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### Cycling subjective experience

*A conceptual framework and methods review*

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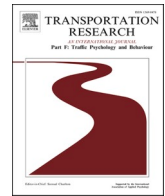
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# Transportation Research Part F: Psychology and Behaviour

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## Cycling subjective experience: A conceptual framework and methods review

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### ABSTRACT

When evaluating cycling subjective experiences (CSE), mobility researchers have questioned the depictions of cycling as an efficient, fast, and solitary mobility mode. By reframing cycling in terms of its emotional impact on the cyclist, research to date has explored dimensions such as fun, relaxation, and sociability of cycling experiences. Yet, these insights have not been integrated into a holistic understanding of CSE. Addressing this gap, this paper asks: what is the CSE exactly and how do we measure it? We selected and analysed in-depth 50 articles with the aim of unpacking the innate characteristics of CSE. The paper makes a contribution to the research on CSE by presenting a novel framework that clarifies the relationships within existing literature, and identifies measurement methods aligned with this framework. The three interrelated core aspects of CSE are 1) sensory interpretation, 2) affective states, and 3) cognitive construction. Additionally, the three identified methods are 1) retrospective, 2) interceptive, and 3) mobile methods. Notably, retrospective surveys and interviews emerged as the dominant methods employed in the field. However, there has been a growing interest in mobile methods, which enable the collection of real-time and context-specific data, thereby enhancing the generalizability of research findings. Through our analysis we have found that the positive values of cycling experiences have been largely ignored in our sample of studies, revealing a bias of researchers to focus on mobility as a disutility. Based on our findings, we urge planners and scholars to rethink their implicit efforts to mitigate the negative effects of cycling experiences and look for opportunities to optimize for positive cycling experiences.

### 1. Introduction

Cycling provides unique subjective experiences for the cyclist and the people in their sphere of interaction (Liu et al., 2019; Pine et al., 1999; Simpson, 2017; te Brömmelstroet et al., 2017). When moving, cyclists are interpreting environments through their senses in pace with emotional and physiological challenges such as varying terrain, familiar environments, vehicular dangers, road obstacles, and other changes along the route. Through these interactions, every cyclist connects through their bodies with bicycles, infrastructures, landscapes, and other road users (Freudendal-Pedersen & Kesselring, 2017). They experience those connections and their relationship with the world in a deep and meaningful manner, and stitch together a series of feelings into one continuous, unbroken narrative, giving cyclists individual impressions of themselves and the journey (Day, 2016). With the "mobility turn"

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contributing to valuing happier trips, human connections on the move, and enhanced well-being as legitimate mobility policy goals, there is an increasing emphasis on the understanding of actual subjective experiences of mobile people in general, and cyclists in particular (Edensor, 2003; Jensen, 2009; Sheller & Urry, 2006; Spinney, 2009).

Emerging research, such as Kalra et al. (2022), Liu et al. (2018), and Lim et al. (2022), show that cycling experiences are linked to spatial and social aspects through their reviews. These studies highlight the experiences linked to cyclists' surroundings, but few unpack the experience itself, i.e. what exactly is the subjective cycling experience (CSE)? Specifically, conceptual models are absent regarding the innate character and mechanisms of recycling experience. The operationalization of this line of research has thus been challenging, as the exact nature of the capturing methods and their correspondence to various aspects of CSE have not been fully understood (Kalra et al., 2022). To address these gaps, this paper aims to answer the research question: How is the subjective experience of cycling defined and measured in academia? Accordingly, the choice and definition of aspects of experience – sensory interpretation, affective states, and cognitive construction – are discussed in section 2. Section 4 analyzes the prominent research trends concerning CSE, the underlying dimensional components of the three basic aspects of CSE identified by academics, and the strengths and limitations of the existing capturing methods.

The paper contributes to the discussion around CSE by clarifying the terminologies surrounding CSE and while presenting a framework that integrates its components. Our review stands out from similar works by highlighting relationships among existing strands of literature. Furthermore, our classification system illustrates relationships between measurement methods in CSE research and presents clear boundaries for the CSE aspects of sensory interpretation, affective states, and cognitive construction.

## 2. Theoretical embedding

A number of previous reviews focused on various aspects of CSE (Table 1). Despite the accumulation of considerable perspectives on cycling experience in this field, terminological inconsistency and the absence of an exhaustive framework are frequently emphasized by academic researchers (e.g. Kalra et al., 2022; Penn, 2011). Not succeeding in finding a generally accepted definition of CSE, Kalra et al., (2022, p. 3) give the most recent definition of *cycling subjective experience (CSE)*: “bicycle riders’ emotional reactions to the bicycling-related situations and events”. Building on this, we view “emotions” as a central aspect of CSE. To enhance conceptual clarity, we address the term “emotions”, which is often applied incorrectly, through the frameworks presented by Ekkekakis (2013). Subsequently, we redefine the central aspect as “affective states” instead of “emotions”. In our pursuit of enhancing the comprehensive understanding of CSE, we have revisited the foundational definition of *subjective experience* in the discipline of psychology as articulated by (Panksepp & Solms, 2012, p. 5) and in the context of User Experience field as delineated by Lim et al., (2022, p. 365). Consequently, two additional key aspects that have previously been neglected within the domain of cycling have been identified: sensory interpretation and cognitive construction (Fig. 2.1). In this review, these three aspects will serve as the foundation for understanding and describing CSE. Below, we discuss each of these aspects.

### 2.1. Sensory interpretation

The term *subjective experience* originates from the field of psychology and is defined as “the cognitive and affective processes that underlie an individual’s interpretation of the objective events and stimuli they encounter in their environment” (Panksepp & Solms, 2012, p. 5). Within the context of cycling, Lim et al., (2022, p. 365) have adapted the definition of *subjective experience* from User Experience as “something individual that emerges from interacting with a product, system, service, or an object”. As they demonstrated, the person-object transaction is one of the defining features in *subjective experience*. Building upon this foundation, we define *sensory interpretation* in cycling context as a dynamic process involving the reception of stimuli from the physical and social environment, followed by the personal absorption and interpretation of these stimuli. This comprehensive process includes the engagement with the fundamental five senses—*aesthetic, auditory, smelling, touching, and tasting*—along with additional senses such as *kineshetics and vestibular* (Bradford, 2017). Recognizing cycling as an embodied practice, sensory interpretation emerges as a crucial aspect for comprehending CSE.

**Table 1**  
Existing reviews discussing various aspects of CSE.

Year	Authors	Title	Sources
2011	Ettema, D., Gärling, T., Olsson, L. E.	Worthwhile travel time: a conceptual framework of the perceived value of enjoyment, productivity and fitness while travelling	Transport Reviews
2017	Reis, P., Mouta, S., Fernandes, O.	Physiological measures of bicyclists’ subjective experiences: A scoping review	Transportation Research Part F: Traffic Psychology and Behaviour
2018	Roozenburg, B., Wayda, V., Paulusse, J., et al.	Cycling under influence: summarizing the influence of perceptions, attitudes, habits, and social environments on cycling for transportation	International Journal of Sustainable Transportation
2018	Liu G, Krishnamurthy S, van Wesemael P.	Conceptualizing cycling experience in urban design research: a systematic literature review	Applied Mobilities
2021	Willis, C., Ross, T., Deshpande, S., et al.	Methods used to capture subjective user experiences in adults while riding bicycles: a scoping review	Transport Reviews

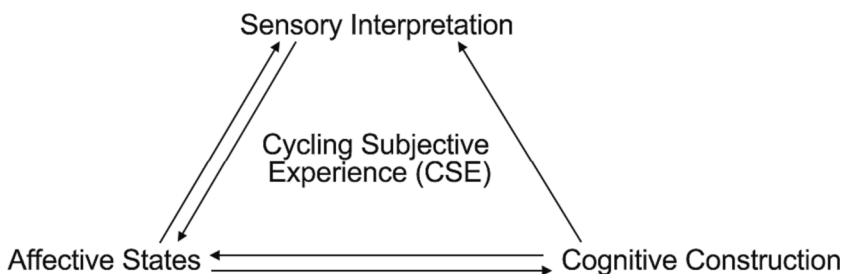


Fig. 2.1. Aspects of Cycling Subjective Experience (CSE).

2.2. Affective states

Subsequent to our acknowledgment of *emotion* as a central aspect of CSE, we encountered an ongoing debate regarding the distinctions among the terms *affect*, *emotion*, and *mood* within the field of affective psychology. This discourse gained momentum following the critique by Carver and Harmon-Jones (2009), who expressed concerns about the ambiguity surrounding these terms. However, it is rare to see extensions of this debate into the field of mobility (see exceptions Anable & Gatersleben, 2005). Some theories and measurements are proposed without a supporting rationale, or even freely interchanging terms. For instance, Passafaro et al., (2014, p. 77) presented a theoretical framework that “enables simultaneous consideration of both the attitudinal or cognitive (pros and cons) and the affective (emotional) implications of travel mode choices”.

As a turning point in affective psychology, Ekkekakis (2013) made a notable effort to differentiate affect, mood, and emotion. While the quest for an exhaustive or definitive system to differentiate affect, emotion, and mood may perpetually face challenges due to the inherent fuzziness of these terms, Ekkekakis (2013) identified sufficient convergence in the literature: categorizing affective states as a broad “umbrella”(Scherer, 1984, p. 298) that “covers all possible variants (including, but not limited to, emotion and mood)” (Ekkekakis, 2013, p. 49). Building on his suggestion, we employ affective states as a key aspect of CSE. This term allows for the collection of various empirical scenarios without assumptions about whether the research target is “an emotion, a change in mood, or free-floating affect” (Ekkekakis, 2013, p. 49).

2.3. Cognitive construction

Cognitive processes constitute an element of *subjective experience*, as outlined in the original psychological definition (refer to 2.1). Nevertheless, this aspect is largely omitted during the transfer of *subjective experience* from its original psychological context to the domain of cycling. In parallel fields, such as Architectural Design, Industrial Design, Anthropology, and Traveling Behavior, cognition-centric research is emphasized. For instance, as one aspect of experience, the understanding of space and self has been highly underscored in Architectural Design. As stated by Robinson and Pallasmaa (2015, p. 225), the gift of architecture is “not in the mere fulfillment of pleasure, but in the ‘delay’ (Duchamp’s famous word) that reveals the space of human existence as a space of desire, actually bittersweet, never-ending with a punctual homeostasis.” The “delay” is originally Duchamp’s expression of his artistic concept of preservation, which has been extended to multiple meanings with his art Large Glass (Britain et al., 1966). Robinson and Pallasmaa (2015) elaborate on the experience of architecture, revealing the temporality in the space of human experience, yet carrying a “delay” that is thick and endowed with dimensions—in a sense, as eternal. Therefore, similar to the experience of visiting architecture, cycling, as a journey through spaces connected by countless temporary moments, should not omit the cognitive aspect in its domain. This aspect refers to a reflective cognitive construction of the cycling environment and the cyclists’ selves.

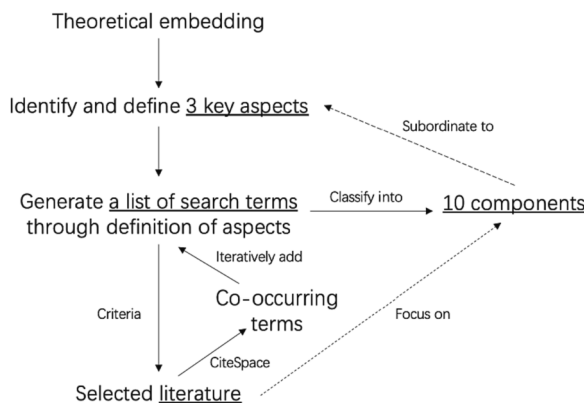


Fig. 3.1. Framework.

Upon synthesizing the theoretical insights derived from literature, the three basic aspects of CSE are identified as: (1) sensory interpretation, (2) affective states, and (3) cognitive construction (Fig. 2.1). CSE comprises the three aspects and their interactions. The interpretation of sensory input can elicit changes in affective states and subsequent cognitive construction. Conversely, cognitive states may influence the personal interpretation of sensory stimuli, with or without the modulation of affective responses. Building on this framework, the following sections aim to unpack the basic three aspects of CSE through empirical review, as well as to elucidate the capturing methods for each aspect.

### 3. Methodology

The theoretical background provides the rationale for this systematic literature review. Fig. 3.1 outlines the methodology framework for this review.

Through the definition of the three aspects, we generated the root search terms: experience, visual, aesthetics, olfactory, smell, acoustic, hear, sound, kinesthetic, senses, affect, mood, emotion, cognition and word derivatives. Following co-occurring analysis with CiteSpace, additional terms were iteratively incorporated into the list, including feeling, happy, pleasure, enjoy, satisfied, safe, upset, fear, anger, disgust, risk, attitude, identity.

We then employed the following criteria to select articles containing the search terms: 1) Combines or includes the purposes of commuting, shopping, visiting, recreation, and traveling (sports or competitive context (e.g., bicycle motocross) are excluded); 2) relevance to any single aspects of subjective experiences during cycling; 3) under real environment (under laboratory settings or virtual environments are excluded); 4) captured subjective experience; 5) after 2000; 6) in English; 7) the impact of papers (total citations is over 10); 8) peer-reviewed journal articles (conference, articles, literature reviews, chapters in books are excluded).

We traced published articles using Scopus and Web of Science, uncovering a total of 271 articles up to May 2023. After the initial review, duplicate papers and papers out of scope were excluded. Vetting for quality narrowed down the scope to 50 empirical articles for deep analysis.

Ultimately, all selected articles are contextualized within the framework 2.1, as their search terms are derived from the definition of CSE outlined in this review and the subsequent elaboration of its constituent aspects. Subsequently, all terms are organized into ten dimensional components subordinate to the three aspects (refer to Fig. 4.2), and all articles are classified accordingly.

## 4. Results

### 4.1. Characteristics of the dataset

The 50 selected articles cover the three aspects of CSE: sensory interpretation ( $n = 8$ ); affective states ( $n = 28$ ); cognitive construction ( $n = 18$ ). Four articles discuss two of these aspects, and are therefore counted twice. The publication years of papers range from 2005 to 2022. Although no obvious linear growth trend was detected, the number of articles reached a peak of 11 in 2019.

Fig. 4.1.1 presents a visual synopsis of the countries based on an examination of the geographic distribution of the empirical case studies. Partially due to the search criteria of ‘English-language articles’, the majority of the empirical work (52 %) was conducted in countries where English is an official language. Additionally, due to this language restriction, only 10 % of the studies’ sample focused on the top five countries with the highest rates of cycling, as outlined by Jones (2022). Besides, it is noteworthy that all the reviewed studies were exclusively conducted in urban areas. Although a limited number of studies involving rural areas within long sports cycling trips were identified, they were not included in the analysis due to their inconsistency with the predetermined selection criteria.

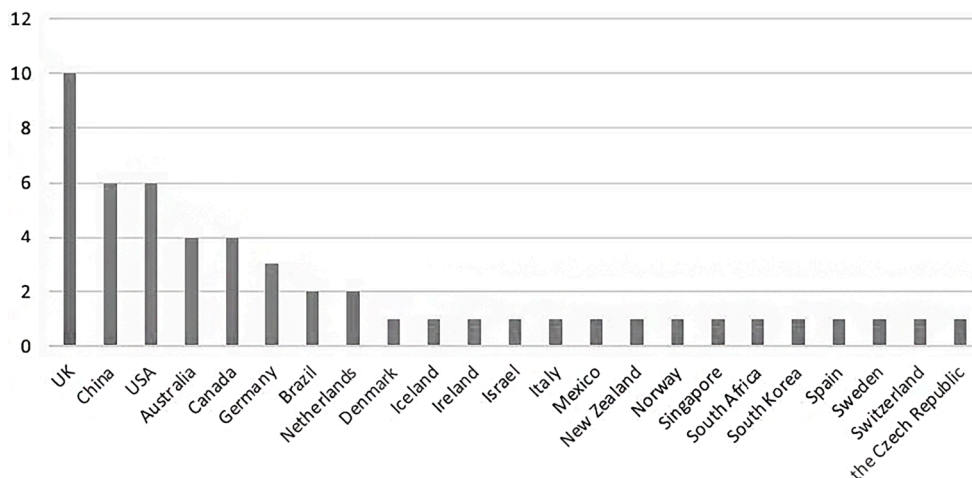


Fig. 4.1.1. Geographic distribution of study cases ( $n = 52$ , one of the articles studied three countries).

The bulk of the studies (38.5 %) were published in the field of transportation-related disciplines, followed by Geography (14 %) (Fig 4.1.2). Upon reviewing the introduction of selected articles, one important research trend in our sample is that the goals of these studies seem to be moving from improving cycling rates to improving the quality of cycling trips. During the 7-year period from 2015 to present, a total of 15 out of 31 articles (48 %) identified improving riding quality as one of their research goals, compared to only 5 out of 19 articles (26 %) over the preceding 15-year period from 2000.

We also looked at the self-reported limitations in the articles. A first limitation is that many investigations on this topic have been conducted on individuals who have the privilege of choosing to cycle, thereby limiting the generalizability of findings to other populations (Dunlap et al., 2021). A second relates to how the synergy among different aspects of the cycling experience is difficult to capture. For instance, it remains elusive how all senses and emotions work together to create a full picture of the journey (Willis et al., 2013; Passafaro et al., 2014)?

#### 4.2. Dimensional components of CSE

The studies in our sample focused on different dimensional components of CSE (see Fig. 4.2). Below, we will discuss those components that belong to the sensory interpretation, affective states, and cognitive construction of CSE.

##### 4.2.1. Sensory interpretation: aesthetic, auditory, smelling, and kinesthetic experience

Through classifying and consolidating terms, we identified eleven articles in our sample that delve into sensory interpretation during cycling experiences. This exploration encompasses several components, including aesthetic, auditory, olfactory, and kinesthetic senses (see Table 1). Six of those articles focus on one individual sense on the move (i.e. aesthetic, auditory, smelling or kinesthetic experience). On the dimension of aesthetic interpretation, Stefansdottir (2014a) presents three main theories in a conceptual framework. And online surveys among commuting bicyclists in three Nordic cities were used to investigate correlations on how certain environmental features are related to aesthetic experiences (Stefansdottir, 2014b). Three papers focus on the component of the auditory senses, as it is related to stressful feelings, with the negative experience of traffic noise being the main motivation of these studies (Aletta et al., 2018; Nuñez et al., 2018; Stelling-Kończak et al., 2015). Using audio isolation and music as a mediating input between the environment and the cyclist is explored through listening to music on experience while cycling (Jungnickel & Aldred, 2014). Smell represents a sense with strong associations to memory, and van Duppen and Spierings (2013, p. 239) reported a coffee smell that creates a fluid sensory experience, which invokes some “being home” or “starting a day” feelings. In addition, one empirical research was found in relation to the kinesthetic experience specifically. Through the detailed description by participants, Clayton and Musselwhite (2013) proved kinesthetic aspects of speed and flow improve the richness of experience.

A notable trend of unpacking sensory interpretation is deliberately exploring around the bias of visually dominated world, pointing out the cycling experience as a multisensory phenomenon (see for example Jones, 2012; Jungnickel & Aldred, 2014; van Duppen & Spierings, 2013). Senses other than visual have been emphasized by researchers as a large part of experience and a particular way of seeing. For instance, van Duppen and Spierings (2013) provide a concept of “sensescape”, which reveals the ‘multimodal’ experience of cycling. Meanwhile, Wild and Woodward (2019) focuses on the different and dynamic sensescape and how they related to euphoria, placemaking, or sensory overload. Despite such a trend, however, some specific senses are likely left out when summarizing multi-sensory experiences. For instance, there is scarcity of research unpacking multisensory interpretation that considers the kinesthetic sense as “adapting devices, bodies and bikes in response to a changing environment” (Wild & Woodward, 2019, p. 4), with most of the multisensory research giving little attention to kinesthetic sense.

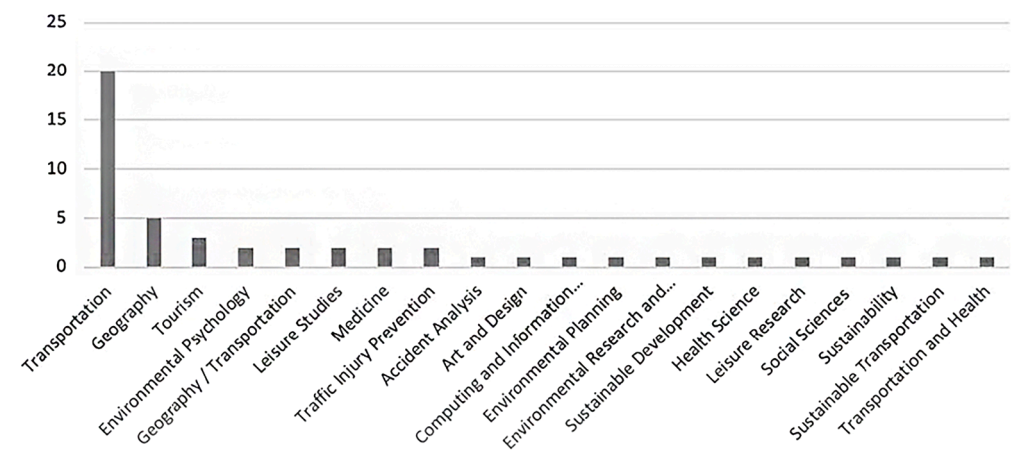


Fig. 4.1.2. Disciplinary Field (n = 50).

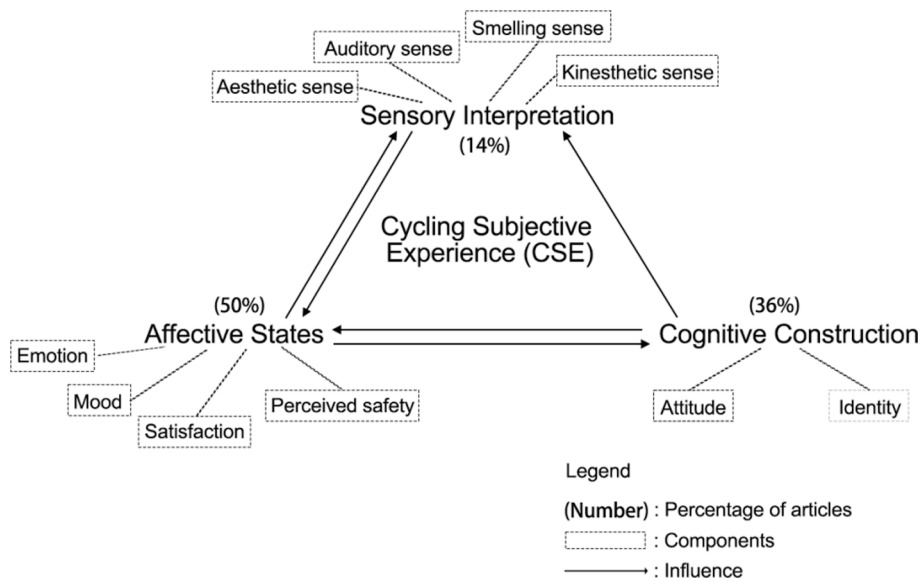


Fig. 4.2. Components of Cycling Subjective Experience (CSE).

#### 4.2.2. Affective states: emotion, mood, perceived risk and satisfaction

Studies under this category ( $n = 31$ ) demonstrate mechanisms that cause changes in the affective states of cyclists (Table 3). Cass and Faulconbridge (2017) have demonstrated that affective states during cycling are not only dependent on the environment, but also on the use of equipment. Cycling as a performative activity is characterized by ambiguous, elusive, and ever-changing affective states. Below describes the key components and indicators captured by authors to unpack affective impact for cyclists.

It was previously noted that Ekkekakis (2013) asserted the potential absence of a clear definition for affect, mood, and emotion in Section 2.2. However, he provided a comprehensive summary of widely accepted distinctions between these constructs in a table (Ekkekakis, 2013, p. 47). Employing these distinctions, we systematically classified articles emphasizing affective states characterized by high intensity and short duration under the term *emotion*. Conversely, those affective states characterized by a longer duration and low intensity were categorized under the term *mood*. In addition, two distinct affective states within the realm of CSE have evolved into areas of dedicated research. One pertains to perceived risk/safety, comfort, anger/fear, while the other is associated with satisfaction. Lacking a precise definition within the domain of CSE, we use the widely accepted definition in the field of traffic studies. Perceived risk is commonly defined as “a road user’s subjective interpretation of risk when involved in different traffic situations” (Deery, 1999, p. 226), and satisfaction refers to “the presence (or absence) of positive (or negative) feelings during a particular trip, possibly in combination with a cognitive evaluation of that trip” (De Vos & Witlox, 2017, p. 3).

**4.2.2.1. Emotion.** The most well-known way of exploring emotions is to divide them into positive and negative qualities. For example, Meenar et al. (2019) applied Plutchik’s sentiment analysis model to identify cyclists’ emotions as anger, disgust, fear, sadness, and joy. etc., then classified them as positive and negative emotions. Gorgul et al. (2019) measure the arousal level of positive and negative emotions to describe the magnitude of their effect. The advantage of measuring the link between environment and emotional impact is that the short-term cause and effect are intuitive and straightforward to measure. The outcomes of this analysis are then used to correlate positive and negative experiences with environmental qualities and attributes (see examples Gamble et al., 2017; Meenar et al., 2019; Snizek et al., 2013).

**4.2.2.2. Mood.** Two authors in our sample have identified certain ambiguous and irreducible features of affective states that are less direct in cause and effect, and more persistent than emotions (Simpson, 2017; Wild & Woodward, 2019). Simpson uses the term *emotional atmospheres*, which is defined by Stewart as “a force field in which people find themselves” (2011, p. 452). This *emotional atmosphere* is described as a felt quality of environmental immersion while also remaining diffuse and ethereal. However, in the field of affective psychology, Ekkekakis criticized the word “mood” should be used to describe the state being described as, “long duration, low intensity, and a certain diffuseness” (2013, p. 44). While the terminology for this diffuse state remains a subject of debate, there are ongoing efforts to explore it. Arguably, it is the cyclists themselves who have the most intimate insight into long-term changes in moods. Hence, ethnographic methods have been employed wherein specific descriptions, such as “convivial”, “disconcerting” (Simpson, 2017), and “euphoria” (Wild & Woodward, 2019) are used as descriptors moods. Using the “force field” description by Stewart (2011), moods are the persistent and lingering force that shapes short-term reactions over the span of one or more cycling journeys.

**4.2.2.3. Perceived risk/safety, comfort, anger/fear.** The feeling of risk caused by traffic pressure has been examined by a considerable amount of literature in transportation and traffic injury prevention studies (see example Mayers & Troy, 2021). One fundamental issue

is the tension between different road users (i.e. drivers, pedestrians, other cyclists), mediated by various street designs. From this point of view, researchers examined cyclists' anger/fear levels or comfort level using the Cycling Anger Scale (see examples Oehl et al., 2019a; O'Hern et al., 2019), and discrepancies between perceived and actual risk (see example Manton et al., 2016). Other studies using the Cycling Anger Scale show demographic differences in anger-related behaviors, such as aggressive riding and radical driving (Zheng et al., 2020). Some attempts have been made to explore the practical possibility of sharing the road space in a peaceful manner, but the much larger mass of automobiles fundamentally makes cyclists more vulnerable in shared environments (Kaplan & Prato, 2016; Wild & Woodward, 2019).

**4.2.2.4. Satisfaction.** In the field of mobility, cyclists are found to achieve higher levels of satisfaction than other travel modes users (St-Louis et al., 2014; Turcotte, 2006). Some attempts have been made to explore cycling satisfaction. Those articles tend to underscore two questions. One is "who is more satisfied with their journeys?" Authors tend to do surveys to compare different traveling modes or cyclists' types (see example Willis et al., 2013). People are required to score qualitative aspects of satisfaction (e.g., enthusiastic, alert, confident) on a quantitative scale (e.g., Likert items, anchored 10-point scales) (Calvey et al., 2015). Another one is "why cyclists are (not) satisfied with their journeys?" Researchers tend to do causal analysis to reach the reason for the high level of satisfaction with cycling (see examples Willis et al., 2013; Sharma et al., 2019).

#### 4.2.3. Cognitive construction: Attitude and identity

Fifteen articles examine cognitive construction while riding (Table 4). Certain features of cognitive construction, such as low security and disadvantaged identity, are found to be driven by the fear of other road users, which is intertwined with the affective aspect. The emphasis of the authors from the cognitive construction aspect is that of a long-term change as a "delayed" experience, such as a social stigma, rather than a short affective reaction resulting from a conflict. The subsequent section will identify the dimensional components of this 'delayed' change.

While conducting searches using the term *cognition* and its derivatives, two pivotal components—*attitude* and *identity*—emerged (Eagly & Chaiken, 1993; Markus & Wurf, 1987). These were subsequently added to the term list for iterative examination. These components involve the interpretation and evaluation of ongoing experiences. Attitude refers to a result of an individual's cognitive appraisal of an object or situation, which can be influenced by their current state and past experiences (Petty & Krosnick, 2013). During

**Table 2**  
Reviewed papers on sensory interpretation.

Year	Authors	Title	Involved components	Country of study	Measuring methods	Sources	Disciplinary fields
2012	Jones P.	Sensory indiscipline and affect: a study of commuter cycling	Multisensory senses	UK	mobile audio diaries (n = 28)	Social & Cultural Geography	Geography
2013	Clayton W, Musselwhite C.	Exploring changes to cycle infrastructure to improve the experience of cycling for families	Kinesthetic senses	UK	1) family interviews; 2) self-documented family cycle rides 3) focus groups (n = 64 pre step)	Journal of Transport Geography	Geography / Transportation
2013	van Duppen J, Spierings B.	Retracing trajectories: the embodied experience of cycling, urban sensescapes and the commute between 'neighbourhood' and 'city' in Utrecht, NL	Multisensory senses	Netherlands	1) tape-recorded, GPS-tracked and video-documented as field notes 2) interview (n = 15)	Journal of Transport Geography	Geography / Transportation
2014	Jungnickel K, Aldred R.	Cycling's Sensory Strategies: How Cyclists Mediate their Exposure to the Urban Environment	Multisensory senses	UK	1) ethnographic fieldnotes 2) interview (n = 132)	Mobilities	Transportation / Geography / Sociology
2014	Stefánsdóttir H.	Urban routes and commuting bicyclists' aesthetic experiences	Aesthetic senses	Iceland, Norway and Denmark	1)questionnaire (n = 276) 2) additional route mapping (n = 109)	FORMakademisk	Art and Design
2015	Stelling-Kończak A, Hagenzieker M, Wee B V.	Traffic Sounds and Cycling Safety: The Use of Electronic Devices by Cyclists and the Quietness of Hybrid and Electric Cars	Auditory senses	Netherlands	1)literature review (n = 33) 2) crash data analysis (n = not provided)	Transport Reviews	Transportation / Logistics
2018	Núñez J Y M, Teixeira I P, Silva A N R, et al.	The Influence of Noise, Vibration, Cycle Paths, and Period of Day on Stress Experienced by Cyclists	Auditory senses	Brazil	1)Wearable sensors measuring (n = not provided)	Sustainability	Environmental Science / Sustainable Development
2019	Wild K, Woodward A.	Why are cyclists the happiest commuters? Health, pleasure and the e-bike	Multisensory senses	New Zealand	open-ended, semi-structured interviews (n = 24)	Journal of Transport and Health	Transportation and Health



**Table 3**  
Reviewed papers on affective states.

Year	Authors	Title	Involved components	Country of study	Measuring methods	Sources	Disciplinary fields
2005	Anable J, Gatersleben B.	All work and no play? The role of instrumental and affective factors in work and leisure journeys by different travel modes	Emotion	UK	Questionnaires (n = R1: 235; R2:666)	Transportation Research Part A: Policy and Practice	Transportation
2007	Gatersleben B, Uzzell D.	Affective appraisals of the daily commute: Comparing perceptions of drivers, cyclists, walkers, and users of public transport	Emotion	UK	Online questionnaires (n = 389)	Environment and Behavior	Environmental Psychology
2012	Jones P.	Sensory indiscipline and affect: a study of commuter cycling	Emotion	UK	mobile audio diaries (n = 28)	Social & Cultural Geography	Geography
2013	Willis D P, Manaugh K, El-Geneidy A.	Uniquely satisfied: Exploring cyclist satisfaction	Satisfaction	Canada	Online questionnaires (n = 4692) (10-item?, 5-point scale)	Transportation Research Part F: Traffic Psychology and Behaviour	Transportation
2014	Passafaro P, Rimano A, Piccini MP, et al.	The bicycle and the city: Desires and emotions versus attitudes, habits and norms	Emotion	Italy	Questionnaires (n = 387)	Journal of Environmental Psychology	Environmental Psychology
2014	Lee C F.	An investigation of factors determining cycling experience and frequency	Satisfaction	China	Questionnaires (n = 221) (28-item, 5-point Likert type scale)	Tourism Geographies	Tourism
2014	Stefánsdóttir H.	Urban routes and commuting bicyclists' aesthetic experiences	Affect	Iceland, Norway and Denmark	1)questionnaire (n = 276) 2) additional route mapping (n = 109)	FORMakademisk	Art and Design
2015	Calvey J C, Shackleton J P, Taylor M D, et al.	Engineering condition assessment of cycling infrastructure: Cyclists' perceptions of satisfaction and comfort	Satisfaction	UK	Questionnaires (n = 75) (23-item?, 5-point scale)	Transportation Research Part A: Policy and Practice	Transportation
2016	Manton R, Rau H, Fahy F, et al.	Using mental mapping to unpack perceived cycling risk	Perceived risk	Ireland	1)mental mapping (n = 104) 2) stated-preference survey (n = 104) 3) transport infrastructure inventory	Accident Analysis & Prevention	Accident Analysis
2016	Kaplan S, Prato C G.	"Them or Us": Perceptions, cognitions, emotions, and overt behavior associated with cyclists and motorists sharing the road	Emotion	Israel	talk-back thematic analysis (n = 1844)	International Journal of Sustainable Transportation	Sustainable Transportation
2017	Simpson P.	A sense of the cycling environment: Felt experiences of infrastructure and atmospheres	Affective atmosphere	UK	Mobile video + interviews(n = 24)	Environment and Planning A	Environmental Planning
2018	Liu X, Huang D, Li Z.	Examining relationships among perceived benefit, tourist experience and satisfaction: the context of intelligent sharing bicycle	Satisfaction	China	Questionnaires (n = 296) (7-point Likert type scale)	Asia Pacific Journal of Tourism Research	Tourism

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Table 3 (continued)

Year	Authors	Title	Involved components	Country of study	Measuring methods	Sources	Disciplinary fields
2018	Nuñez J Y M, Teixeira I P, Silva A N R, et al.	The Influence of Noise, Vibration, Cycle Paths, and Period of Day on Stress Experienced by Cyclists	Emotion (stress)	Brazil	1)Wearable sensors measuring (n = not provided)	Sustainability	Environmental Science / Sustainable Development
2019	Oehl M, Brandenburg S, Huemer A K.	Cyclists' anger experiences in traffic: the cycling anger scale	Anger	Germany	1)focus groups (n = 73) 2) cycling diary (n = 144) 3 ) online questionnaire (n = 421)	Transportation research part F: traffic psychology and behaviour	Transportation
2019	Gorgul E, Zhang L, Günther F, et al.	Mapping human response to street experience: a study on comparing walking with cycling on streets through wearable sensors	Emotion	China	Wearable sensors measuring (n = 16)	Adjunct Proceedings of the 2019 ACM International Joint Conference on Pervasive and Ubiquitous Computing and Proceedings of the 2019 ACM International Symposium on Wearable Computers	Computing and Information Technology
2019	Meenar M, Flamm B, Keenan K.	Mapping the emotional experience of travel to understand cycle-transit user behavior	Emotion	USA	Survey 1) mapping (n = 59) 2) comments (n = 62)	Sustainability	Sustainability
2019	Wild K, Woodward A.	Why are cyclists the happiest commuters? Health, pleasure and the e-bike	Satisfaction	New Zealand	open-ended, semi-structured interviews (n = 24)	Journal of Transport and Health	Transportation and Health
2019	O'Hern S, Stephens A N, Young K L, et al.	What makes cyclists angry? The relationships between trait anger, interest in cycling and self-reported comfort levels	Angry, comfort	Australia	Online questionnaire (n = 636)	Transportation Research Part F: Traffic Psychology and Behaviour	Transportation
2019	Oehl M, Brandenburg S, Huemer A K.	German bike messengers' experiences and expressions of cycling anger	Anger	Germany	Online and paper questionnaire (n = 544)	Traffic Injury Prevention	Traffic Injury Prevention
2019	Sharma B, Nam H K, Yan W, et al.	Barriers and enabling factors affecting satisfaction and safety perception with use of bicycle roads in Seoul, South Korea	Satisfaction and perceived safety	South Korea	questionnaire (n = 190) (5-point Likert type scale)	International Journal of Environmental Research and Public Health	Environmental Research and Public Health
2020	Griffin W, Haworth N, Twisk D.	Patterns in perceived crash risk among male and female drivers with and without substantial cycling experience	Perceived risk	Australia	Online questionnaire (n = 595)	Transportation Research Part F: Traffic Psychology and Behaviour	Transportation
2020	Zheng Y, Ma Y, Cheng J.	Cycling anger in China: The relationship with gender roles, cycling-related experience, risky and aggressive riding	Anger	China	Online questionnaire (n = 442)	Transportation Research Part F: Traffic Psychology and Behaviour	Transportation
2021	Oehl M, Becker T, Che M, et al.	Validation of the cycling anger scale in Singapore	Anger	Singapore	Online questionnaire (n = 116)	Traffic Injury Prevention	Traffic Injury Prevention
2021	McIlroy R C, Plant K L, Stanton N A.	Thinking aloud on the road: Thematic differences in the experiences of	Emotion	UK	1)Demographics questionnaires 2) Mobile verbal reports	Transportation Research Part F: Traffic Psychology and Behaviour	Transportation

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Table 3 (continued)

Year	Authors	Title	Involved components	Country of study	Measuring methods	Sources	Disciplinary fields
2021	Dunlap R, Rose J, Standridge S H, et al.	drivers, cyclists, and motorcyclists Experiences of urban cycling: emotional geographies of people and place	Emotion (pleasure and freedom, etc.)	USA	(audio taken) (n = 46) semi-structured interviews (n = 16)	Leisure Studies	Leisure Studies
2021	Kazemzadeh K, Camporeale R, D'Agostino C, et al.	Same questions, different answers? A hierarchical comparison of cyclists' perceptions of comfort: in-traffic vs. online approach	Comfort	Sweden	in-traffic (n = 258) and online (n = 120) questionnaires	Transportation Letters	Transportation
2021	Mayers R, Glover T.	Safe cycling space: How it is produced and experienced by cyclists	Perceived safety	Canada	semi-structured interviews with photography (n = 16)	Journal of Leisure Research	Leisure Research
2022	von Stülpnagel R.	Gaze behavior during urban cycling: Effects of subjective risk perception and vista space properties	Perceived safety	Germany	1) mobile eye tracking system 2) survey (n = 18)	Transportation research part F: traffic psychology and behaviour	Transportation

cycling, this cognitive appraisal may be jointly shaped by environmental factors, other road users, events that they encountered, or past experiences with cycling. Identity refers to the cognitive construction of an individual's sense of self (Brewer & Gardner, 1996), which is subject to change as they continually interpret their attributes during cycling. In the cycling context, identity may be shaped by factors such as the cyclist's perception of themselves as a cyclist, their relationship to the cyclist group, and their cycling goals and aspirations.

**4.2.3.1. Attitude.** The majority of studies (n = 12) that investigate (non-)cyclists' cognitive construction target travelers' attitudes. Various existing keywords overlap with travelers' attitudes, such as intention (Fernández-Heredia et al., 2016), motivation (Rérat, 2019), perception (Fernández-Heredia et al., 2014), and willingness (Namgung & Jun, 2019). The attitudes towards cycling are often investigated by measurable variables. Four articles in our sample demonstrate the overall attitudes or roughly sort attitudes into physical/instrumental and mental/affective parts, then evaluate them in terms of positive/good or negative/bad (Heesch et al., 2015; Meng & Han, 2016; Namgung & Jun, 2019; Rérat, 2019). Two articles focus exclusively on the attitude towards owning a bicycle (de Wet et al., 2022; Zhao et al., 2018). Five articles unpack attitudes towards specific elements or qualities of cycling, such as convenience, fun and safety (Thigpen, 2019), security and comfort (Piatkowski & Marshall, 2015), lifestyle, landscape and community (Gabrhel, 2019), flexibility, fitness and vandalism (Fernández-Heredia et al., 2016), and embodiment (Lee, 2016). The purpose of evaluating attitudes in the study of cycling experience is to examine the underlying reasons for people's decision to (not) cycle, instead of understanding the experience itself. To explore the behaviors associated with certain attitudes, some theories have been employed, and some models, such as "decision-making" (Meng & Han, 2016) and "transport/ mode choice" (Gabrhel, 2019; Steinbach et al., 2011), are proposed to demonstrate the bi-directional relationship between attitudes and behavior. Those models suggest that "attitude" has more impact on bicycle use than sensory and affective components of the subjective cycling experience.

**4.2.3.2. Identity.** Six articles examine the marginalized (Mayers & Glover, 2020; Steinbach et al., 2011), stigmatized (Aldred, 2013; T. Jones & de Azevedo, 2013), disadvantaged (Heesch et al., 2011), and invisible (Aldred, 2013; T. Jones & de Azevedo, 2013; Steinbach et al., 2011) image of cyclists across Australia, UK, Brazil, and Canada. All the countries under consideration demonstrated notably lower cycling rates compared to most European countries. In these studies, the cyclist identity is located in a dynamic relationship with other social identities. Four social identities consistently discussed are gender, ethnicity, class, and age (Aldred, 2013; Heesch et al., 2011; Jones & de Azevedo, 2013; Ravensbergen, 2022). In Canada and Brazil, the image of a cyclist is usually identified as at odds with femininity and as a symbol of poverty (Jones & de Azevedo, 2013; Ravensbergen, 2022). In the UK, it carries an image of incompetence, ignorance, and illegality (Aldred, 2013). Two notably different identities are the "rich recreational cyclist" (Ravensbergen, 2022, p. 689) and "young people linked to academia" (Jones & de Azevedo, 2013, p. 214). Steinbach et al., (2011, p. 1128) reported that both positive and negative identity can be strengthened by the experience of cycling: "an 'assertiveness' in female's identity or 'aggressive' in some male cyclists' identities can be bolstered by cycling." In the literature review section by Aldred (2013), the adoption of assertive or aggressive attitudes emerges as one of the tactics employed to negotiate a stigmatized identity as cyclists.

Without exception, those locally constituted and mutable identities are conceptualized as part of the cyclists' ever-changing cognitive constructions that are produced along with their movement, mostly in their conflict with car drivers and motorbike riders and the studies report that motorists perceive cyclists as an "out-group" of road users. The most reported abuse is driving too close, shouting abuse, and making obscene gestures/sexual harassment (Aldred, 2013; Heesch et al., 2011; Jones & de Azevedo, 2013).

**Table 4**  
Reviewed papers on cognitive construction.

Year	Authors	Title	Involved components	Country of study	Measuring methods	Sources	Disciplinary fields
2011	Heesch K C, Sahlqvist S, Garrard J.	Cyclists' experiences of harassment from motorists: Findings from a survey of cyclists in Queensland, Australia	Identity	Australia	online questionnaire (n = 1830)	Preventive Medicine	Medicine
2011	Steinbach R, Green J, Datta J, et al.	Cycling and the city: A case study of how gendered, ethnic and class identities can shape healthy transport choices	Identity	UK	interview (n = 78)	Social science & medicine	Social Sciences & Medicine
2013	Aldred R.	Incompetent or too competent? Negotiating everyday cycling identities in a motor dominated society	Identity	UK	narrative interviews (n = 59)	Mobilities	Geography
2013	Jones T, de Azevedo L N.	Economic, social and cultural transformation and the role of the bicycle in Brazil	Identity	Brazil	1)focus group 2) interview (n = more than 27)	Journal of Transport Geography	Geography
2014	Fernández-Heredia Á, Monzón A, Jara-Díaz S.	Understanding cyclists' perceptions, keys for a successful bicycle promotion	Attitude	Mexico	1)focus group 2) online questionnaires (n = 3048)	Transportation Research Part A: Policy and Practice	Transportation
2014	Heesch K C, Giles-Corti B, Turrell G	Cycling for transport and recreation: Associations with socio-economic position, environmental perceptions, and psychological disposition	Attitude	Australia	questionnaires (n = 11,036)	Preventive Medicine	Medicine
2015	Piatkowski D P, Marshall W E.	Not all prospective bicyclists are created equal: The role of attitudes, socio-demographics, and the built environment in bicycle commuting	Attitude	USA	1)questionnaires (n = 2030) 2) GIS-based built environment measures	Travel behaviour and society	Transportation
2016	Fernández-Heredia Á, Jara-Díaz S, Monzón A.	Modelling bicycle use intention: the role of perceptions	Attitude	Spain	online questionnaire (n = 3048)	Transportation	Transportation
2016	Lee D J.	Embodied bicycle commuters in a car world	Attitude	USA	1)participant observations(n = 20) 2) interviews (n = 22) 3) video observations(n = 20) 4) route mapping(n = 20)	Social & Cultural Geography	Geography
2016	Meng B, Han H.	Effect of environmental perceptions on bicycle travelers' decision-making process: developing an extended model of goal-directed behavior	Attitude	China	questionnaires (n = 394)	Asia Pacific Journal of Tourism Research	Tourism
2018	Zhao C, Nielsen T A S, Olafsson A S, et al.	Cycling environmental perception in Beijing – A study of residents' attitudes towards future cycling and car purchasing	Attitude	China	face-to-face structured questionnaire interviews (n = 1427)	Transport Policy	Transportation
2019	Gabrhel V.	Feeling like cycling? Psychological factors related to cycling as a mode choice	Attitude	the Czech Republic	questionnaires (n = 1 301)	Transactions on Transport Sciences	Transportation
2019	Namgung M, Jun H J.	The influence of attitudes on university bicycle commuting: Considering bicycling experience levels	Attitude	USA	Online questionnaire (n = 1189)	International Journal of Sustainable Transportation	Transportation
2019	Rérat P.	Cycling to work: Meanings and experiences of a sustainable practice	Attitude	Switzerland	questionnaire (n = 13,700)	Transportation Research Part A:	Transportation

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Table 4 (continued)

Year	Authors	Title	Involved components	Country of study	Measuring methods	Sources	Disciplinary fields
2019	Thigpen C.	Do bicycling experiences and exposure influence bicycling skills and attitudes? Evidence from a bicycle-friendly university	Attitude	USA	annual campus travel survey (questionnaire) (n = 3498)	Policy and Practice Transportation Research Part A: Policy and Practice	Transportation
2020	Mayers R F, Glover T D.	Whose Lane Is It Anyway? The Experience of Cycling in a Mid-Sized City	Identity	Canada	semi-structured interviews (n = 16)	Leisure Sciences	Leisure Studies
2022	de Wet T, Dzinotyiweyi T, Ellison G T H.	Introducing Johannesburg's new cycle lanes to potential student users: experiences, impact and recommendations	Attitude	South Africa	1) supervised cycle ride 2) questionnaires (n = 281) 3) fieldworkers' photographic and reflective accounts	Journal of American College Health	Health Science
2022	Ravensbergen L.	'I wouldn't take the risk of the attention, you know? Just a lone girl biking': examining the gendered and classed embodied experiences of cycling	Identity	Canada	interview (n = 56)	Social & cultural geography	Geography

Carrying a fear of motorists, cyclists keep showing their resistance to stigma throughout their cycling life, from self-deprecation to classifying others as "bad cyclists" (Aldred, 2013). In spite of that, Jones and de Azevedo (2013, p. 213) found that lots of cyclists aspire to own a car or motorbike with an ingrained picture of car ownership as a status symbol of "modernity and success".

### 4.3. Methods of capturing cycling experience

The three tables in 4.2 provide inventories of methods used by the 50 selected empirical papers to capture CSE. In Fig. 4.3 below, we have classified them as mobile methods, retrospective methods, interceptive surveys, and combinations thereof.

#### 4.3.1. Mobile, retrospective, and interceptive methods

Mobile methods aim to capture the experience while the participant is on the move. This includes methods such as wearable sensor measuring, mobile audio and video, participant observation, and GPS tracking (see examples Jones, 2012; Lee, 2016; Nuñez et al.,

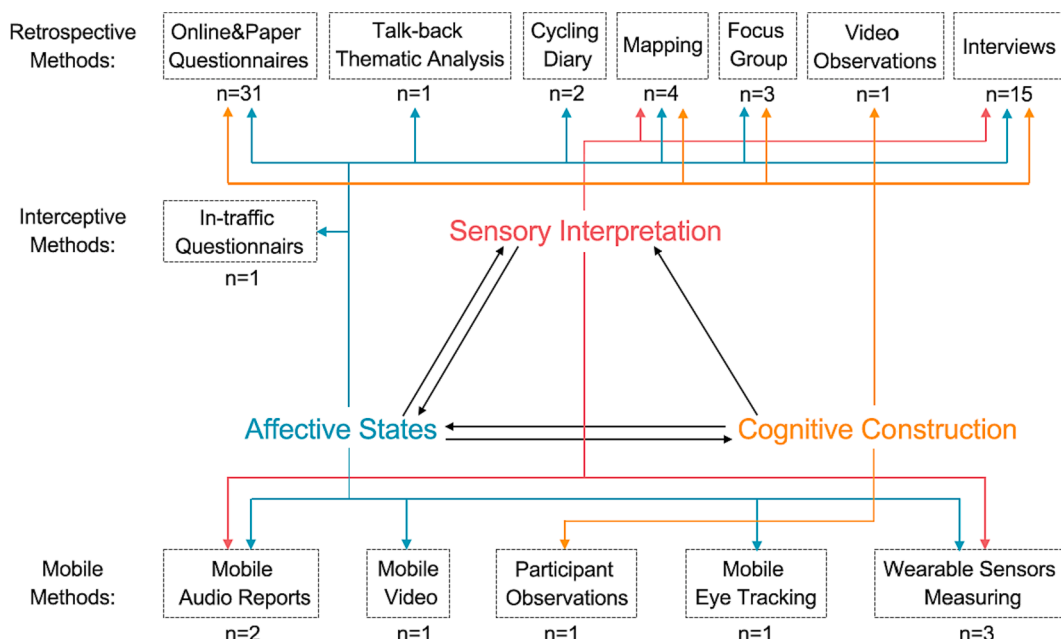


Fig. 4.3. Methods of capturing CSE in reviewed literature (n is numbers of articles).

2018; Simpson, 2017). These methods can capture the cyclists' experience as it unfolds and provide an accurate representation of the senses, affects, and cognitions experienced during the ride. But the number of participants tends to be low, where the median is 26.5.

Retrospective measuring gather data after the cycling experience has taken place. This includes methods such as paper and online questionnaires, interviews, focus groups, and diaries. These methods can reach a larger number of participants, where the median of those retrospective methods ranges from 20 to 407.5, as well as provide more in-depth information about the cycling experience. However, the accuracy of the data collected may be affected by memory bias and the participant's ability to recall their experience accurately.

We found only one instance of in-traffic questionnaires, which is categorized as interceptive surveys. An interceptive survey is defined as a research method wherein researchers interrupt and approach people during their active participation in order to elicit their participation in the study.

In light of the distinct advantages of mobile and retrospective research methods, certain authors have integrated these two to attain a more comprehensive and nuanced dataset. There are two well-established combinations. One is the combination of mobile video records plus retrospective interviews. Researchers, such as Simpson (2017), developed a set of interview questions for each participant. Another one is a combination of mobile equipment (i.e. eye-tracking and wearable sensors) measurements plus retrospective questionnaires. For instance, von Stülpnagel (2020), recorded the continuous perceptual processes, then linked them to consciously retrievable emotional and perceptual states through questionnaires.

#### 4.3.2. Commonalities in the application of methods for capturing senses, affect, and cognition

Retrospective surveys and interviews are the most commonly used methodologies for collecting experience data. Both methods rely on self-reported data from participants. Surveys provide the advantage of a larger participant pool, typically ranging from the first quartile (225) to the third quartile (1698), with a high average of 1628. Interviews are better suited for obtaining in-depth information, at the cost of lower sample size. But one bias of all retrospective methods is that without guidance for recalling specific moments and locations, participants may not recall changes as being as significant to the overall quality of their journey.

Of the survey methods, online questionnaires received a significantly higher response rate than paper questionnaires, with a median of 615.5 (Fig. 4.3). Paper questionnaires, however, have a high deviation, indicating that only a small fraction of wide baseline surveys that are mailed out are capable of reaching a large number of participants. The advantage of paper questionnaires lies in their ability to reach populations who may not have digital access or proficiency. For instance, Heesch et al. (2015) utilized mailed self-administered questionnaires to gather a representative sample of adults aged 40–65 years in Brisbane, Australia. However, all authors who use surveys, as structured methods, do not able to capture other extenuating factors not predicted in questionnaires.

Additionally, some scholars acknowledge the potential biases inherent in retrospective surveys compared to interceptive surveys. For instance, Kazemzadeh et al. (2021) argue that the completion environment for retrospective surveys is typically more relaxed and comfortable, which may result in a less accurate representation of the stress and physical exertion experienced by cyclists during cycling. To address this, they conducted a comparative study using two types of questionnaires, intercept and online. The results suggest that cyclists exhibit a more positive and optimistic attitude towards cycling comfort when completing online questionnaires compared to interceptive questionnaires for certain questions. Other possible limitations of retrospective questionnaires reported by Oehl et al., (2019a) are the risk of social desirability and the risk of substantial memory loss or temporal displacement.

Mobile methods have the potential to increase the generalizability of findings by capturing real-time and contextual data. However, guided cycling trips may introduce some bias: Firstly, it can be challenging to create a specific atmosphere or feeling during a trip (Simpson, 2017). Secondly, the researcher is closely involved in the production of the study, which may influence the data collected (McIlroy et al., 2021). Thirdly, other road users could affect cyclists' focus or lead the way, which can make it difficult to ensure independent experience (Gorgul et al., 2019). Fourthly, the order of the scenarios and configuration may not be balanced among participants, leading to order effects (Griffin et al., 2020). Moreover, familiarity with the study route may influence the outcome (McIlroy et al., 2021). Lastly, it remains unclear whether wearing mobile equipment affected participants' behavior and perception (von Stülpnagel, 2020).

#### 4.3.3. Differences in application of methods for capturing senses, affect, and cognition aspects

In addition to the commonality in capturing experience data, each aspect tends to employ distinct additional measuring methods, depending on the specificity of the sensory, affective, and cognitive experiences. The following section demonstrates the specificity of each aspect.

##### 4.3.3.1. Sensory interpretation. 1) Diversified methods

The study of sensory interpretation employs a diverse range of data collection methods, encompassing 11 distinct approaches across 8 studies (with some utilizing mixed methods) (see Figure 4.3). This highlights the absence of a universally accepted "optimal" approach for comprehending individuals' sensory experiences during cycling. Amid the array of diverse methods employed, a discernible pattern emerges where retrospective interviews tend to prevail as the preferred approach for gathering data related to multiple sensory experiences (as exemplified in Jungnickel & Aldred, 2014; van Duppen & Spierings, 2013; Wild & Woodward, 2019).

##### 2) Geolocation

Although a variety of methods are utilized in the sensory aspect, a common characteristic among them is their ability to achieve a high degree of geo-location accuracy compared to the other two aspects. The location information is gathered while they apply retrospective and mobile methods. For instance, retrospective interviews can gather location information through self-documentation

(see example Clayton & Musselwhite, 2013) or mapping (see example Stefansdottir, 2014b), and mobile audio reports combined with GPS tracking (see example Jones, 2012). This emphasis on gathering geographic information reflects the significant impact that the environmental context has on sensory interpretation.

#### 4.3.3.2. Affective states. 1) Established subjective scales

The data collection of affective states is reliant on questionnaires. One specificity of the survey within this aspect is there are some well-developed measurement scales regarding certain emotions and satisfaction. For instance, Oehl et al., (2019a) proposed the Cycling Anger Scale, representing the inaugural tool designed to evaluate cycling anger in traffic. This scale consists of four dimensions with detailed items, each appraising cyclists' interactions within the cycling environment, encompassing police, cyclist, car, and pedestrian interactions. Subsequently, several articles, four of which are included in our sample, have further refined and developed the scale, demonstrating high convergent validity (Oehl et al., 2019b, 2021; O'Hern et al., 2019; Zheng et al., 2020). In addition, five researchers ask their participants to indicate their satisfaction on 5 or 7 -point Likert type scales, which are well-applied scales from measure models in marketing (Willis et al., 2013), tourism (Lee, 2014; Liu et al., 2018) and public service (Calvey et al., 2015) field.

#### 2) Physiological measurements

Recently the boom of technology-driven approaches has led to a growing interest in the collection and analysis of biological and visual data. Among those technological measurements, eye-tracking technology and wearable biosensor technologies are applied to analyze cycling affective experiences. Gorgul et al. (2019) use wearable sensors to measure skin conductance and heart rate as indicators for stressful arousal levels. A similar application of wearable sensors by Nuñez et al.'s research (2018) combines skin conductivity levels (SCLs) and skin temperature to identify stress peaks. In addition, a mobile eye-tracking system is employed by von Stülpnagel (2020) to test the experience of subjective risk. These technical measures were all applied to capture negative affects. One possible explanation is negative affects are able to elicit greater fluctuations in human physiological indicators.

#### 3) Mental and emotional mapping

In the context of cycling, several mapping methods have been developed and adapted from geography to explore CSE. In a study by Manton et al. (2016), participants were instructed to produce mental maps which yielded data-rich perceived safety observations. In another study, Meenar et al. (2019) utilized sketch maps from participants to identify 50 negative and 31 positive emotions, and subsequently created four types of emotional maps. The sketch maps captured memorable track and perceived features, while the summarized emotional maps offered an intuitive depiction of cyclists' emotional episodes.

4.3.3.3. *Cognitive construction.* The exploration of cognitive construction is primarily reliant on retrospective qualitative research methods, specifically, surveys (61 %) and interviews (39 %). As retrospective methods offer access to the "delayed" feature of CSE, they have been recognized as an effective approach to studying cognitive construction. Besides, several supplementary methods, including focus groups (n = 2), observations (n = 1), and route mapping (n = 1), are used alongside the dominant retrospective methods. These supplementary methods provide additional information from the researcher's perspective or investigate the correlation between cognitive changes and the environment by providing geo-location information.

## 5. Discussion and conclusion

The paper makes a valuable contribution to the discourse on CSE by introducing a novel framework that disentangles terminological complexities, encompassing sensory interpretation, affective states, and cognitive construction. Additionally, it identifies measurement methods aligned with this framework. Our review sample consisted of 50 empirical articles.

We found that the exploration of senses has evolved from a perspective biased towards visual methods to a broader understanding of the multisensory phenomenon known as "sensescape". However, the interplay and relationships between different senses remain underexplored, providing a promising avenue for future investigation. Additionally, the study of affective states encompasses diverse and intricate sub-fields such as emotions, satisfaction, and perceived safety, each exhibiting independent development. Nonetheless, there is still a lack of a universally agreed-upon definition for certain affects which are often characterized by their longer durations, ambiguity, and irreducibility. Furthermore, the significance of cognition in shaping cycling experiences has received relatively less attention in our review sample. Some functionalist studies have examined attitudes as a means to enhance cycling rates, while research on cycling identity emphasizes the strong local context. The prevailing image of cyclists in our sample reflects marginalization, stigma, disadvantage, and invisibility.

In capturing methods employed in the study of CSE, retrospective, interceptive, and mobile methods were delineated. Among these methods, retrospective surveys and interviews emerged as the most utilized approaches. Recently, attention has been directed towards mobile methods, which offer the advantage of capturing real-time and context-specific data, thus enhancing the generalizability of findings. Additionally, several established scales and physiological measurements have been adapted to capture affective states within CSE. However, it is noteworthy that these measures predominantly focus on the negative aspects of CSE, thereby highlighting the need for further development and refinement to encompass the positive values of CSE.

By shedding light on the existing research gaps and potential avenues for future exploration, this review provides a resource for further studies in the field of CSE. In practice, through attaining a more profound understanding of the subjective experience of cycling, policymakers and practitioners can design environments and initiatives that encourage cycling as a transportation mode, and enhance the overall well-being of cyclists.

### 5.1. Limitations

In light of the results, several limitations should be acknowledged. Firstly, the search strategy may have overlooked pertinent literature. For instance, search strings explicitly related to “cycling avoidance”, “unpleasant cycling experience”, or similar phrases, as well as incomplete word derivatives like “safety perceptions” were not included. This omission could potentially impact the comprehensiveness of the review and contribute to the narrowing of the domain, such as the lack of psychology-related literature and the predominant focus on transportation-related literature. Next, some articles do not specifically focus on any one of the three aspects but rather on the broader cycling experience, as exemplified by [Snizek et al. \(2013\)](#). While these were not included in our review, acknowledging their relevance is essential for future research. Thirdly, while acknowledging the importance of potential variations in the dimensions of sensory interpretation, affective states, and cognitive construction across gender or diverse geographic locations, our study did not conduct an in-depth analysis of these differences. Subsequent research endeavors could delve into and uncover these potential variations. After that, some articles that employ equipment to measure CSE were found only in conference proceedings rather than peer-reviewed academic journals, and as such, they were not included in this study. Consequently, caution should be exercised when considering articles that have not undergone peer review in future research. Subsequently, the development of a survey scale for CSE is essential to enable more accurate comparisons and greater understanding of results across studies. Moreover, future research could examine in more detail the causality between the three components of the CSE triangle. Finally, more research is needed to explore the relationship between CSE and the physical environment to enhance our understanding of the phenomenon.

### 5.2. Positive values and negative costs

This review reveals that many researchers have directed their efforts towards addressing the negative issues of cyclists’ journeys, rather than seeking to comprehend the positive values that such experiences may yield. Since the turn of the century, an increasing number of scholars have criticized the conventional notion of mobility in transport planning, which centers bringing people fast and efficiently from A to B (see examples [te Brömmelstroet et al., 2022](#); [Sheller & Urry, 2006](#); [Spinney, 2009](#)). Instead, an emphasis is being placed on the meaningful experience of the journey between two points (see examples [Adey, 2017](#); [Cresswell, 2006](#); [Gössling, 2023](#); [Nikolaeva & Nello-Deakin, 2020](#)). Nonetheless, one potential explanation why the positive values of cycling experiences have not been thoroughly examined is that current studies continue to be primarily guided by the assumption that the cost of mobility ought to be minimized, thus focusing our efforts on the mitigation of the negative effects of cycling experiences, such as reducing stress and conflict.

Another possible explanation for the limited exploration of the positive values of cycling experiences is the challenge of measurement. While advancements have been made in measuring traffic noise ([Nuñez et al., 2018](#); [Stelling-Kończak et al., 2015](#)), analyzing natural sounds such as birdsong or rustling leaves as part of the positive experience remains an emerging science. Smells are a challenge too. Compared to the universally repulsive smell of trash, measuring the aroma of coffee while cycling presents a challenge due to its highly subjective interpretation. [Van Duppen and Spierings \(2013, p. 239\)](#) reported some individuals may perceive the aroma of coffee as a comforting feeling of “being home”, while others may only associate it with an indicator of wind direction. Wearable sensors can capture physiological changes associated with stressful emotions ([Gorgul et al., 2019](#)), but measuring the effects of relaxing emotions presents more challenges. In the United Kingdom, it may be easier to investigate the identity of cycling as a response to marginalization and stigma fueled by anger ([Aldred, 2013](#)), compared to the Netherlands where cycling is viewed as a source of cultural pride but may also be taken for granted.

This review explores a niche literature that shows not only the positive experiences of cycling, but also the potential to incorporate utilitarian cycling within a healthy social, mental, and physical lifestyle. The components of CSE that we reviewed shows that cyclists gain opportunities to be alone, to daydream and to fantasize. For instance, [El-Geneidy et al. \(2013\)](#) stated that among all modes of transportation, cycling has the great potential to achieve a high level of satisfaction with some intrinsic benefits, such as slowness, socializing, sensory richness, place-making, and playfulness. Therefore, more attention should be paid to the connections of mobility with well-being and quality of life. Further empirical inquiry is warranted to systematically identify the positive values of cycling subjective experience that can drive the promotion of playful engagement, diversity of cyclists, place attachment, and social connection.

### CRediT authorship contribution statement

**Ran Zhang:** Conceptualization, Methodology, Data curation, Software, Visualization, Validation, Writing – original draft, Writing – review & editing. **Te Brömmelstroet Marco:** Conceptualization, Methodology, Funding acquisition, Supervision, Project administration, Writing – review & editing. **Nikolaeva Anna:** Conceptualization, Methodology, Project administration, Supervision, Writing – review & editing. **George Liu:** Writing – review & editing.

### Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.



## Data availability

Data will be made available on request.

## References

- Adey, P. (2017). *Mobility*. Routledge.
- Aldred, R. (2013). Incompetent or too competent? Negotiating everyday cycling identities in a motor dominated society. *Mobilities*, 8(2), 252–271.
- Aletta, F., Van Renterghem, T., & Botteldooren, D. (2018). Influence of personal factors on sound perception and overall experience in urban green areas. A case study of a cycling path highly exposed to road traffic noise. *International Journal of Environmental Research and Public Health*, 15(6). <https://doi.org/10.3390/ijerph15061118>
- Anable, J., & Gatersleben, B. (2005). All work and no play? The role of instrumental and affective factors in work and leisure journeys by different travel modes. *Transportation Research Part A: Policy and Practice*, 39(2–3 SPEC. ISS.), 163–181. <https://doi.org/10.1016/j.tra.2004.09.008>
- Brewer, M. B., & Gardner, W. (1996). Who is this “We”? Levels of collective identity and self representations. *Journal of Personality and Social Psychology*, 71, 83–93. <https://doi.org/10.1037/0022-3514.71.1.83>
- Britain, A. C. of G., Hamilton, R., & Gallery, T. (1966). *The Almost Complete Works of Marcel Duchamp: Catalogue of an Exhibition at the Tate Gallery 18 June-31 July 1966*. Arts Council of Great Britain. <https://books.google.fr/books?id=jrcdW7-AJbUC>.
- te Brömmelstroet, M., Mladenović, M. N., Nikolaeva, A., Gaziulusoy, I., Ferreira, A., Schmidt-Thomé, K., Ritvos, R., Sousa, S., & Bergsma, B. (2022). Identifying, nurturing and empowering alternative mobility narratives. *Journal of Urban Mobility*, 2, Article 100031. <https://doi.org/10.1016/j.urbmob.2022.100031>
- Calvey, J. C., Shackleton, J. P., Taylor, M. D., & Llewellyn, R. (2015). Engineering condition assessment of cycling infrastructure: Cyclists’ perceptions of satisfaction and comfort. *Transportation Research Part A: Policy and Practice*, 78, 134–143. <https://doi.org/10.1016/j.tra.2015.04.031>
- Carver, C. S., & Harmon-Jones, E. (2009). Anger and approach: Reply to Watson (2009) and to Tomarken and Zald (2009). *Psychological Bulletin*, 135, 215–217. <https://doi.org/10.1037/a0015026>
- Cass, N., & Faulconbridge, J. (2017). Satisfying Everyday Mobility. *Mobilities*, 12(1), 97–115. <https://doi.org/10.1080/17450101.2015.1096083>
- Clayton, W., & Musselwhite, C. (2013). Exploring changes to cycle infrastructure to improve the experience of cycling for families. *Journal of Transport Geography*, 33, 54–61. <https://doi.org/10.1016/j.jtrangeo.2013.09.003>
- Cresswell, T. (2006). *On the Move: Mobility in the Modern Western World*. Taylor & Francis.
- Day, J. (2016). *Cyclogeography: Journeys of a London Bicycle Courier*. London: Notting Hill Editions.
- De Vos, J., & Witlox, F. (2017). Travel satisfaction revisited. On the pivotal role of travel satisfaction in conceptualising a travel behaviour process. *Transportation Research Part A: Policy and Practice*, 106, 364–373. <https://doi.org/10.1016/j.tra.2017.10.009>
- De Wet, T., Dzinotiyiweyi, T., & Ellison, G. T. H. (2022). Introducing Johannesburg’s new cycle lanes to potential student users: Experiences, impact and recommendations. *Journal of American College Health*, 70(5), 1584–1595. <https://doi.org/10.1080/07448481.2020.1817031>
- Deery, H. A. (1999). Hazard and Risk Perception among Young Novice Drivers. *Journal of Safety Research*, 30(4), 225–236. [https://doi.org/10.1016/S0022-4375\(99\)00018-3](https://doi.org/10.1016/S0022-4375(99)00018-3)
- Dunlap, R., Rose, J., Standridge, S. H., & Pruitt, C. L. (2021). Experiences of urban cycling: Emotional geographies of people and place. *Leisure Studies*, 40(1), 82–95. <https://doi.org/10.1080/02614367.2020.1720787>
- Eagly, A. H., & Chaiken, S. (1993). *The psychology of attitudes* (pp. xxii, 794). Harcourt Brace Jovanovich College Publishers.
- Edensor, T. (2003). Defamiliarizing the Mundane Roadscape. *Space and Culture*, 6(2), 151–168. <https://doi.org/10.1177/1206331203251257>
- Ekkekakis, P. (2013). *The Measurement of Affect, Mood, and Emotion: A Guide for Health-Behavioral Research*. <https://web.p.ebscohost.com/ehost/ebookviewer/ebook/ZTAwMHh3d19fNTI3ODY4X19BTG2?sid=a933c9b4-916c-4525-91d9-35572b0bdacb&redis&vid=0&format=EB&Krid=1>
- Fernández-Heredia, Á., Jara-Díaz, S., & Monzón, A. (2016). Modelling bicycle use intention: The role of perceptions. *Transportation*, 43(1), 1–23. <https://doi.org/10.1007/s11116-014-9559-9>
- Fernández-Heredia, Á., Monzón, A., & Jara-Díaz, S. (2014). Understanding cyclists’ perceptions, keys for a successful bicycle promotion. *Transportation Research Part A: Policy and Practice*, 63, 1–11. <https://doi.org/10.1016/j.tra.2014.02.013>
- Freudental-Pedersen, M., & Kesselring, S. (2017). *Exploring Networked Urban Mobilities: Theories, Concepts, Ideas*. Routledge.
- Gabrhel, V. (2019). Feeling like cycling? Psychological factors related to cycling as a mode choice. *Transactions on Transport Sciences*, 10(1), 19–30. <https://doi.org/10.5507/tots.2019.006>
- Gamble, J., Snizek, B., & Nielsen, T. S. (2017). From people to cycling indicators: Documenting and understanding the urban context of cyclists’ experiences in Quito, Ecuador. *Journal of Transport Geography*, 60, 167–177. <https://doi.org/10.1016/j.jtrangeo.2017.03.004>
- Gorgul, E., Zhang, L., Günther, F., & Chen, C. (2019). Mapping human response to street experience: A study on comparing walking with cycling on streets through wearable sensors. In *Adjunct Proceedings of the 2019 ACM International Joint Conference on Pervasive and Ubiquitous Computing and Proceedings of the 2019 ACM International Symposium on Wearable Computers* (pp. 69–72).
- Gössling, S. (2023). Extending the theoretical grounding of mobilities research: Transport psychology perspectives. *Mobilities*, 18(2), 167–183. <https://doi.org/10.1080/17450101.2022.2092886>
- Griffin, W., Haworth, N., & Twisk, D. (2020). Patterns in perceived crash risk among male and female drivers with and without substantial cycling experience. *Transportation Research Part F: Traffic Psychology and Behaviour*, 69, 1–12. <https://doi.org/10.1016/j.trf.2019.12.013>
- Heesch, K. C., Giles-Corti, B., & Turrell, G. (2015). Cycling for transport and recreation: Associations with the socio-economic, natural and built environment. *Health and Place*, 36, 152–161. <https://doi.org/10.1016/j.healthplace.2015.10.004>
- Heesch, K. C., Sahlqvist, S., & Garrard, J. (2011). Cyclists’ experiences of harassment from motorists: Findings from a survey of cyclists in Queensland. *Australia. Preventive Medicine*, 53(6), 417–420. <https://doi.org/10.1016/j.ypmed.2011.09.015>
- Jensen, O. B. (2009). Flows of Meaning, Cultures of Movements – Urban Mobility as Meaningful Everyday Life Practice. *Mobilities*, 4(1), 139–158. <https://doi.org/10.1080/17450100802658002>
- Jones, D. (2022, August 13). *How Many Bicycles Are There in the World?* Discerning Cyclist. <https://discerningcyclist.com/how-many-bicycles-in-world/>.
- Jones, P. (2012). Sensory indiscipline and affect: A study of commuter cycling. *Social and Cultural Geography*, 13(6), 645–658. <https://doi.org/10.1080/14649365.2012.713505>
- Jones, T., & Novo de Azevedo, L. (2013). Economic, social and cultural transformation and the role of the bicycle in Brazil. *Journal of Transport Geography*, 30, 208–219. <https://doi.org/10.1016/j.jtrangeo.2013.02.005>
- Jungnickel, K., & Aldred, R. (2014). Cycling’s Sensory Strategies: How Cyclists Mediate their Exposure to the Urban Environment. *Mobilities*, 9(2), 238–255. <https://doi.org/10.1080/17450101.2013.796772>
- Kalra, A., Lim, T., Pearson, L., & Beck, B. (2022). Methods used to capture subjective user experiences in adults while riding bicycles: A scoping review. *Transport Reviews*. <https://www.tandfonline.com/doi/abs/10.1080/01441647.2022.2123064>.
- Kaplan, S., & Prato, C. G. (2016). “Them or Us”: Perceptions, cognitions, emotions, and overt behavior associated with cyclists and motorists sharing the road. *International Journal of Sustainable Transportation*, 10(3), 193–200. <https://doi.org/10.1080/15568318.2014.885621>
- Kazemzadeh, K., Camporeale, R., D’Agostino, C., Lareshyn, A., & Winslott Hiselius, L. (2021). Same questions, different answers? A hierarchical comparison of cyclists’ perceptions of comfort: In-traffic vs. Online approach. *Transportation Letters*, 13(7), 531–539. <https://doi.org/10.1080/19427867.2020.1737373>
- Lee, C. (2014). An investigation of factors determining cycling experience and frequency. *Tourism Geographies*, 16(5), 844–862. <https://doi.org/10.1080/14616688.2014.927524>
- Lee, D. J. (2016). Embodied bicycle commuters in a car world. *Social & Cultural Geography*, 17(3), 401–422. <https://doi.org/10.1080/14649365.2015.1077265>

- Lim, T., Kalra, A., Thompson, J., Caldwell Odgers, J., & Beck, B. (2022). Physiological measures of bicyclists' subjective experiences: A scoping review. *Transportation Research Part F: Traffic Psychology and Behaviour*, 90, 365–381. <https://doi.org/10.1016/j.trf.2022.09.007>
- Liu, G., Krishnamurthy, S., & van Wesemael, P. (2018). Conceptualizing cycling experience in urban design research: A systematic literature review. *Applied Mobilities*, 6(1), 92–108. <https://doi.org/10.1080/23800127.2018.1494347>
- Liu, G., te Brömmelstroet, M., Krishnamurthy, S., & van Wesemael, P. (2019). Practitioners' perspective on user experience and design of cycle highways. *Transportation Research Interdisciplinary Perspectives*, 1. <https://doi.org/10.1016/j.trip.2019.100010>
- Liu, X., Huang, D., & Li, Z. (2018). Examining relationships among perceived benefit, tourist experience and satisfaction: The context of intelligent sharing bicycle. *Asia Pacific Journal of Tourism Research*, 23(5), 437–449. <https://doi.org/10.1080/10941665.2018.1466814>
- Manton, R., Rau, H., Fahy, F., Sheahan, J., & Clifford, E. (2016). Using mental mapping to unpack perceived cycling risk. *Accident Analysis and Prevention*, 88, 138–149. <https://doi.org/10.1016/j.aap.2015.12.017>
- Markus, H., & Wurf, E. (1987). The Dynamic Self-Concept: A Social Psychological Perspective. *Annual Review of Psychology*, 38(1), 299–337. <https://doi.org/10.1146/annurev.ps.38.020187.001503>
- Mayers, R. F., & Glover, T. D. (2020). Whose Lane Is It Anyway? The Experience of Cycling in a Mid-Sized City. *Leisure Sciences*, 42(5–6), 515–532. <https://doi.org/10.1080/01490400.2018.1518174>
- Mayers, R., & Troy, G. (2021). Safe cycling space: How it is produced and experienced by cyclists. *Journal of Leisure Research*, 52(3), 370–391.
- McIlroy, R. C., Plant, K. L., & Stanton, N. A. (2021). Thinking aloud on the road: Thematic differences in the experiences of drivers, cyclists, and motorcyclists. *Transportation Research Part F: Traffic Psychology and Behaviour*, 83, 192–209. <https://doi.org/10.1016/j.trf.2021.09.014>
- Meenar, M., Flamm, B., & Keenan, K. (2019). Mapping the emotional experience of travel to understand cycle-transit user behavior. *Sustainability*, 11(17), 4743.
- Meng, B., & Han, H. (2016). Effect of environmental perceptions on bicycle travelers' decision-making process: Developing an extended model of goal-directed behavior. *Asia Pacific Journal of Tourism Research*, 21(11), 1184–1197. <https://doi.org/10.1080/10941665.2015.1129979>
- Namung, M., & Jun, H. J. (2019). The influence of attitudes on university bicycle commuting: Considering bicycling experience levels. *International Journal of Sustainable Transportation*, 13(5), 363–377. <https://doi.org/10.1080/15568318.2018.1471557>
- Nikolaeva, A., & Nello-Deakin, S. (2020). Exploring velotopian urban imaginaries: Where Le Corbusier meets Constant? *Mobilities*, 15(3), 309–324. <https://doi.org/10.1080/17450101.2019.1694300>
- Núñez, J. Y. M., Teixeira, I. P., da Silva, A. N. R., Zeile, P., Dekoninck, L., & Botteldooren, D. (2018). The Influence of Noise, Vibration, Cycle Paths, and Period of Day on Stress Experienced by Cyclists. *Sustainability*, 10(7), Article 7. <https://doi.org/10.3390/su10072379>
- Oehl, M., Becker, T., Che, M., & Brandenburg, S. (2021). Validation of the cycling anger scale in Singapore. *Traffic Injury Prevention*, 22(1), 32–36. <https://doi.org/10.1080/15389588.2020.1843161>
- Oehl, M., Brandenburg, S., & Huemer, A. K. (2019a). Cyclists' anger experiences in traffic: The cycling anger scale. *Transportation Research Part F: Traffic Psychology and Behaviour*, 62, 564–574.
- Oehl, M., Brandenburg, S., & Huemer, A. K. (2019b). German bike messengers' experiences and expressions of cycling anger. *Traffic Injury Prevention*, 20(7), 753–758. <https://doi.org/10.1080/15389588.2019.1616179>
- O'Hern, S., Stephens, A. N., Young, K. L., & Koppel, S. (2019). What makes cyclists angry? The relationships between trait anger, interest in cycling and self-reported comfort levels. *Transportation Research Part F: Traffic Psychology and Behaviour*, 62, 672–680. <https://doi.org/10.1016/j.trf.2019.03.004>
- Paige Willis, D., Manaugh, K., & El-Geneidy, A. (2013). Uniquely satisfied: Exploring cyclist satisfaction. *Transportation Research Part F: Traffic Psychology and Behaviour*, 18, 136–147. <https://doi.org/10.1016/j.trf.2012.12.004>
- Panksepp, J., & Solms, M. (2012). *The Consciousness Instinct: Unraveling the Mystery of How the Brain Makes the Mind*. MIT Press.
- Passafaro, P., Rimano, A., Piccini, M. P., Metastasio, R., Gambardella, V., Gullace, G., & Lettieri, C. (2014). The bicycle and the city: Desires and emotions versus attitudes, habits and norms. *Journal of Environmental Psychology*, 38, 76–83. <https://doi.org/10.1016/j.jenvp.2013.12.011>
- Penn, R. (2011). *It's All About the Bike: The Pursuit of Happiness on Two Wheels*. Bloomsbury Publishing USA.
- Petty, R. E., & Krosnick, J. A. (Eds.). (2013). *Attitude Strength: Antecedents and Consequences*. Psychology Press. <https://doi.org/10.4324/9781315807041>
- Piatkowski, D. P., & Marshall, W. E. (2015). Not all prospective bicyclists are created equal: The role of attitudes, socio-demographics, and the built environment in bicycle commuting. *Travel Behaviour and Society*, 2(3), 166–173. <https://doi.org/10.1016/j.tbs.2015.02.001>
- Pine, B. J., Pine, J., & Gilmore, J. H. (1999). *The experience economy: Work is theatre & every business a stage*. Harvard Business Press.
- Ravensbergen, L. (2022). 'I wouldn't take the risk of the attention, you know? Just a lone girl biking': Examining the gendered and classed embodied experiences of cycling. *Social & Cultural Geography*, 23(5), 678–696.
- Rérat, P. (2019). Cycling to work: Meanings and experiences of a sustainable practice. *Transportation Research Part A: Policy and Practice*, 123, 91–104. <https://doi.org/10.1016/j.tra.2018.10.017>
- Robinson, S., & Pallasmaa, J. (Eds.). (2015). *Mind in architecture: Neuroscience, embodiment, and the future of design*. MIT Press.
- Scherer, K. R. (1984). On the nature and function of emotion: A component process approach. *Approaches to Emotion*, 2293(317), 31.
- Sharma, B., Nam, H. K., Yan, W., & Kim, H. Y. (2019). Barriers and enabling factors affecting satisfaction and safety perception with use of bicycle roads in Seoul, South Korea. *International Journal of Environmental Research and Public Health*, 16(5). <https://doi.org/10.3390/ijerph16050773>
- Sheller, M., & Urry, J. (2006). The new mobilities paradigm. *Environment and Planning A*, 38(2), 207–226. <https://doi.org/10.1068/a37268>
- Simpson, P. (2017). A sense of the cycling environment: Felt experiences of infrastructure and atmospheres. *Environment and Planning A*, 49(2), 426–447. <https://doi.org/10.1177/0308518X16669510>
- Snizek, B., Sick Nielsen, T. A., & Skov-Petersen, H. (2013). Mapping bicyclists' experiences in Copenhagen. *Journal of Transport Geography*, 30, 227–233. <https://doi.org/10.1016/j.jtrangeo.2013.02.001>
- Spinney, J. (2009). Cycling the City: Movement, Meaning and Method. *Geography. Compass*, 3(2), 817–835. <https://doi.org/10.1111/j.1749-8198.2008.00211.x>
- Stefansdottir, H. (2014a). A Theoretical Perspective on How Bicycle Commuters Might Experience Aesthetic Features of Urban Space. *Journal of Urban Design*, 19(4), 496–510. <https://doi.org/10.1080/13574809.2014.923746>
- Stefansdottir, H. (2014b). Urban routes and commuting bicyclists' aesthetic experiences. *FORMakademisk*, 7(2).
- Steinbach, R., Green, J., Datta, J., & Edwards, P. (2011). Cycling and the city: A case study of how gendered, ethnic and class identities can shape healthy transport choices. *Social Science & Medicine*, 72(7), 1123–1130.
- Stelling-Kończak, A., Hagenzieker, M., & Wee, B. V. (2015). Traffic Sounds and Cycling Safety: The Use of Electronic Devices by Cyclists and the Quietness of Hybrid and Electric Cars. *Transport Reviews*, 35(4), 422–444. <https://doi.org/10.1080/01441647.2015.1017750>
- Stewart, K. (2011). Atmospheric Attachments. *Environment and Planning D: Society and Space*, 29(3), 445–453.
- St-Louis, E., Manaugh, K., van Lierop, D., & El-Geneidy, A. (2014). The happy commuter: A comparison of commuter satisfaction across modes. *Transportation Research Part F: Traffic Psychology and Behaviour*, 26, 160–170. <https://doi.org/10.1016/j.trf.2014.07.004>
- te Brömmelstroet, M., Nikolaeva, A., Glaser, M., Nicolaisen, M. S., & Chan, C. (2017). Travelling together alone and alone together: Mobility and potential exposure to diversity. *Applied Mobilities*, 2(1), 1–15. <https://doi.org/10.1080/23800127.2017.1283122>
- Thigpen, C. (2019). Do bicycling experiences and exposure influence bicycling skills and attitudes? Evidence from a bicycle-friendly university. *Transportation Research Part A: Policy and Practice*, 123, 68–79. <https://doi.org/10.1016/j.tra.2018.05.017>
- Turcotte, M. (2006). Like commuting? Workers' perceptions of their daily commute. *Canadian Social Trends*, 82, 35–40.
- van Duppen, J., & Spierings, B. (2013). Retracing trajectories: The embodied experience of cycling, urban sensescapes and the commute between 'neighbourhood' and 'city' in Utrecht, NL. *Journal of Transport Geography*, 30, 234–243. <https://doi.org/10.1016/j.jtrangeo.2013.02.006>
- von Stülpnagel, R. (2020). Gaze behavior during urban cycling: Effects of subjective risk perception and vista space properties. *Transportation Research Part F: Traffic Psychology and Behaviour*, 75, 222–238. <https://doi.org/10.1016/j.trf.2020.10.007>

- Wild, K., & Woodward, A. (2019). Why are cyclists the happiest commuters? Health, pleasure and the e-bike. *Journal of Transport and Health*, 14. <https://doi.org/10.1016/j.jth.2019.05.008>
- Zhao, C., Nielsen, T. A. S., Olafsson, A. S., Carstensen, T. A., & Fertner, C. (2018). Cycling environmental perception in Beijing – A study of residents' attitudes towards future cycling and car purchasing. *Transport Policy*, 66, 96–106. <https://doi.org/10.1016/j.tranpol.2018.02.004>
- Zheng, Y., Ma, Y., & Cheng, J. (2020). Cycling anger in China: The relationship with gender roles, cycling-related experience, risky and aggressive riding. *Transportation Research Part F: Traffic Psychology and Behaviour*, 68, 52–66.