionnaire	List, open	Germany; life course (in 2003)	91	Life events (education, residential relocation, change in employment, co-habitation), travel behaviour , accessibility, vehicle ownership
Lanzendorf, 2010	Interviews	Calendar	Leipzig, parents; shortly before/after childbirth (in 2003–2004)	20	Life events (childbirth), vehicle ownership / availability, season tickets; travel behaviour (car, green mode use)
Muromachi, 2017	Survey	List	Metropolitan Tokyo, university students; life course (in 2013)	351	Travel behaviour, vehicle ownership, accessibility (metro), prospect study attitudes
Nakanishi & Black, 2015	Semi-structured interviews	List	Canberra, Australia, (semi) retired residents; life course (in 2014)	37	Travel behaviour, vehicle ownership (car), future prospect car use
Oakil et al., 2014	Postal, paper–pencil	Calendar	Utrecht; 1990–2010 (in 2010)	45	Life events (marriage, childbirth, leaving home, divorce and death; employment biography, residential biography), travel behaviour (commuting), vehicle ownership (car)
Rau & Manton, 2016	Online questionnaire	Calendar	Ireland and Northern Ireland; life course (in 2015)	324	Life events, residential relocation, employment, vehicle ownership (car, bicycle), travel behaviour, accessibility (driving license)
Rau & Sattlegger, 2018	Semi-structured interviews	Timeline	Vienna, Austria; life course	15	Mobility practice careers, mobility-related life events of carless households
Roorda et al., 2000	Telephone interview (+computer aid)	List	Toronto Area, Canada; 9 years before interview (in 1998)	876	Life events (residential relocation, employment), travel behaviour, vehicle ownership (car)
Sharmeen et al., 2014	Web + paper-based surveys	List	Netherlands; life course (in 2011)	703	Life events (marriage, residential relocation, change of job, starting university and children of household starting school), social networks, travel needs
Schönduwe et al., 2015	Postal	Calendar	Zurich; 1991–2005 (in 2006)	646	Life events, vehicle ownership (cars), travel behaviour
Scheiner & Holz-Rau, 2013	Interview	List	Cologne; 14 years before survey (in 2002–2003)	791	Life events (residential relocation) travel behaviour, housing mobility, life situation, lifestyle, location preferences and residential satisfaction
Stanbridge et al., 2004	In-depth interview		Bristol; recent movers, before and after move (in 2004)	229	Life events (residential relocation), mode change (commuting), habits
Underwood et al., 2014	In-depth interview, survey	List	Davis, California; life course (in 2010)	54	Travel behaviour: bicycle attitudes / experience, socialization, social norms
van der Waerden et al., 2003	Postal, paper–pencil	List	Eindhoven & Geldrop	173	Life events (change in education, residential relocation, change in employment, marriage), vehicle ownership, travel behaviour, attitude
Vandersmissen et al., 2009	Questionnaire		Quebec City Metropolitan Area, professional workers; since left parental home (in 1996)	418	Life events (employment, residential, household dimension), accessibility
Verhoeven et al., 2005	Internet-based questionnaire	List	Netherlands; 1986–2005	554	Life events (education/employment, residential relocation, change in employment, household

(*continued on next page*)

Table 2 (*continued*)

Authors	Design	Place and time	N	Object of research
				and household income), travel behaviour, car availability, PT ticket
Yu et al., 2017; Zhang et al., 2014	Web-based survey	Japan; age 18 to recent (in 2010)	1.000	Life events (residential location, employment), vehicle ownership (car)

* Publications within the mobility biographies project: Albrecht, Holz-Rau, & Scheiner, 2017; Döring, Albrecht, Scheiner, & Holz-Rau, 2014; Müggenburg, 2015.

4.2.5. Respondents' motivation

Retrieval needs time. The more difficult a search request in terms of quantity and details, the more time it takes. Thus, asking about a longer period or many different questions may not add any new information but involve the risk of causing rough estimates. Even the efforts of motivated participants may not enable retrieval. In addition to the effort and choice of a recall strategy, giving participants sufficient time to think about the retrieval task can improve the quality of answers (Blair & Burton, 1987). Increasing the length of questions in interviews in order to provide participants with more time to think achieves the same effect (Bradburn & Sudman, 1979; Cannell et al., 1977). Finally, explicitly asking participants to make a greater effort may enhance willingness as well (Cannell et al., 1981).

4.2.6. Life course calendar as an instrument of biographical research

A questionnaire design with regard to life course acquisition that takes into account different supporting strategies, such as the context dependency of memory, temporal and thematic cues (see Section 4.1.), is the calendar instrument or life course calendar (Belli, 1998). The life course calendar builds up an internal frame in respondents to enhance recall. Anchor points and life events may facilitate the recalling of further events. A review of calendar instruments shows that terms and instruments are not standardized, but there are three characteristics that all instruments have in common (Glasner and van der Vaart, 2009); (i) time is presented graphically in a horizontal fashion (often separated into smaller units such as years or months), (ii) different themes or domains exist and (iii) cues, such as landmark events, are used. To date there is still a lack of systematic research on their potential to improve data quality (Glasner and van der Vaart, 2009). First results indicate that calendars might be especially helpful for the recall of less recent, more frequent and less salient events (Glasner and van der Vaart, 2009). A comparative study of lists and life course calendars shows that the quality of data is higher in life course calendars (Belli et al., 2001). Completeness of data is enhanced, and dating errors are reduced (although results are unclear regarding telescoping) (Glasner and van der Vaart, 2009). However, the study only considers a period of one to two years before the survey, which means that results for a longer period are still outstanding. Further studies also report that calendar instruments have the positive effect of reducing information gaps (Engel et al., 2001). Initial studies tried to implement calendars in online surveys (Glasner et al., 2015; Rau & Manton, 2016). Even though a calendar is regularly used in various research areas, such as life course research, health and family planning, to date it has only been used rarely in transport research. Exceptions are studies from Schönduwe et al. (2015), Beige and Axhausen (2008), Ohnmacht and Axhausen (2005) and Rau and Manton (2016). These instruments allow inquiries to be thematically and temporally connected using a timeline combined with thematic dimensions, such as family history, residence and place of education and/ work, means of transport, etc. (Schönduwe et al., 2015).

4.2.7. Inclusion of external sources

The consideration of external sources can be a useful tool for (i) verification and (ii) to investigate collective processes (see Section 2.1.). (i) Asking close relatives or friends may support retrieval as well as the examination of relevant official documents. (ii) In order to track down collective processes while following sociological theories of memories, apart from interviews various data sources can be consulted, such as, libraries, TV archives, bibliographies, folk legends, photo albums, history textbooks, calendars, memorials, historical objects and 'halls of fame' (Zerubavel, 2004).

In conclusion, recall can be improved by choosing significant events that are notable and emotional for the individual and that are accompanied by severe consequences. However, if repeated events or even routines are of special interest, it is advisable to choose a short recall period. Different strategies can support the search for memories, such as cued retrieval: landmark events help with remembering other events. Expanding the reference frame in terms of content by consulting further characteristics of context may facilitate recall as well. Furthermore, ordering questions in a chronological and thematically related way is important. Questions should be as specific and simple as possible, the time allowed and the amount of questions appropriate. Asking for important events in a recall period of a few years can enhance data accuracy. External sources may verify data and investigate collective memory.

5. An assessment of retrospective methods in travel research

Since travel research discovered long-term travel behaviour as an important research field, retrospective methods are applied more often (see Table 2, adapted from Rau & Manton, 2016). Frequently used instruments are life course calendars (see Section 4.2.6), travel diaries, biographical interviews (sometimes with visual support using calendars, photographs, videos) or lists, with for example, partial biographies or means/ availability of transport. Objects of research encompass the following categories: the majority of studies using retrospective methods investigate mobility biographies and take into consideration life events (5.1.), such as childbirth,

marriage, entrance onto the job market and their association with changes in travel patterns (5.2.), such as daily mode choice or ownership of a means of transport. Changes in travel distances and social networks (5.3.) during the life course are of further interest in this context as well. Other studies concentrate on aspects of mobility socialization (5.4.) in relation to recent travel behaviour. A few studies focus on travel needs and attitudes (5.5) regarding various forms of transportation. Lastly, a new wave of studies that combine the mobility biographies approach with sociological, collective orientated approaches emerges (5.6.). For each of the categories, this paper will go into detail below, transferring insights from memory research and cognitive psychology to the application field of travel research. Later, the discussion section will consider the contribution that retrospective methods can make to travel research.

5.1. Life events

Investigations of mobility biographies often ask about different (critical) life events and their relation to changes in travel patterns (Lanzendorf, 2003; Müggenburg et al., 2015; Scheiner, 2007). As shown in the theoretical foundations (see Section 3), such life events can be remembered well even with detailed dates due to their higher significance for the individual, rarity and intense emotions. The following paragraph sheds some light on research results concerning the ability to (accurately) remember a selection of life events that are prominent in mobility (biographies) research. Research shows that marriage and divorce (Klein & Fischer-Kerli, 2000) as well as the birth or death of close persons (van der Vaart & Glasner, 2010) are remembered reliably. Research found that respondents remember events in the context of employment and places of residence well, even after 50 years (Berney & Blane, 1997). This is especially true for job phases; apprenticeships are remembered even better (Dex, 1995). Jacobs (2002) showed that unemployment might be remembered in the short term, but in the long term context phases of work can be better recalled than unemployment. Furthermore, different subjective definitions of unemployment exist, particularly among women, such as seeing oneself rather than family carer or economically inactive. Participants remember details of household biography and residential relocation well (Hollingworth & Miller, 1996). However, there are indications that individuals may recall relocations in incorrect chronological order (Beckett et al., 2001). Studies found that long-term residential relocations that were related to important life events, such as childbirth, marriage and a change of job, may be remembered particularly accurately (Auriat, 1993; Smith & Thomas, 2003). Also, the first move after a marriage is remembered well (Auriat, 1996; Reimer, 2001). Less well-remembered relocations are those that are short term, local and performed at younger ages. Remembering details over a longer period does not seem to be accurate, as a study on household spending shows (Neter & Waksberg, 1964). Thus, it might be helpful to exclude very detailed queries or, if necessary and possible, select events experienced for the first time or recently. If compatible with the research interest, the choice of critical life events should be preferred.

5.2. Changes in travel patterns

When asking about travel behaviour, answers might be inaccurate, because the memory of past daily behaviour is subject to the risk of bias due to scripts and memories for unique events being more vivid (Peterson et al., 2016). It is tricky. On the one hand, details of the decision process or behaviour on a daily basis might not be remembered accurately. On the other hand, semantic knowledge ("I took the bus to school") might be remembered well if it was stable over a long period. So what can we do to investigate travel patterns?

It is important to break questions down and ask about specific behaviours (means of transport used to travel to work, to the supermarket, to friends, etc.) in order to avoid rounding and to support recall. On the other hand, surveys should refrain from asking details of everyday past behaviour in order to avoid generalization of behaviour. For example, do not ask for the weekly frequencies of shopping trips ten years prior to the survey.

Furthermore, incisive events in transportation, so called disruptive events, might be a good starting point for questions, as habitual daily behaviour is interrupted and decisions are necessary which should be remembered well if the time lapse is not too great. These decisions caused by disruptive or (critical) life events can mark the beginning of a different travel behaviour (Müggenburg et al., 2015). Consequently, the event as such but also related (changed) travel behaviour should be remembered better due to network effects (see Section 4.2.1). Disruptive events in transport research are, for example, temporarily closed roads (Fujii & Gärling, 2003; Fujii et al., 2001; Watling et al., 2012; Yun et al., 2011); changes in infrastructure, such as improved roads (Dowling & Colman, 1995) and new public transport connections (Brown & Werner, 2008; Nordlund & Westin, 2013); increased car costs (Eriksson et al., 2010; Horeni et al., 2007; Wegener, 2013); a limited supply of fuel (Marsden & Docherty, 2013); traffic policy interventions, such as tolls (Eliasson, 2014; Kim et al., 2013; Marsden & Docherty, 2013); strikes (van Exel & Rietveld, 2009); and natural catastrophes such as earthquakes (Wesemann et al., 1996), floods (Marsden & Docherty, 2013) or volcanic eruptions (Birtchnell and Büscher, 2011; Guiver and Jain, 2011). In addition, disruptive events are often accompanied by external factors, which are potential anchor points. However, as is the case with external landmarks, significance can differ between individuals. Depending on the strength of the interruption, the events described should not have happened too long ago.

Apart from daily travel behaviour, ownership of means of transport in the past is an interesting variable. The purchase or disposal of a car, bike, tickets or joining a car-sharing organization does not happen on a daily basis and therefore recall might not be biased by scripts. It may be especially useful to combine questions concerning means of transport with other events and provide questions and cues for top-down retrieval (e.g. "when I started working in X, I bought a car."). At this point, additional verification strategies, such as complementary documentation (e.g. copies of car registration certificates), can help as a reminder and prevent telescoping. In contrast, it is often much more difficult to reliably capture bicycle ownership and use longitudinally. Here, problem- or event-centred interviewing techniques can be useful tools for prompting people to recall travel behaviour (e.g. Chatterjee et al., 2013). These techniques make use of retrieval strategies (presented in Section 4.1.3). Another approach dealing with biases in retrospective data is computing

specific weightings as Papon (2013) did with survey sampling, response rate and survival bias. In contrast to the techniques presented here, this concerns the subsequent correction of the data in terms of sample biases and not strategies for improved memory retrieval.

5.3. Social networks and travel distances

As we have seen, dates and detailed numbers, especially details on habitual behaviour, are less likely to be remembered and need to be reconstructed. This is even more the case if these characteristics are insignificant to the individual and happened long ago. Thus, data related to distances (e.g. miles from one's apartment to work) or characteristics of one's place of residence are probably especially subject to biases, such as rounding or scale effects. As retrieval and reconstruction need a lot of resources, respondents might additionally use a satisficing strategy. Thus, in this context it is especially important to define what data was needed for research and to adjust questions and aim recall strategies at this level. For example, a temporal answer might be sufficient instead of distances in miles. Furthermore, bounding may help to reduce the omission of less salient events and data. When asking about social networks and travel distances, it is especially important to carefully construct a substantial framework, e.g. by asking further details, and evoke a vivid memory. The research group around Axhausen (Axhausen, 2008; Beige & Axhausen, 2008) investigated social networks and their structural determinants in relation to mobility biographies using retrospective methods. They used various elements to support consistent and accurate recall, such as visual telephone books, photo albums and life history calendars, and evaluated their use positively, especially in terms of reducing omission (Ohnmacht & Axhausen, 2005). In this context, they also discuss the response rates of retrospective mobility biography surveys (Axhausen, 2008). Establishing a thematic and temporal framework while asking about social networks in relation to important life events probably supports recall as well.

5.4. Mobility socialization

There is increasing research focus on the development of individual travel behaviour in relation to the behaviour of family, peers and the requirements of relevant institutions, especially during childhood and adolescence. Studies investigating socialization often use panel methods (Döring et al., 2019; Haustein et al., 2019). Asking close relatives is another approach to supplement respondents' views. Retrospective methods can supplement research on mobility socialization (Baslington, 2008; Döring et al., 2019). Asking about experiences in childhood and youth from the present perspective enables the consideration of a wider reference period. Respondents can assess particularly influential phases and draw conclusions in relation to current travel behaviour. A few studies have combined aspects of youth with future predictions (Delbosc & Nakanishi, 2017; Muromachi, 2017; Nakanishi & Black, 2015). In this context, two characteristics of the distribution of memories over the lifespan are important for methodological approaches and operationalization. Firstly, very early memories fall into the phase of childhood amnesia. While the phenomenon is indisputable, the cut-off age remains controversial and depends on individual biological, social, cognitive, and linguistic abilities (Nelson & Fivush, 2004). The literature suggests cut-offs for fragmentary memories at about 3 1/3 years and for episodic memories at about four to five years (Bruce et al., 2005, 2000). Secondly, as described above, the increased frequency of memories from ages between 10 and 30 is known as the reminiscence bump for older respondents and needs to be considered when planning research and analysing data. In addition, with greater age, childhood becomes more distant and memories less accurate. Photo albums or memories of close relatives may help.

5.5. Attitudes and travel needs

Various arguments raise doubts about the reliability of measuring attitudes in the past (Klein & Fischer-Kerli, 2000; Petty, 2012): As attitudes are part of self-conception (ego defensive function and value express function; Haddock & Maio, 2014), it is most likely that the retrospective recall of attitudes is subject to reconstruction and biases towards a coherent perception of self (see functions of autobiographical memory). Thus, mood congruency may influence the reconstruction of attitudes and cognitive dissonance might be reduced. As shown above, emotions can lead to biases in recall. As emotions are part of the definition of attitudes (Rosenberg & Hovland, 1960), such biases become especially relevant when recalling attitudes. Consequently, it is, for instance, important to choose the time of survey distribution carefully, as seasonal effects might influence the reconstruction of attitudes according to recent moods. Furthermore, even the context in which a question is embedded can change both the attitude's rating and the attitude itself (Petty, 2012; Vogel et al., 2014; Wilson & Hodges, 1992).

As attitudes are not directly observable, researchers need to interpret the construct of attitudes. Consequently, the measurement of attitudes is difficult even in the present. While, in general, there are explicit (self-report f.e. semantic differential) and implicit (measuring for example skin conductance, response time) measures to investigate attitudes (Haddock & Maio, 2014), it is only possible to use explicit measures for the measurements of attitudes in the past. In any case, explicit measures are relatively reliable (Haddock & Maio, 2014).

As attitudes are not time-stamped, it seems appropriate to ask questions in terms of larger reference periods, perhaps in relation to other phases (e.g. "when at school, I liked cycling."). However, researchers should bear the attitude-behaviour gap in mind and try to consider factors which strengthen the correlation when trying to explain behaviour through attitudes (Haddock & Maio, 2014).

Underwood et al. (2014) and Bonham and Wilson (2012) conducted one of the rare studies on travel attitudes in the past. Underwood et al. (2014) limited the reference period to childhood to young adulthood and shed light on the context making retrieval easier. Both studies lack a critical assessment of the ability to remember attitudes in the past. Other approaches that cover also aspects of attitudes are studies which combine mobility biographies with the more collective orientated sociological theories on practices (see Section 5.6.).

Other studies concentrate on travel needs as a consequence of social network evolution in relation to life events. Following Sharmeen et al. (2014), it seems reasonable to focus on just one very recent event as a starting point and to consider its consequences especially for ties and social contacts. This allows a framework to be established around an event, which is as yet unlikely to have been assigned to oblivion.

5.6. Mobility practices

In contrast to the capture of objective correct data, constructivist approaches acknowledge the inherently social and relational nature of human memory (e.g. Zerubavel, 2020) and therefore make use of retrieval biases and consider them as important indications of social construction processes (see Section 2.1.). Advocates of the constructivists' approach are interested not in what actually happened, but how it is remembered. Zerubavel (2004) proposes a 'sociomental topography of the past' (p. 2), rooted in a sociology of memory, which considers the past in the context of communities in spite of the individual. He shows that the process of retrieval depends on cultural socialization, which functions as a filter during recall and thus calls for the investigation of a collective memory. Approaches in travel research that focus on more collective processes are social mobility practices (Shove et al., 2012). The research group around Henrike Rau describes a turning point in mobility biographies research and identifies two waves: classical life-orientated approaches and narrative mobility biography approaches. Belonging to the second group, they combine the mobility biographies approach with social mobility practices and develop a retrospective methodology for operationalization (Greene & Rau, 2008; Rau & Sattlegger, 2018). They repeatedly conducted semi-structured interviews with relational mobility time lines and analysed them with question-guided content analysis. Questions for the subsequently interview were derived from theoretical assumptions developed in the first interview phase. Proponents of social mobility practice approaches assume that the elements of mobility practices – meaning, material and competence – cannot be considered isolated, but rather shape each other. Even if 'objectively' correct memories are not the aim of constructive approaches, it is important to have in mind that the way of asking influences the way of remembering. Thus, it is important to reflect on the choice of questions: asking for context in interviews makes retrieval easier as memories are connected and diving in vivid imagination is stimulated. As we have seen, asking for concrete behaviour facilitates retrieval instead of open, general questions. Thus, in semi- or unstructured interviews, asking for more details may be helpful. Furthermore, the collection of additional material, as suggested by Rau with time lines, life history calendars or videos, becomes even more important to get an overview and narrow topics.

6. Conclusions

The first aim of this paper was to give an overview of the current findings and discussions concerning the quality of retrospective data based on the theoretical foundations of cognitive psychology and memory research, including frequent biases and errors. The theoretical foundations of autobiographical memory were presented in relation to possible errors and biases in the retrieval of memories. The use and aims of retrospective methods in travel research were summarized and systematized through a literature review structured according to categories of life events, changes in travel patterns, social networks and travel distances, mobility socialization and attitudes. In a next step, insights from the disciplines of cognitive psychology and memory research on biases and errors and strategies to aid recall were transferred to travel research in order to review the potentials and risks of retrospective methods.

Reflecting on the quality of retrospective data and possible miscalls and distortions begs the question as to whether the quality of retrospective data is less accurate than panel studies. Using retrospective data certainly involves the risk of errors and bias in retrieval. However, as shown in this paper, response behaviour and retrieval can be influenced and supported by various techniques. The careful choice of events and memories that can be subject to retrospective inquiry is important, as is the design of the retrospective survey. Travel researchers use retrospective methods to focus on significant life events with their strong emotions and severe consequences. The choice of such events enhances the chances of (accurate) recall, as these events serve as anchor to find associated memories in the memory organized in networks. Episodic memories may be less influenced by social, normative and cultural scripts and might therefore be addressed first. Similarly, directly retrieved dates should be preferred over reconstructed ones. If not available, recall aids, such as temporal and thematic landmarks, help improve accuracy. In this context, it is important not to mix cued and non-cued recall to prevent systematic biases. Dates are often not remembered correctly. Therefore, it is important to build up an internal temporal and thematic framework. The characteristics of individuals, such as age, culture and emotions, should be controlled and integrated in analysis. Finally, it is important to give respondents enough time and to highlight the difficulties of questions, as retrieval is resource intensive.

In summary, both methods – panel and retrospective – offer unique opportunities to investigate travel behaviour over long periods. Neither method prevails over the other, as a comparison of panel and retrospective methods shows (Solga, 2001). Both methods have their pros and cons with the consequence of "design-specific appropriateness for certain research issues" (Solga, 2001, p. 307). Thus, it is important to design methods in line with the subject of investigation. In this context, Solga (2001) claims to have developed mixed designs and improved retrospective approaches in panel studies as well as various measurements in retrospective data acquisition. It is clear that the use of retrospective methods offers great potential in travel research. However, despite the good start made by Hollingworth and Miller (1996) in evaluating the use of retrospective methods in residential mobility, there remains a lack of up-to-date systematic research on the potentials and biases of retrospective methods and the recall of events in the past, especially in relation to daily travel behaviour. In this context, most of the retrospective studies in travel research lack the use or at least the description of strategies to increase the ability to remember and a critical assessment of data quality. Even if Sattlegger and Rau (2016) initiate a

discussion on the retrospective methods of mobility biographies research, they do not reflect on the consequences of these different approaches for the support of respondents to remember travel behaviour through the life-course. This article draws attention to this neglected and at the same time substantial aspect of retrospective data collection in travel behaviour research. It tries to bridge this gap in combining findings from research on memory with the approaches of mobility biographies research. The paper aims to raise awareness of the fact that the type of question has an influence on the way of remembering and that reflection on methods can lead to an improvement in data quality. Thus, it provides a starting point for further discussions on the quality of retrospective data in travel behaviour research, hoping that future studies will make use of the strategies presented and reflect more strongly on their methodologies, thereby contributing to higher data quality.

CRediT authorship contribution statement

Hannah Müggenburg: Conceptualization, Writing - original draft, Writing - review & editing, Visualization.

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