Modelling Access Ergonomics to Daily Life Resources using Sustainable Modes within the Eurométropole de Strasbourg

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Abstract
High-quality surroundings and the comfort of journeys encourage the use of sustainable modes of transportation to attend daily-life resources. Spatial ergonomics studies the capacity of a territory to fulfil the needs of its inhabitants at least costs. Its subdomain access ergonomics which provides an approach through mobility, offer a relevant analytical framework to assess if a territory enables its residents to access essential daily-life resources, efficiently and comfortably. Ergonomics should be analysed both qualitatively and quantitatively, and simulation provides many insights relevant to this evaluation. This paper focuses on a state of the art of ergonomics in urban planning then proposes a framework to improve precision in access ergonomics assessment using multi-agent modelling to simulate mobility behaviours based on socio-spatial profiles.

Keywords
access ergonomics; sustainable mobility; multi-agent models; proximity; accessibility

Introduction

Since the 1980s, many European cities have implemented several policies to reduce transportation and mobility related negative externalities, especially those caused by individual cars. Among them, the Eurométropole de Strasbourg, a mid-size city located in the extreme east of France, along the German border. Strong measures have been introduced to limit car use while promoting sustainable transport (Stambouli, 2005, Héran, 2020). This includes developing public transportation, enhancing shared and active modes (walking, cycling) usage, and urban planning focused on a "proximity metropolis" model (Eurométropole de Strasbourg, 2024) to support sustainable mobility. Furthermore, the Eurométropole de Strasbourg has restricted motorized mobility, particularly internal combustion engine vehicles, by creating one of the first Low Emission Zone in France covering its 33 municipalities. The city also supports energy transition, encouraging the adoption of electric vehicles including electric bikes through purchase subsidies. Strasbourg is also a precursor in France for its actions to encourage cycling. It has had a significantly higher cycling modal share than other French cities from 1980 to 2000 (Guidez, 2007) and the Eurométropole de Strasbourg is the French metropolis with the highest modal share for cycling in the 2021 census. Like many other cities, previous studies have shown that amenities and transportation infrastructures are not uniformly distributed throughout the city (Hached, 2019) and that some areas are underserved for active modes users (Saint-Gérand et al., 2021). The main question is how well the Eurométropole de Strasbourg enables its residents to access essential daily-life resources, efficiently, comfortably, and at which cost (financial cost, effort, risk, emissions, energy, and time) while using sustainable transport modes. The obtained indicators (both a synthetic score and subscores on a 200 by 200 metre grid) can then be employed to assess equity and highlight social disparities.

This paper focuses on three aspects: first a review of the uses of ergonomics applied in urban settings, in particular to urban mobility, with a focus on access ergonomics, its similarities and differences with related concepts. After a review of modelling methods to find the most suitable one to assess access ergonomics. Then, we propose an integrated method for the appraisal of ergonomics of access through multi-agent modelling. The proposed approach deploys multi-agent activity-based modelling to place trips in activity chains. In further studies, more parameters will be considered to assess access ergonomics on a larger scale.

1. Review of urban ergonomics

Ergonomics is "the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data, and methods to design in order to optimize human well-being and overall system performance" (IEA, 2000). On an etymological standpoint, it is the science of work, also referred to as human factors engineering, especially in American English and workplaces are historically the first places where ergonomics was developed and applied. In this paper, we will consider its applications and transpositions to urban settings. In the Scopus Database, as of May 20th, 2025, 632 documents[1] contain both the words urban and ergonomics (Figure 1). Of those, 151 are applied to vehicles (including 80 regarding cars and motorcycles[2]) and 110 are applied to the urban scale, with 15 of them considering the ergonomics of urban mobility and 11 of them considering pedestrian behaviours in cities.

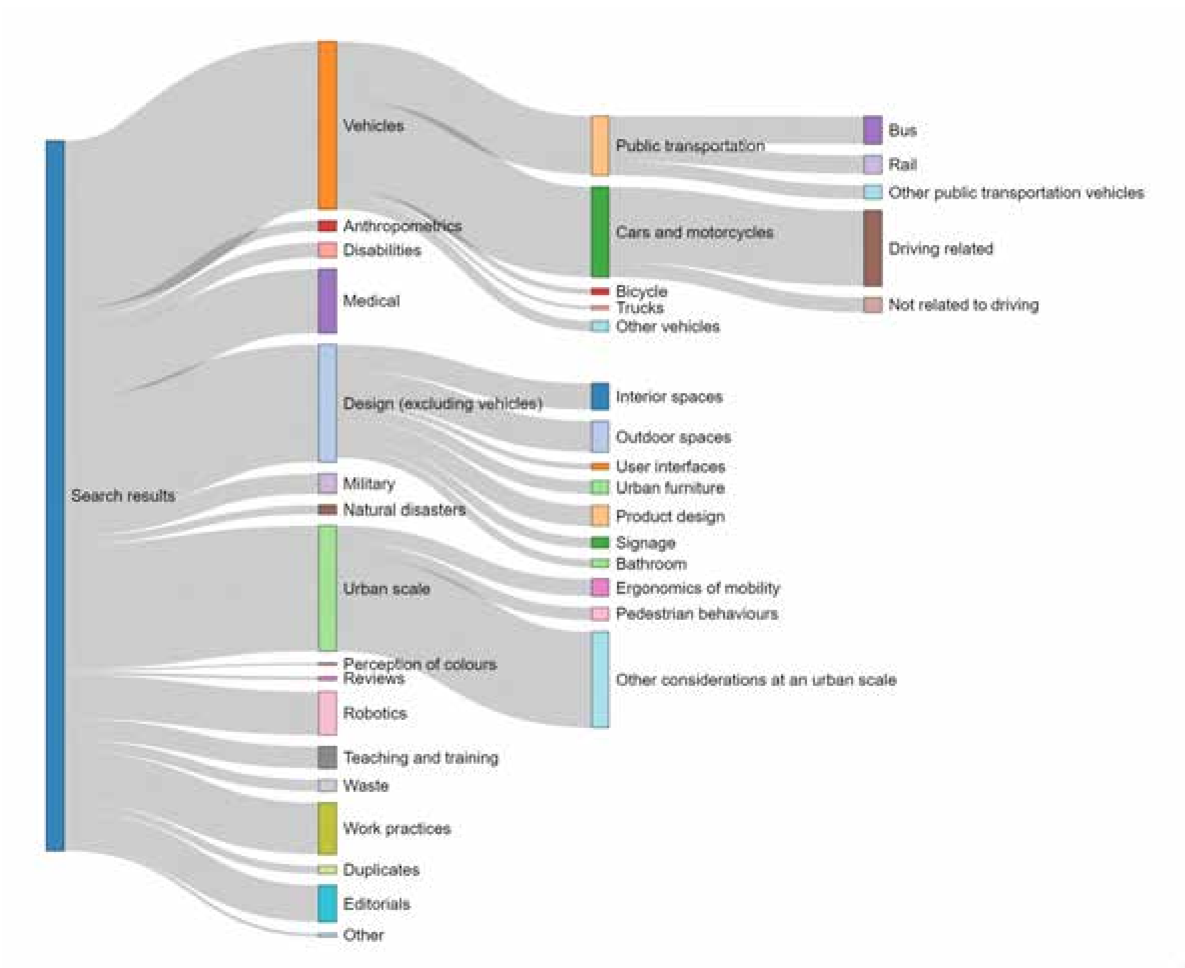

Figure 1: Topics covered in Scopus (Hacquard, 2025)

Macroergonomics (Hendrick, 1985), developed from the end of the 1970s considers organisational aspects in ergonomics, opposed to the human-machine interactions (microergonomics) that were solely considered before and relies on group dynamics. Its scope not only includes work but "any form of human effort or activity, including recreation and leisure pursuits" (Hendrick, 2002). As such, macroergonomics have been leveraged as community ergonomics to improve inner cities (Smith et al., 1994) and for the analysis of mobility in the Brazilian city of Belo Horizonte (Botelho et al., 2018). Several authors have used the concept of ergonomics in geography and urban planning. In their paper Human Factors in Urban Transportation, Hoag and Adams (1975), note the overwhelming proportion of data from military settings considered in ergonomics and their low relevance for urban transportation. They analyse the travel conditions, not only on an anthropometric standpoint, but also on

1 Seven duplicates are found in the results and are not processed further.
2 A paper (Nathanael et al., 2019) concerns pedestrian-vehicle interactions and is classified both in pedestrians and vehicles.

a psychological one, and envisioning user evaluation. De Carvalho (2012) proposes ERGOPOLIS: an ergonomics approach applied to a city, mobilising the macroergonomics and listing nine projects that might be considered for an ergonomic approach to the city, including accessibility and improvement of urban mobility. The same term ergopolis is also used in unrelated manners by Gangadhar, Nagendra and Chikkarangaswamy (2012) about sustainable rural development and at a French roundtable with both researchers and practitioners (POPSU, 2016) where ergopolis (also called ergonomic metropolis in the roundtable's report) is defined as a "territory that takes better into account the question of work" (J.M. Offner in the said roundtable), also underlining that "a metropolis should deliver to its users, not only to its inhabitants", as a reference to the origin of ergonomics as the science of work.

Other authors have considered ergonomics of walking: Stevens and Salmon (2015) apply cognitive work analysis to footpaths and public places to make them more inclusive, further research was then performed on other spaces (Stevens et al., 2021). Appolloni et al. (2020) developed an approach to evaluate walkability with ergonomic criteria, three main needs for the "Human-Environment Interface" are identified: well-being, safety and usability, the weight for the different factors has been elaborated with "a multidisciplinary panel of 10 experts", the methodology has been applied to various areas in Rieti, Italy.

Antoni (2014) has reviewed various approaches of spatial ergonomics in the French-language literature. Sperandio (1976) proposed the concept of "ergonomics of the built environment" as he remarked that "ergonomists [were] starting to take interest in the design of built environment" with scales ranging from the interior to neighbourhoods. His research on this topic were not pursued, mostly due to ergonomists taking interest on human-machine interfaces in computer science (Sperandio, 2011). Hached and Propeck-Zimmermann (2021) have proposed a methodology to assess ergonomics of access of daily life resources. Their approach includes most of the criteria considered by other authors for walkability and cyclability but can also be applied to other modes. We retain the ergonomics of access (also called access ergonomics in other sources), as this framework is suitable not only for a specific mode but can be applied to different modes, including intermodal trips.

2. Access ergonomics: spatial ergonomics applied to access to daily life resources

The ergonomic approaches in urban settings can then be classified in two groups: either the city is a human-machine system to which the methods from ergonomics of workplaces can be directly applied (Sperandio, 1976) or a conceptual transfer is needed from classical ergonomics such as in spatial ergonomics (Saint-Gérand, 2002).

Spatial ergonomics is a conceptual transfer from ergonomics as it is applied in industrial settings to geography (Saint-Gérand, 2002, Propeck-Zimmermann et al., 2018). The geographical space is assimilated (Figure 2) to the industrial settings considered in classical ergonomics, while socio-economic resources are assimilated to the industrial settings' products and resources (Propeck-Zimmermann et al., 2018). Spatial ergonomics is then defined as the "endogenous and exogenous capacity of a space to provide a population/society with the entire set of social and economic resources they require at the least cost" (Saint-Gérand, 2002).

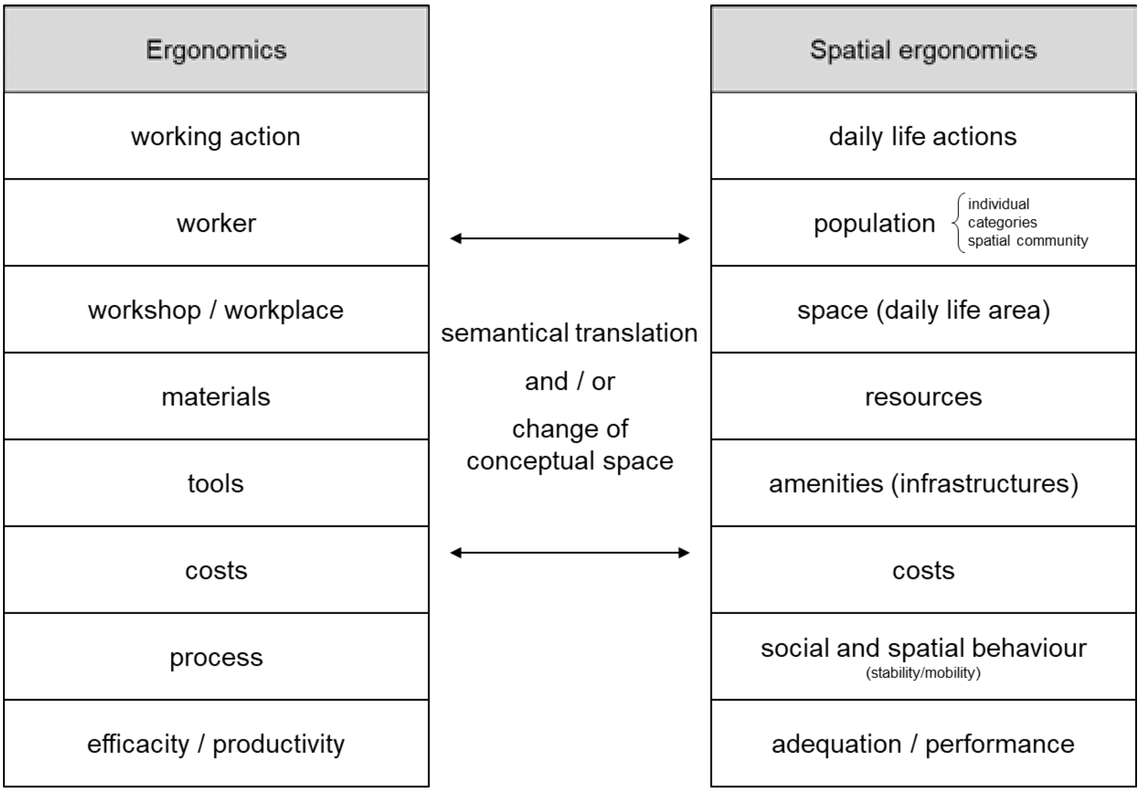

Figure 2: Spatial Ergonomics Concepts translated from Saint-Gérand (2002)

Access ergonomics (Hached, 2019) is a subdomain of spatial ergonomics as an approach through mobility. It provides a framework for the analysis of the disposal of daily life resources and "assesses the more or less capacity to minimize the costs (in the broad sense) of appropriating the resources that the population needs in daily life" (Hachette, Propeck-Zimmermann and L'Hostis, 2024). This approach assesses accessibility while focusing on its conditions not only regarding travel duration but also considering daily-life resources availability, infrastructure, as well as mobility conditions and quality (facilities, safety, comfort, environment) adapted to each transport mode. Access ergonomics relies on the hypothesis is that a high-quality environment helps to promote sustainable transport, especially for active modes. Mobility behaviours are known to be influenced by safety, comfort, and environmental factors (Piombini, 2013). Access ergonomics integrates these factors into a synthetic access ergonomics score composed of several sub-indicators to identify and analyse socio-spatial inequalities in accessing daily resources. The sub-indicators consider the urban environment, network and infrastructure, alternative resources availability, number of proximity resources, diversity of proximity resources, availability of resources, and safety. Access ergonomics consider interactions between three constituents of the territory: the resource potential, population and stakeholders needs and practices, and the structure of the territory (Figure 3).

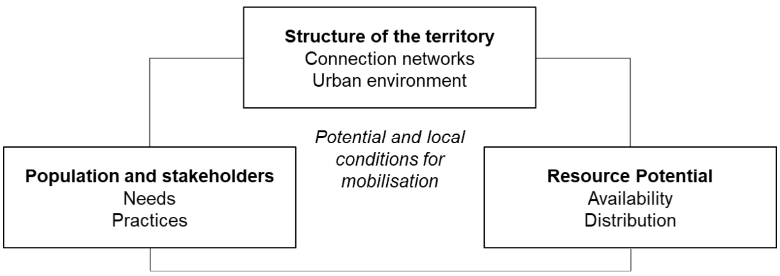

Figure 3: General model of access ergonomics (Hachette, Propeck-Zimmermann and L'Hostis, 2024)

Two previous approaches for access ergonomics have been developed:

- A large-scale isochrone-based approach, used to assess ergonomics of access to resources of the whole Eurométropole de Strasbourg (Propeck-Zimmermann et al., 2018).
- A more detailed route-based approach (Figure 4) has been used to assess ergonomics of access for 13 locations in the Eurométropole de Strasbourg (Hachette, Propeck-Zimmermann and L'Hostis, 2024).

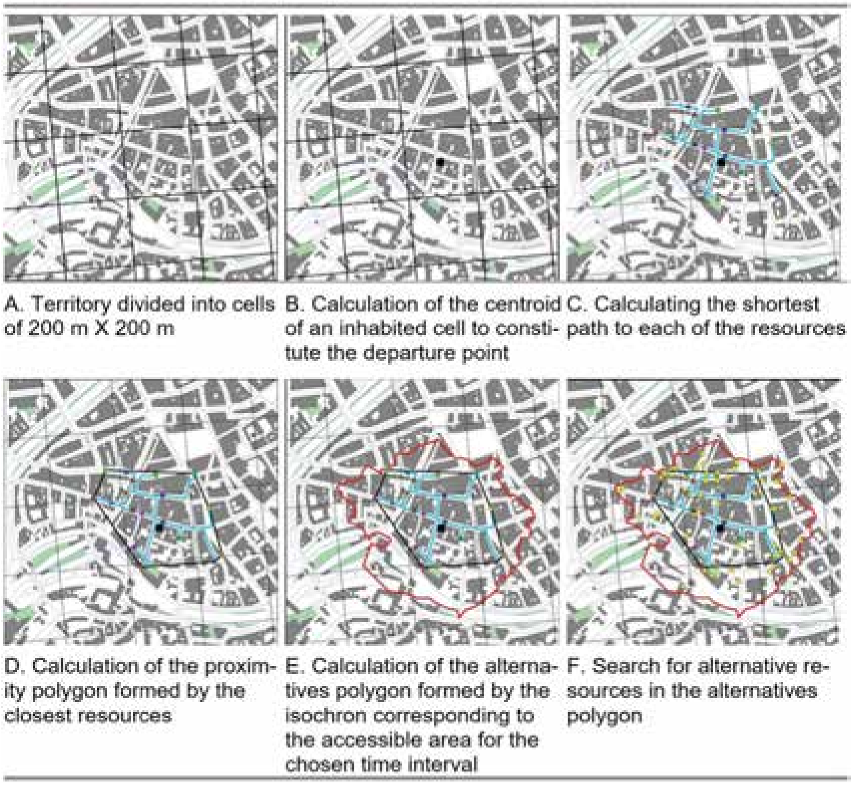

Figure 4: Computation of Access Ergonomics (Hachette, Propeck-Zimmermann and L'Hostis, 2024)

Both methods use a 200 × 200 m grid corresponding to the highest resolution (in France) for income and census data and use the shortest path from the centre of each tile. Both approaches consider not only the closest amenity but also its suitable alternatives. The detailed method generates a synthetic score from 0 to 100 but its subscores can also be analysed individually to distinguish between situations with the same synthetic score while having different characteristics. In both approaches, travel times were not issued from modelling, but from the distance travelled. Hached (2019) showed significant variability in access ergonomics across the Eurométropole de Strasbourg through a synthetic indicator built using GIS for active modes, showing a gradient from the centre and comparing it between walking, cycling and driving. The highest ergonomics of access for bicycles and pedestrians was in the city centre whereas it was highest in the outer ring by car, due to traffic calming actions in the city centre. The amenities considered are classified from a statistical classification (nomenclature d'activités française) to classes containing similar amenities (Table 1) that are considered together in the assessment of ergonomics of access.

Table 1: Amenities considered in Hached, 2019

Category	Class	Resource type in the *nomenclature d'activités française*
Shops	A	Bakery
		Pastry shop
		General food store
		Grocery
		Butcher shop
	B	Small-size supermarket
		Medium-size supermarket
	C	Large supermarket
	D	Tobacco shop
		Newsstand and stationery shop
	E	Pharmacy
	F	Market
Schools	G	Preschool
		Primary school
	H	General secondary school
Healthcare	I	Hospital
		Surgical activities (clinics)
	J	General practitioner
		Nurse or midwife
	K	Radiodiagnosis or radiotherapy
		Dental practice
		Medical laboratory
Public services	L	City hall
		Police station
		Medical and social centre
		Employment agency
Leisure	M	Cinema
		Museum
		Performance venue
	N	Public library
	O	Sports clubs
		Sport facility

Evaluations of access ergonomics were performed considering a temporal threshold. Three values (5, 10 and 20 minutes) were considered. This corresponds to a proximity criterion, in line with the renewed interest in proximity, in particular with the rise of the 15-minute city concept. Electric vehicles and micromobility were not considered, nor was public transportation. The rise of micromobility and intermodality requires adaptation of these analyses. Hachette, Propeck-Zimmermann and L'Hostis (2024) also note that access to employment should ideally be considered. Access ergonomics, as its name suggests, attach importance not only to ergonomics but also to accessibility. As such, its assessment can only be performed it the condition of accessibility is ensured.

3. Notions close to access ergonomics: accessibility, proximity, and mobility

Access ergonomics is linked to several other notions: ensuring accessibility is possible is a prerequisite to the appraisal of access ergonomics. Accessibility can be attained through two means: proximity and mobility whereas walkability and cyclability are applications of accessibility to a particular means of transportation. The differences in scales, modes, and goals of these close notions are summarised in Table 2.

Accessibility is considered "an important dimension of quality of life" and though it has varying meanings among authors, it can be defined as "the ease of reaching desired activities" (Silva et al., 2024). It is a major field of interest in geography, Silva et al. (2024) note that "scientific papers concerned with accessibility have grown tenfold in one decade, surpassing the average of 200 papers per year in 2014" though mobility is still more represented in scientific literature. Dumolard (1999) distinguishes distance, an "abstract and theoretical notion", and accessibility which is a "more contextual and concrete metric of remoteness". Geurs and Van Wee (2004) categorize four components of accessibility: "transport component", "land-use component", "temporal component" and an "individual component"; these components can be analysed through four types of measures: "infrastructure-based", "location-based", "person-based" and "utility-based". They note that interpretability and communicability need to be improved and that "spatial–temporal constraints" of an individual should be included in accessibility studies.

Silva and Larsson (2019) describe accessibility as a goal whereas proximity and mobility are means towards accessibility. Hachette, Propeck-Zimmermann and L'Hostis (2024) differentiate spatial ergonomics and accessibility on their objectives: "access ergonomics seeks to understand the overall functioning of the territory and its capacity to meet needs through different elements, in particular the arrangement of its resource potential and its ability to respond to disturbances, whereas accessibility focuses on a very specific aspect of the functioning of the territory, that of travel and transport".

The 15-minute city concept (Moreno et al., 2021), which relies on proximity of amenities by walking or cycling to improve accessibility while reducing the need for motorised transportation between activities is gaining traction; 98 cities were identified by Teixeira et al. (2024) as implementing or planning to implement the concept or practices close to it. However, Papadopoulos, Sdoukopoulos and Politis (2023) identified multiple shortcomings in the current approaches to measure compliance with the 15-minute city concept, noted a focus on walking but a lack of consideration of the different walking speeds among the population and recommend the use of disaggregated origins to represent the travellers. They also note a low scalability in most of the considered studies.

Table 2: Comparison between access ergonomics and close notions (Hacquard, 2025)

Term	Scale	Mode	Goal
15-minute city	Citywide	Walking, cycling or other active modes	Proximity of resources so inhabitants can fulfil their needs within a 15 min radius
Access ergonomics	Living area	Ideally multimodal	"*Understanding of the overall functioning of the territory*"
Accessibility	Varying (from the building to global)	Varying between studies (can be mode-focused or multi-modal)	Ease of reach
Cyclability	Varying (from the neighbourhood to city-wide)	Cycling	Ease of reach by cycle
Mobility	Varying (from the neighbourhood to global)	Varying between studies (can be mode-focused or multi-modal)	Ease of reach through efficient transportation
Proximity	Neighbourhood to living area	Usually either walking or cycling	Ease of reach through low distances
Walkability	Varying (from the neighbourhood to city-wide)	Walking	Ease of reach by walking (Cervero and Kockelmann's 3D: density, diversity, design)

4. Transportation modelling approaches

Most of the forementioned notions include spatial and temporal (either travel time or variation during the day) aspects. Modelling allows to analyse both spatial and temporal travellers' behaviours, which can refine the assessment of access ergonomics. In this part, we review different modelling approaches to find the most suitable one to analyse access ergonomics.

Multi-agent systems are made of agents, which are "computing entities able to act and interact to perform a fragmentary task in a system where the consideration of complexity is left to the interactions" (Dumolard, 1999). These systems can be used for modelling purposes. Agent-based models in transportation provide a "microscopic representation of travel individuals as they move from place to place" (Kagho et al., 2020) whereas activity-based models are transportation models describing activities of the population of interest with transportation as a derived need between activities. Agent-based models have multiple advantages, especially the possibility to have individuals as agents as well as a representation of interactions between individuals, making them particularly relevant for activity-based models (Ortúzar and Willumsen, 2016).

Activity-based models are used for evaluating accessibility through a trip completion rate by measuring the proportion of the trips below a certain threshold (Somanath et al., 2025). This approach however does not consider key parts of access ergonomics (safety and convenience of trips). Staves et al. (2025) use an agent-based model to estimate travel times and take street-level environment into account to model active travel accessibility in Greater Manchester. Their approach includes gradient, surface, ambience and stress though a mix of open and proprietary data with parameters that "were chosen through an iterative process and validated in consultation with regional experts" from heuristics and literature. Cycling accessibility is assessed through personas who can cycle on links with varying levels of cyclable infrastructure.

Activity-based models require a population with multiple socio-economical characteristics for each individual and an initial demand with initial activity plans. As these data are not directly available, either from census or from surveyed individuals, for privacy concerns among others, a synthetic population is necessary to run most activity-based models. Hörl and Balac (2021a) have developed eqasim, an open-source and reproducible pipeline to recreate a synthetic population and its travel demand for the Île-de-France region using only open access data. The use of the pipeline for other locations in France such as Nantes (Le Bescond et al., 2023), Lyon (Manout and Diallo, 2023) has been successfully done and for locations in other countries including Switzerland (Grübel et al., 2023) and China (Hu et al., 2022). The required input data for the pipeline is laid out in a data paper (Hörl and Balac, 2021b) and consists of national census (which in France contains commute flows between municipalities), income distribution data (Fichier Localisé Social et Fiscal, FILOSOFI), an household travel survey (either a local one or the national household travel survey), the address database (Base Adresse Nationale, BAN), enterprise census (Système national d'identification et du répertoire des entreprises et de leurs établissements, SIRENE) and a service and facility database (Base permanente des équipements), OpenStreetMap and GTFS data are additionally used to create the MATSim network. The travel demand and activities of the synthetic population are built around "primary activities" (home, work and education) while "secondary activities" are fitted in the schedule around the constrained primary activities.

5. Assessing access ergonomics through multi-agent modelling

To answer the question stated in the introduction, we retain access ergonomics as the approach considers not only travel time but also travel conditions and alternatives. It can be extended to include more modes and to consider access to other amenities. To overcome limitations from previous approaches, in particular the fact that trips related to work are not considered, nor is public transportation; a new methodology is being developed to improve realism and precision in evaluating access ergonomics (Figure 5). Multi-agent modelling is used to simulate mobility behaviours based on detailed socio-spatial profiles, considering diverse socio-economic and demographic data at a fine scale (200 × 200 m). These profiles are fed to a geographic information system to assess access conditions using various transport modes (car, public transportation, cycling and walking). Trips are analysed within activity chains, where each activity (work, leisure, services) can be interconnected. The model also considers resource availability and transport service schedules, identifying potential inconsistencies that impact access ergonomics.

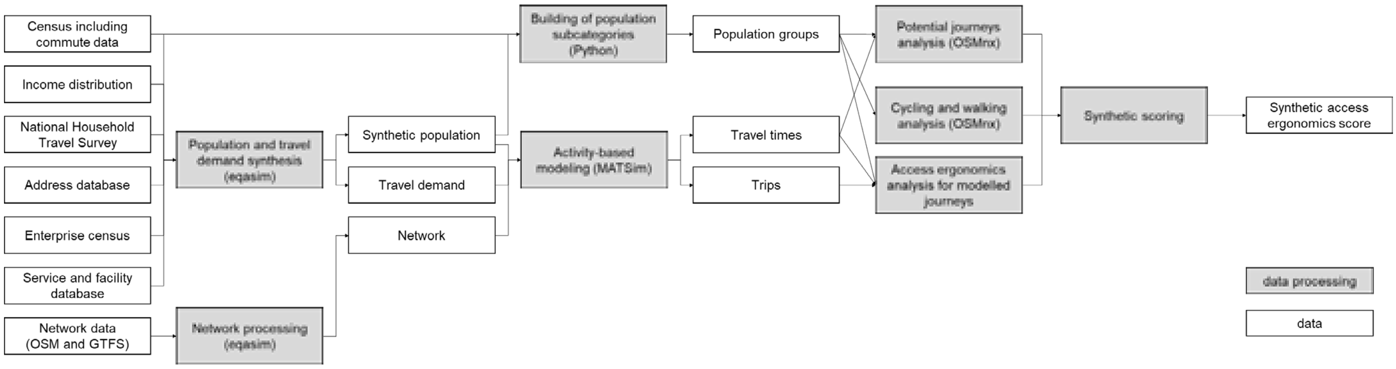

Figure 5: Data processing steps (Hacquard, 2025)

The study relies on open geographic and statistical data covering the Eurométropole de Strasbourg. The synthetic population is generated using eqasim (Hörl and Balac, 2021a) with the input data following its accompanying data paper (Hörl and Balac, 2021b). The main difference with the Île-de-France Region considered in the data paper is that public transport networks are in different GTFS files as multiple competent local authorities cover the sector. As the latest local household travel survey (Enquête Mobilité 2019) is not in open access and a newer household travel survey is being performed in 2024-2025, the national household travel survey (Enquête Nationale Transports et Déplacements 2008) has been used instead. The multi-agent model is larger than the Eurométropole de Strasbourg and includes the whole département of Bas-Rhin (1,152,662 inhabitants in the 2021 census) where the Eurométropole is located to include interactions with the surroundings.

Simulations are performed using MATSim (Horni et al., 2016) and are run using a sampling rate of 10%. Car assignment is performed with QSIM (Dobler, 2010) while public transport routing is performed using SwissRailRaptor (based on Round-Based Public Transit Routing, Delling et al., 2015), this method considers journeys using different public transport modes and walking. In accordance with the eqasim pipeline, bicycle and pedestrian routing is not performed and replaced with beeline distance factors to estimate travel time.

The national household travel survey does not contain data about micromobility such as electric scooters. Results from local household travel surveys in France between 2021 and 2023 show that micromobility represents 0.4 % of the trips of the surveyed individuals aged between 15 and 44 (Cerema, 2024). Due to its low share, as a first approach, micromobility is not modelled and is only considered in the score computing phase.

Two types of journeys need to be considered to assess ergonomics of access: the ones that actually took place (or the one modelled in this case) and the one that would have happened, should the users have decided to travel to a resource. Both must be separated in the modelling phase as potential journeys should not cause congestion.

Public transportation and car journeys representing the journeys that would have happened in the modelled day are directly available from the multi-agent model whereas the links travelled cycling or walking are rebuilt using OSMnx (Boeing, 2025). Potential travels are modelled using OSMnx and NetworkX (Hagberg, Schult and Swart, 2008) on a network with the travel times from the simulation at peak periods for car journeys and without taking congestion into account for other modes.
Population groups are built to recreate the variation of walking speed between age classes, to reflect the varying use of cycling according to age and to reflect the needs of various groups (i.e., households with young children need access to childcare).

6. Study case
The Eurométropole de Strasbourg regroups 33 municipalities with population ranging from 802 to 291,313 in the 2021 Census and a total population of 514,651. The Eurométropole is located on the left bank of Rhine River which is the border between France and Germany in this area. The highest population densities are in the central part of Strasbourg and in neighbouring municipalities (Figure 6).

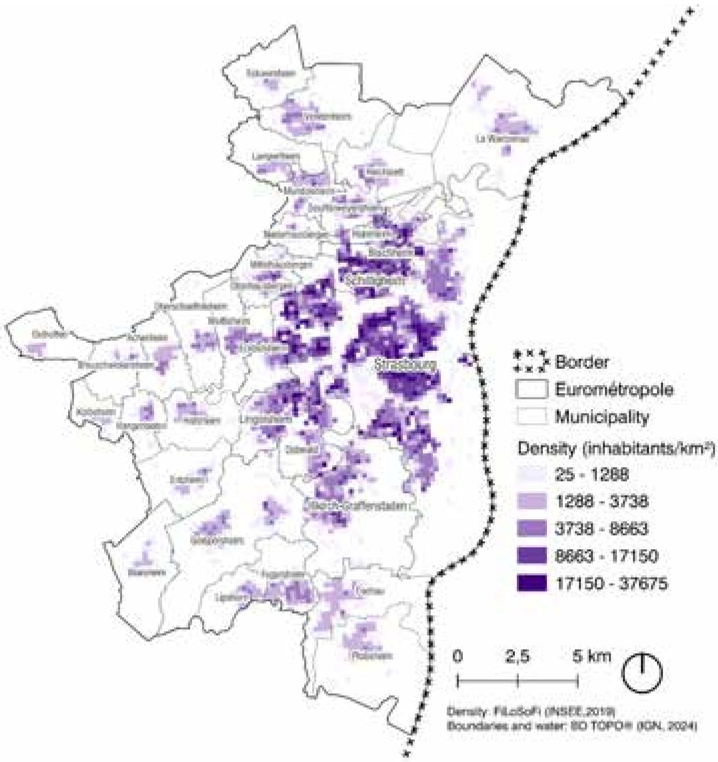

Figure 6: Population density in the Eurométropole de Strasbourg

Mobility in the Eurométropole de Strasbourg is characterised by a higher modal share of cycling compared to other cities in France; with a 14.3 % share for commuting trips in the 2021 Census, cycling in the Eurométropole de Strasbourg has the highest modal share of all 22 French metropolises.

The meshed tram network (Le Tourneur, 2016) serves Strasbourg as well as 6 other municipalities in the Eurométropole (Bischheim, Hœnheim, Illkirch-Graffenstaden, Lingolsheim, Ostwald and Schiltigheim) and Kehl in Germany with 6 lines, some of them partially overlapping. The tram network is completed by two bus rapid transit lines that serve municipalities also served by the tram network.

7. First Results

The literature review for ergonomics in urban settings indicates that published documents are split between three major topics: vehicle-related topics, urban-scale matters and design. Cars and motorcycles constitute the main part of the literature on vehicle-related topics and most of the documents consider the ergonomics of driving. On urban-scale matters, various authors have written on methodologies to assess urban ergonomics, especially regarding mobility; most of them focus on a particular mode and walking is particularly represented. Most of the approaches rely on existing data on travel conditions.

The proposed methodology uses open data, is sensitive to changes in travel conditions and aims to be replicable. The post-processing mitigates some artifacts that may happen with population synthesis: the use of personas alleviates some issues linked to structural zeroes. This method is however more computer intensive than methods solely relying on isochrones made from existing travel times or purely distance based.

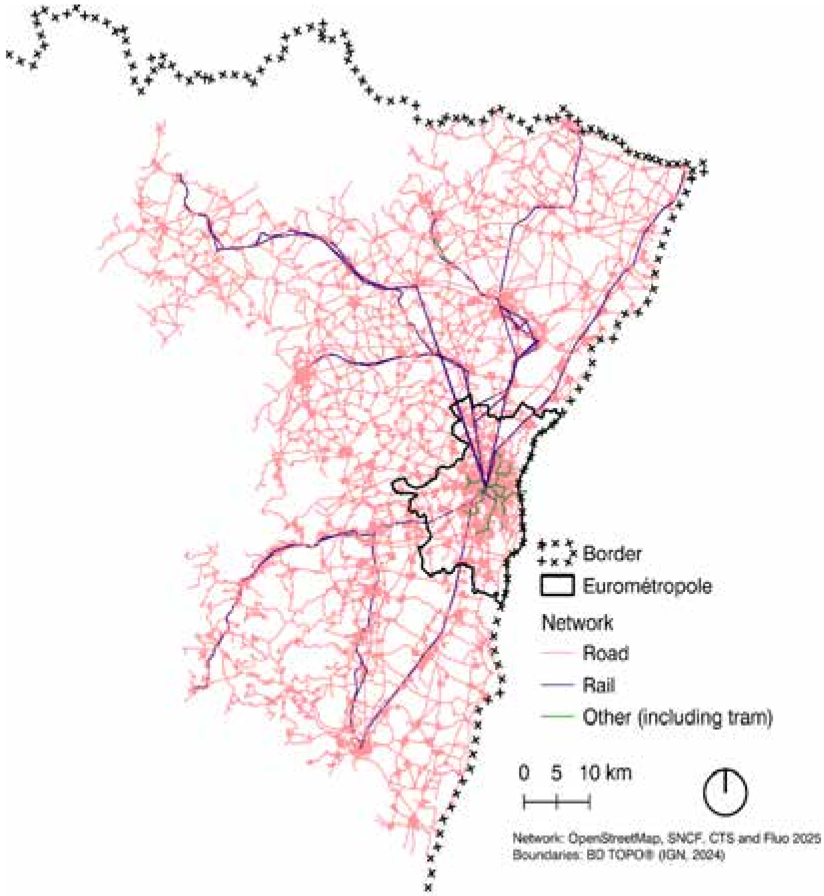

Figure 7: Modelled network

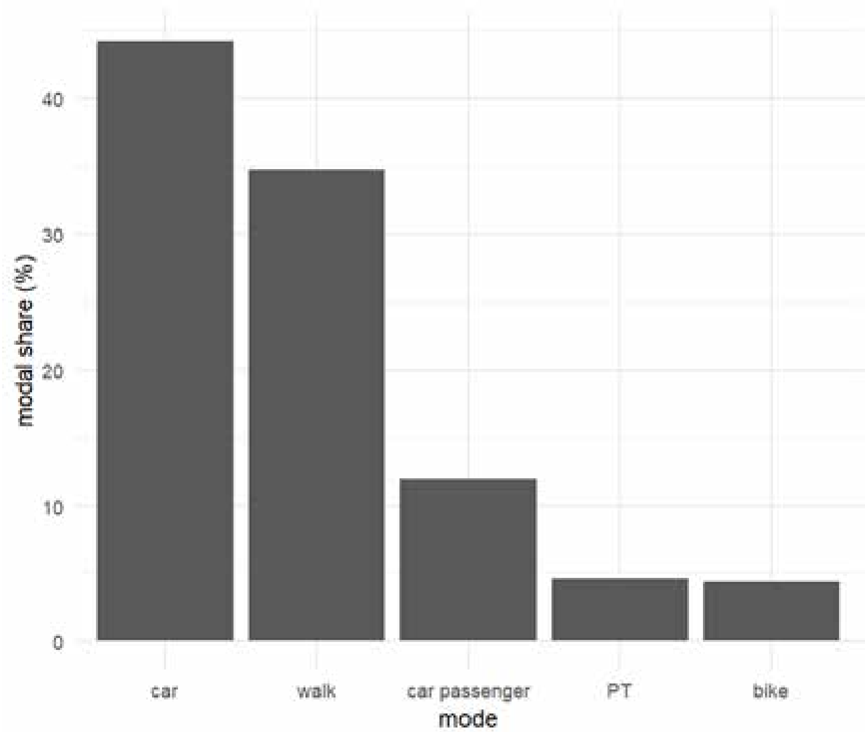

Figure 8: Modal shares

The modelled network (Figure 6) covers a wider area than the Eurométropole and includes 161,269 links. The German side of the border is not modelled due to the difference between data sources. The modal share (Figure 7) differs from the ones for Bas-Rhin in the 2021 census, this is due both to a lack of calibration and to differences in the way data is accounted for as modal share in the census only includes home to work travels.

8. Discussion

Many approaches in urban ergonomics are defined and trialled in an initial paper but are not applied further in other places. The transferability of many methods seems to be a significant issue as most of them rely on data that either requires manual input or depends on local authorities and is not standardised among data sources, qualitative approaches are more sensitive to this issue. The challenge is however that most datasets that cover more places are less defined. A challenge is then to find an equilibrium between data definition and availability, the identification of correlation between lower-scale elements and higher-scale indicators may be a way to reduce the number of needed data sources in further studies while considering the quality of surroundings during journeys.

Regarding modelling and post-processing, a further goal is also to streamline the process and develop a tool which will generate an access ergonomics score for each inhabited grid square, providing a detailed and comprehensive view of socio-spatial inequalities. The synthetic score broken down into sub-indicators (travel time, safety, comfort, etc.) and transport modes will enable comparison across the territory. These results will help to identify actions for improving access ergonomics and for reducing inequalities. In further studies, the developed tool will be improved by considering the aspect of energy transition, especially to take its consequences into account on the access ergonomics. The electric scooter availability is considered uniform in the study area in the present study. As the newer household travel survey will include data about micromobility vehicle availability, further studies may represent variations in the availability rate, the same way car ownership is modelled. The current model is uncalibrated as the latest local household travel survey results are to be released and uses the national household travel survey from 2008. Pedestrian and bicycle routing might also be an enhancement of the model, though these modes are less prone to congestion. Disposal of resources in Germany is not considered in this current paper though some communities in France near the border include amenities in Germany for their daily life, mostly for shopping purposes according to the report of the 2019 Household Travel Survey. A synthetic population of Bavaria has been built (Hörl et al., 2025) using an adapted version of the eqasim pipeline. Data availability in Baden-Württemberg (the German state neighbouring the Eurométropole de Strasbourg) and data heterogeneity between the two countries represent however a significant challenge.

Conclusion

Ergonomics in the city includes both the ergonomics of objects or spaces in the city as well as the ergonomics of the city as a system. Though the original definitions of ergonomics initially considered the human-machine interactions at the workplace, several authors have written about non-work activities and have created a wider frame for ergonomics: macroergonomics considers not only human-machine interactions, but the interaction between humans and organisations, on activities that are not limited to work. Macroergonomics have been applied to transportation systems since the 1970s with approaches such as the one Hoag and Adams applied to public transportation networks.

More recently, the return of consideration of proximity is linked to a renewed interest in the environment during travels as the users of active modes being more sensitive to their environments and literature regarding walkability includes elements of ergonomics. Most of the approaches however are either focused on a particular means of transportation or lack quantitative elements. The ergonomics of access has mostly been trialled with walking and cycling, but its outline can be adapted to other transportation modes, especially public transportation.

The proposed framework links the assessment of access ergonomics to a multimodal activity-based multi-agent model. The multi-agent paradigm allows the analysis of interactions between users and the analysis of individual properties of each agent. As access ergonomics not only describe travels done by users but also the potential ease of access to amenities including their alternatives, post-processing of the transportation simulation is necessary.

The objective to the approach is to provide a toolkit for a more holistic analysis of access to resources that is sensitive to changes in mobility conditions, whether from the network or from the demand. The multi-agent paradigm also allows further developments such as considering competition between the users for resources.

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The Sankey diagram (Figure 1) has been generated with the networkD3 (Allaire et al., 2025) and Figure 7 has been created with ggplot2 (Wickham, 2011). dplyr (Wickham et al., 2023) was used to process data to produce the figures and census with the R language (R Core Team, 2024).

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