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Encyclopedia of Transportation

Title: Active Transport: Heterogeneous Street Users Serving Movement and Place Functions
Alternative Short Title: Active Transport

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Abstract (100-150 words)
The overarching term 'active transport' includes all transport modes which require physical activity to reach a destination. It encompasses (1) movement functions when people move to reach their destination and (2) place functions when people use streets and public spaces as destinations for activities to be carried out directly in the street. Pedestrians and cyclists have similarities and differences that need to be considered in all efforts for increasing active transport. Walking is the slowest of all transport modes and heavily depends on short distances to relevant destinations. Bicyclists can cover longer distances thanks to higher possible speeds; and, in terms of fostering cycling, the perceived and objective safety as well as comfort of cycling facilities play a more critical role than dense urban structures. Active transport is one integral component of future sustainable transport systems. It must be prioritized in order to meet the various societal challenges at hand.

Keywords (10-15)
Active transport, vulnerable street users, walking, cycling, pedestrians, public health, public space, transport planning, urban planning, active mobility, active travel, nonmotorized transport, micro-mobility, slow modes

Evolving Terminology

The overarching term 'active transport' includes all transport modes which require physical activity to reach a destination. Active transport is a quite recent term; traditionally, walking and cycling were categorized as non-motorized modes of transport (Gerike and Parkin, 2016). This definition can have negative connotations in that non-motorized transport modes comprise everything else but motorized vehicles. This more narrow perspective suggests low level of attention and priority given in this direction as compared to motorized transport modes. The term 'active transport' has a completely different connotation. It suggests positive dynamics and attracts higher attention; active modes are not on the periphery but are to be treated with equal regard along side the individual and public motorized transport modes both in political discussions and in level of assigned priority. The increased acceptance and usage of the term active transport thus reflects the substantial growth of and support for walking and cycling that can be observed in many cities and countries worldwide.

The term active transport also allows for electric support of the human-powered vehicles as this is the case for electrically assisted bicycles such as pedelecs: These belong to the active transport modes as long as human power is necessary for moving forward. The term 'vulnerable road users' is also used for summarizing walking and cycling in the context of safety analysis and management. Further terms such as 'slow modes' also are also in use but are less present in the academic and non-academic terminology.

The variety of bicycles has increased substantially in recent years with growing numbers of special bicycles such as cargo bikes, bicycles with trailers, folding bikes, tandems, e.g., for parents with their kids, or electrically assisted bicycles. In addition, the new solely electrically powered micro-vehicles such as the electric scooters are currently spreading worldwide. These share many similarities in their characteristics and requirements with cyclists. This chapter focuses on walking and human-powered cycling, particularly when it comes to drivers and barriers. Empirical evidence on users and usage of the new electrically powered micro-vehicles is, thus far, fragmented; it documents the high dynamics triggered by these innovative services and vehicles but does not give a consistent picture of users and usage. All traditional and innovative forms of micro-mobility are considered in the discussion of measures for promoting active transport and micro-mobility in the second part of this chapter.

Characteristics of Active Transport

Common Characteristics of Walking and Cycling

Pedestrians and cyclists are vulnerable street users; they do not have any physical shell that protects them in case of an accident or fall. Both modes are far more space efficient than the motorized modes due to their smaller dimensions and slower speeds. Standard pedestrians have a width of mostly 0.80 m and bicylists of 1.00 m according to international guidelines on urban street design; the design car has a width of around 1.80 m and needs additional space on both sides for rear-view mirrors and lateral movements (Gerike *et al.*, 2019). Lanes for pedestrians and bicyclists are thus narrower compared to lanes for the motorized modes and, in addition, have higher capacities measured as moved users per hour.

Both active modes have low or no emissions in terms of noise, air pollutants and greenhouse gases. They are flexible in space and time. Users can walk or cycle wherever and whenever they want to; they do not depend on any fixed schedule of public transport services or dedicated parking facilities for cars. Walking and cycling require little to no money, presenting low costs for users, operators, and

society as a whole. Walking and cycling also contribute to public health objectives as they are one type of moderate physical activity and thus improve quality of life and health (Mueller *et al.*, 2015).
With these common characteristics, active transport is located at the intersection of urban planning, transport planning, and public health. Active transport supports the achievement of objectives in all three of these disciplines. At the same time, stakeholders from all three disciplines can foster active transport through their specific policy measures and expertise. Joint efforts efficiently allow for the maximization of synergies and the attainment of the common objective of increased walking and cycling levels.

Walking

Walking is the slowest of all transport modes. Pedestrians are therefore very distance and detour sensitive. They need direct connections between their origins and destinations and hardly respect any detours, e.g., when crossing a street after having left the bus. People only walk for short distance trips; 61 percent of walking trips in Germany are shorter than 1 kilometers (80 % for 2 km) (infas *et al.*, 2018). Dense spatial structures and mixed land-use are therefore paramount for achieving high walking levels. Another consequence of pedestrians' distance-sensitivity is that pedestrian facilities generally need to be designed for movements in two directions; pedestrians will not accept changing the side of the street for walking on one-directional sidewalks. Walking as a transport mode will never be suitable for satisfying all daily travel needs of any one person; it needs to be combined with cycling or motorized modes and shows particular synergies with high quality public transport provision (Gascon *et al.*, 2019).
Unencumbered walking does not require any specific equipment or skills; it is a human desire from the very early to the latest of life stages. For many, walking represents a form of independence, self-confidence, social participation, and health. These specific characteristics of walking lead to the phenomenon that the pedestrians group is the most heteregeous one from all transport modes and includes the whole of society with all social and age groups, people with and without mobility restrictions, women and men, etc. Another consequence of this inherent human desire to walk and to move is that people do not reflect on walking. Is is a strongly habitual activity and as normal as brushing one's teeth. As a result, people do not remember walking trips and activities as reliably as other transport modes (Aschauer *et al.*, 2018). Pedestrians are flexible in terms of the quality of walking facilities and the physical environment—high pedestrian volumes are found even for narrow sidewalks and at streets with high traffic loads (Kim *et al.*, 2019). At the same time, the literature shows that walking behavior is influenced by the streetscape, the quality of the public space, and the characteristics and usages of the buildings abutting the street and in the neighborhood (Ewing *et al.*, 2016; Mehta and Bosson, 2018; Mehta, 2013; Gehl, 2010).
Due to their low speed, pedestrians can spontaneously stop or change direction which leads to conflicts with bicyclists if both use the same space in the street. Walking not only serves movement but also place functions. When people walk to reach their destinations, streets serve as conduits that should enable all user groups to move safely and comfortably. Pedestrians also use streets as destinations for carrying out 'place activities'. These include: (1) necessary activities such as waiting for the bus; (2) optional activities such as eating or watching the street; and (3) social activities in the form of communication which require the presence of further persons (Gehl, 2010). The objective functions for movement and place functions are completely different: the maximization of moving comfortably and safely vs. the maximization of the number and duration of place activities, respectively.

Pedestrians, i.e. those walking as a transport mode, hardly have any lobby support in political discussions. Important reasons for this are that no technology is needed for walking and that no walking industry exists; in addition, all societal groups are (potential) pedestrians. With the exception of safety, almost no data exist on walking, nor do any measurable political goals or monitoring systems, thus significantly reducing the ability to report on the stastistics or the successes of walking as a transport mode.

Cycling

Cycling, in contrast to walking, is a conscious activity. Bicyclists and non-bicyclists have a clear opinion about cycling and about why they personally cycle or do not cycle. The level of cycling depends far more than walking on high quality infrastructure. Seamless, comfortable, and safe cycling facilities substantially contribute to higher cycling levels (Mueller *et al.*, 2018). Many municipalities have invested and are still investing high efforts into improving cycling facilities leading to substantial increases in cycling levels in many places in recent years (see http://www.epomm.eu/tems/ for an overview of modal split developments in various European cities). The type of cycling facility as well as the rules for deciding which cycling facility is suitable for each setting differ greatly between countries and also between municipalities within one country (Gerike *et al.*, 2019). One reason for this is that cyclists are the only street user group that can be provided either in the carriageway together with or next to the motorized transport modes or on the footway together with pedestrians.

Cycling requires a bicycle, suitable clothes, and safety gear (e.g., a helmet, reflectors, etc.). Cyclists are more affected by varying weather conditions than pedestrians as they are less protected (e.g., they cannot take an umbrella) and more sensitive to slippery or snowy surfaces. In contrast to walking, this leads to substantial differences in cycling levels depending on the season and climate. One of the main barriers for cycling is the inherent higher demand for physical effort (than, e.g., walking), particularly in hilly areas (Heinen, 2011; Handy *et al.*, 2014).

Cycling speed is also increased and is in urban areas almost equal to the motorized modes (when looking at the complete trip, including all stages from the origin to the destination). Such relatively high speeds allow for longer distances than for walking. 31% of all cycling trips range between 2-5 kilometers—this appears to be a feasible distance for many cyclists. 11% of all cycling trips are 5-10 kilometers long, and 6% of all cycling trips are even longer (infas *et al.*, 2018). The higher availability of electrically assisted bicycles might further increase the proportion of longer cycling trips. For all transport modes, 58% of trips are shorter than 5 kilometers and 74% are shorter than 10 km; thus, in terms of distance, cycling is well suited for covering daily travel needs. It can also be used for transportation of relatively large and heavy items, enabling cycling as a transport mode for most distances and trip purposes. Synergies with public transport nevertheless also exist for cycling.

The proportion of mandatory trips (work, education and, business) is higher for cycling than for walking. Therefore, once a person decides to cycle, this behavior remains more stable than walking for leisure as the main trip purpose (infas *et al.*, 2018). Another result of the higher speed of cycling is that personal security is less of an issue than for walking, but safety in general and, more particularly, perceived safety of cycling facilities are more important.

Drivers and Barriers

Overview

Various conceptual frameworks concerning drivers as well as barriers for active transport are available in the literature (Götschi *et al.*, 2017; Koszowski *et al.*, 2019). There is consensus that multi-level and multi-disciplinary approaches are required in order to understand and to purposefully shape walking and cycling. One important determinant of active transport is the built environment which includes urban structures, land-use, and transport supply. It has an impact on travel behavior in general, but specifically on active transport on the regional, city, neighborhood and street levels. The whole transport system must be considered in order for active transport to be well understood. The most efficient measures for promoting active transport could potentially be those which address motorized modes, e.g., through the improvement of public transport supply or the restriction of car traffic.

Socio-demographic, socio-economic, and socio-psychological variables are relevant at the levels of single persons, households, peers, and the (neighborhood) community. The distinction between objective and perceived quality of the available built environment and transport services is imperative; for example, objectively safe cycling facilities will not be used if they are perceived as risky by the (potential) users. Implemented policy measures and feedback loops for promoting active transport can change the system and bring dynamics into the conceptual frameworks of active transport. Policies can directly influence travel behavior when, for example, new walking and cycling infrastructures are implemented. Policies might also indirectly influence travel behavior through a change in overall attitude and mindset. Policies should also address governance structures including institutions, processes, finance and legal issues.

Person and Household Characteristics

Socio-demographic and socio-economic characteristics are important indicators for the propensity to walk and to cycle (Gascon *et al.*, 2019; Handy *et al.*, 2014). Walking levels are highest in the youngest and oldest age groups with hardly any differences between women and men (infas *et al.*, 2018; Harms *et al.*, 2014). Cycling levels are more evenly distributed across age groups and gender in countries with high modal-split proportions of cycling whereas, in countries with lower cycling levels, mainly young men cycle (Götschi *et al.*, 2015). The age group of 9-17 year-old children and adolescents shows a high affinity toward the active modes (Harms *et al.*, 2014). Through modelling their own travel behavior and setting an example, parents have a primary role in shaping their childrens' travel behavior and for shaping independent travel in early years (Ghekiere *et al.*, 2016). The odds of walking and cycling increase with higher levels of education (Handy *et al.*, 2014); however, findings on the influence of income on active transport are inconclusive (Koszowski *et al.*, 2019).

There is consensus in the literature regarding the influence of the ownership of a driving license and the availability of motorized vehicles. Both factors inhibit active transport and encourage people to adopt car-oriented travel behaviors (Damant-Sirois and El-Geneidy, 2015; Clark and Scott, 2013). Accordingly, better availability of bicycles in a household increases the propensity to cycle (Heinen *et al.*, 2011).

Socio-psychological factors such as perceptions, preferences, attitudes, habits, perceived controls on behavior (e.g., linked with the ability to carry luggage or to ride a bicycle), and social and personal norms are generally found to determine individual mode choice, more specifically active mode shares. The theory of planned behavior is often applied in this context (Ajzen, 1991). Affirmative opinions about active transport are positively correlated with active transport levels in a bidirectional causal relationship (Kroesen *et al.*, 2017). Motivating factors for cycling include status and lifestyle promotion, mental and physical relaxation, comfort, time savings, privacy and security (Heinen *et al.*, 2011). Heinen (2011) lists the following individually perceived barriers for cycling: time loss compared to motorized transport modes, overly long distances to relevant destinations, bad weather, lack of parking facilities for bicycles, physical overload (e.g., caused by differences in altitude or insufficient fitness and sweating). The influence of subjective motivational factors on walking is less clear than for cycling. For walking, the built environment is of highest importance as described below.

Density of Spatial Structures and Diversity of Land-Use

The "5 Ds" (Density, Diversity, Design, Distance to public transport, Destination accessibility) are consistently significant and influential particularly for walking (Ewing and Cervero, 2010; Lai and Kontokosta, 2018; Gascon *et al.*, 2019). Ewing *et al.* (2016) demonstrate the specific relevance of Density, measured in their example as floor area ratio and population density within a quarter mile of the investigated commercial streets. Diversity is often measured by entropy measures describing the number and variety of different land-use types in a given area (Ewing and Cervero, 2010; Lai and Kontokosta, 2018). Lower Distances particularly to rail-based public transport consistently and significantly increase pedestrian volumes (Ewing *et al.*, 2016). Design-variables describe the characteristics and, more specifically, the connectivity of the street network, measured, e.g., as intersection density or as a proportion of 4-way intersections (Ewing and Cervero, 2010). Destination accessibility describes the level at which relevant activities can be reached (Ewing and Cervero, 2010). Destinations are operationalized, e.g., by the number of nearby stores and amenities weighted by their distance; these are hardly significant and show an overlap with Diversity.
Urban design and land-use are less important for cycling than for walking (Buehler *et al.*, 2017). Thanks to higher speeds, longer distances can be covered with the bicycle resulting in less dependence on the proximity of relevant destinations. The range of bicycle trips further increases with higher availabilities of electrically assisted bicycles in the population and the extension of bicycle facility networks that allow for high speed and cover larger areas, e.g., on the regional as well as municipal levels.

Connectivity and Density of Walking and Cycling Networks

Mixed findings exist for the design variables related to the connectivity and density of infrastructure networks as introduced above. These are significant in some studies, in others they are not (Ewing *et al.*, 2016). Hooper *et al.* (2015) find positive correlations, the higher the street connectivity and the higher the accessibility to commercial land-use within the neighborhood, the higher the odds of walking. Cervero *et al.* (2009) find that residents in neighborhoods with highly connected street networks tend to have higher active transport levels of a minimum of 30 minutes per day on average. A high connectivity is mainly related to fine-grained street networks with many intersections [nodes] and requires many route options to get from each starting point to the respective destination. The shorter the distances are between the intersections, the higher the share of pedestrians and cyclists in the local modal split (Kaplan *et al.*, 2016; Ewing and Cervero, 2010). Various studies confirm the importance of the density and connectivity of the network of cycling facilities for achieving high cycling levels (Damant-Sirois and El-Geneidy, 2015; Handy *et al.*, 2014; Mueller *et al.*, 2018).

Comfort and Safety of Walking and Cycling Facilities

A safe and comfortable infrastructure is as important for cycling as urban design and land-use are for walking. This is in direct contrast to pedestrians who also walk on deficient pedestrian facilities if dense and mixed spatial structures and public transport services generate high walking levels.

The perceived safety of provided infrastructure is hence essential for the acceptance of cycling as a transport mode (Handy *et al.*, 2014). Types of cycling facilities and criteria for deciding on their suitability differ greatly between countries and also between municipalities within one country (Schröter *et al.*, submitted). Countries with high levels of cycling such as the Netherlands or Denmark tend to provide facilities for cyclists located off the carriageway and only allow for mixing cyclists with motorized vehicles in the carriageway with low speed limits of maximum 30 km/h. Cycling facilities should be designed in a way that allows for the accommodation of standard and non-standard bicycles as well as for all the innovative electric micro-vehicles that have emerged in the last years and months or that might emerge in the future. The so-called safety-in-numbers effect describes the phenomenon of improved safety for cyclists when the number of cyclists in specific regions or at single infrastructure points such as junctions increases (Elvik and Bjørnskau, 2017). The explanation of the safety-in-numbers effect is bi-directional: Better infrastructures for cyclists potentially increase cycling levels which, in turn, lead to higher visibility and safety levels for bicyclists.

For walking, Kang (2015) and Kim *et al.* (2019) find significant positive impacts of sidewalk widths, crosswalks, trees, and negative impacts of slope on pedestrian volumes. The number of traffic lanes has a significantly positive influence on walking levels but is highly correlated with the distance to public transport. Lai and Kontokosta (2018) compute a composite variable streetscape as the product of sidewalk coverage, pavement quality, and street amenity. This variable significantly increases pedestrian volumes on weekend days but not on work days.

Quality of Streetscape as Public Space

The "5 Ds" as introduced above are of high relevance particularly for walking not only on the neighborhood level but for the streetscape itself. This holds particularly for Design but also for the other Ds. Ewing *et al.* (2016) show the significant influence of floor-area ratios of the streets themselves (computed as the total building floor area for parcels abutting the street, divided by the total area of tax lots) and of the proportion of retail frontage along the block face on pedestrian volumes.

For the D-variables on the street level, the streetscape itself also matters for walking. Transparency is defined as the degree to which people can see or perceive what lies beyond the edge of a street. This is measured, e.g., by the proportion of first floors with windows and of active uses of adjacent buildings, and significantly increases walking volumes (Ewing *et al.*, 2016; Ameli *et al.*, 2015; Hamidi and Moazzeni, 2019). Ewing and Handy (2009) define, based on expert ranking, further relevant variables for walking; these are imageability, enclosure, human scale, and complexity. These are significant in some of the few existing studies that empirically analyze their influence on walking volumes (Gehl, 2010; Ewing *et al.*, 2016; Mehta and Bosson, 2018).

Ewing *et al.* (2016) view Transparency as the most important urban design quality on the street level; they analyze the influence of the following three variables separately: proportion of windows, of street furniture, and of active uses. The latter two are found to significantly increase pedestrian volumes. Overall, the three streetscape design features add significantly to the explanatory power of the statistical models explaining pedestrian volumes compared to models with only the D-variables on the neighborhood and street levels. Street furniture includes signs, benches, parking ticket machines, trash cans, newspaper boxes, bollards, street lights as well as anything at the human scale that increases the complexity of the street. Public seating is found to be of particular importance. The active use includes shops, restaurants, public parks, and other uses that generate significant pedestrian traffic. Inactive uses include blank walls, driveways, parking lots, vacant lots, abandoned buildings, and offices with no apparent activity.

Policies and Strategies for Promoting Active Transport

The aforementioned similarities and differences between walking and cycling directly translate into policies and strategies for their promotion. Both active modes benefit from integrated strategies that aim on the one hand at strengthening walking, cycling and also public transport and on the other hand at restricting car use. Improvements of public transport services are important in this context, particularly when walking levels should be increased. Measures for restricting car use are of highest relevance for promoting active transport; fast access to destinations by car and comfortable parking facilities at the destination are one main barrier for choosing to walk (often in combination with public transport) or to cycle. Examples for these restrictive measures are the re-allocation of street space to active modes or public transport (as in, e.g., London) (Wittwer *et al.*, 2019) or parking management—when the number of car parking facilities is reduced, their prices are increased or the maximum parking duration is limited.

Both walking and cycling benefit from public health campaigns and activities aimed at stimulating active transport as physical activity. One of the core objectives in the Mayor of London's Transport Strategy is that by 2041, all Londoners should do "at least the 20 minutes of active travel they need to stay healthy each day" (Mayor of London, 2018:22).

The main barrier for walking specifically is distance. Dense and mixed land uses are therefore key for the promotion of walking. On the detailed micro level of a street segment, the ground-floor usages and the design of the façades of the buildings abutting the street are of high relevance and more important than the street design. Pedestrians move slowly and experience their environment intensively, particularly when they are place users in the street. Active frontages and soft edges of the adjacent building invite pedestrian activities and city life whereas inactive walls without any interesting things to see or do cause people to walk more quickly and as efficient as possible to their destination.

Streetscape also matters for pedestrians. Unobstructed through zones with sufficient widths should be provided at the footway for accommodating the expected pedestrian volumes (Gerike *et al.*, 2019). Seating significantly increases place activities in all identified studies; shade and shelter as well as all measures increasing the perceived attractivity of the public street space also invite street life (Mehta, 2013; Mehta and Bosson, 2018). Safe crossing facilities need to be provided at main crossing points at specific locations or in linear forms. The principles of inclusive design need to be respected, particularly when providing for walking in order to enable all user groups to use the available facilities.

Cycling is less dependent on dense urban structures. Seamless, safe, and comfortable infrastructures that accommodate all forms of cycling vehicles are key for achieving high cycling levels. (Potential) cyclists do not cycle when they do not feel safe even when the provided facilities are judged to be safe by planners and further experts. Suitable cycle parking facilities are one integral component of these infrastructures.

Mobility cultures supporting active transport are more important for cycling than for walking. Particularly in starter cities and countries, the uptake of cycling can be accelerated with campaigns, festivals, and further so-called soft measures (Koszowski *et al.*, 2019).
Conflicts in space and time between pedestrians and cyclists exist. Both compete for the available street space that is clearly limited, particularly in inner urban areas; both compete for green time at signalized junctions. Such conflicts can only be solved on a case-by-case basis based on clear political priorities given on the city level.

The Way Forward

Active transport currently shows positive dynamics in many urban areas and countries around the world. Walking and cycling levels are increasing which goes hand in hand with growing support and commitment from planners and political decision makers. More and more stakeholders agree that there is no alternative to high levels of walking and cycling in combination with public transport and the emerging new micro-vehicle types when shaping future transport systems.
Societies worldwide are facing major challenges with growing cities, congested transport systems, ambitious goals for greenhouse gas emissions, noise, and air pollutants. Highest attention needs to be paid to safety so that achievements in promoting active transport are not compromised by increased numbers in accidents and injuries. More and more stakeholders commit to the Vision-Zero goal: No person should be killed or severely injured in traffic. This is a challenging goal but one key success factor for strengthening walking and cycling.
The promotion of active transport and the design and management of liveable streets is an interdisciplinary task which supports ambitions in urban planning, transport planning, and public health and can be achieved more successfully and efficiently if all the relevant stakeholders collaborate.

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