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Two models of accessibility to railway traveling for vulnerable, elderly persons

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ABSTRACT

Public transport mobility is restricted for the vulnerable travelers, e.g., those with functional limitations. By removing barriers, a more flexible and independent travel behavior is accomplished. For whole-trip traveling, we model accessibility as a three-way reciprocal relationship among travelers' functional ability, barriers met and resulting travel behaviors. For every journey and destination, an accessibility measure is constructed from all barriers' weights and the probabilities of encountering each of them in traveling to specific destinations. The accessibility to whole-trip traveling is then modeled by travelers' individual weightings of sets of barriers and the probabilities of encountering them. By using specific reference values, as in master scaling, we estimate the measurement error for each participant's perceived effort to overcome a certain barrier, and thus obtain a calibrated measure of accessibility. We conclude that customized abatement procedures must accomplish better accessibility for all, especially for the vulnerable travelers.

1. Introduction

1.1. Vulnerable travelers

Our research goal is to develop a methodology with which to measure accessibility in the public transport environment for vulnerable travelers. An overarching aim is to achieve an improved accessibility in the transport environment by enabling more flexible and independent travel behavior. For various reasons, a traveler may be vulnerable in the transport environment. Old age or functional limitations, such as restricted mobility, cognitive and psychiatric deficits or sensory impairment may enhance potential barriers in the transportation system and thus hinder traveling. Moreover, traveling with children or with heavy luggage may imply a greater vulnerability. We focus in the present study on elderly persons with functional limitations.

Because of the heterogeneity of the group of vulnerable travelers, research needs to adopt an individual approach to capture their needs [1]. Different kinds of functional limitations lead to different problems in the transport environment. For example, persons with cognitive impairment, as a result perhaps of stroke and dementia, may face specific accessibility problems in trying to cope with the ever- changing travel environment. Also, the elderly may have problems with the increasingly computerized solutions typical of today's travel environment. Moreover, the severity of a functional limitation as well as other factors such as earlier experiences and personality, can influence the interpretation of, and the ability to cope with, the travel situation. A focus on the individual might reveal needs

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that would be hidden in a larger population. Specifically, there is a need for more knowledge about how older persons *experience* traveling; for example what emotions and meanings are ascribed to travels [2].

Mobility, including accessible transport, enhances the quality of life for many elderly persons [3–5]. Increased mobility may reduce the risk of social exclusion, that is, in turn, associated with well-being of the individual [6]. In particular, persons without a driver's license; those living in rural areas; and the women, have been found to have unfulfilled travel needs [1,7]. Because of the strong association between car driving and mobility, as a group, older women are more vulnerable and dependent on others since they more often do not have a driver's license. As a majority in the oldest old, the women are also more vulnerable than men.

In addressing potential barriers, the whole travel chain must be taken into consideration, from the start to arrival at the intended destination. Therefore, also outdoor environments are included, such as the way between a person's home and means of transportation. Moreover, the remoteness of public transport may be critical for accessibility; for example, Kim and Ulfarsson [8] found that older persons were more likely to use public transport if they lived closer than five blocks from a bus stop. Moreover, connecting travel means may create barriers for some travelers, and, with increasing age, travelers tend to make less complex trips, especially over the age of 85 [5].

In research on accessibility for travelers in public transport, it seems wise also to include persons who are *not* traveling because they have already encountered too serious barriers. Without including these would-be-travelers, the most influential factors for accessibility might be missed; an example could simply be "the necessity to use an elevator instead of a staircase".

1.2. Accessibility

There is no agreed upon way of defining and measuring accessibility. However, a major division is often made between *place* accessibility and *individual* accessibility [9]. Place accessibility refers to characteristics of the physical place, whereas individual accessibility refers to features of a person, e.g., a traveler in the transport system. Here, we focus on *individual accessibility* and therefore, accessibility is measured with the individual as the measuring instrument.

An earlier attempt to measure accessibility is the AIMFREE by Rimmer et al. [10]. It consists of a set of psychometric measuring instruments for persons with functional limitations. In all, they developed and validated 16 survey instruments for measuring accessibility to recreational and fitness environments. By applying the Rasch model [11,12], Rimmer et al. [10] demonstrated that their instruments had good psychometric properties. In a separate publication, we report on a psychometric Rasch modeling of transport accessibility, based on a survey sample of about 1000 elderly travelers with functional limitations. This model, where in the present case the measured perceived effort for each person [according to Eq. (3)] is entered in the Rasch model, enables estimates of separate measures for place and individual accessibility attributes [13].

Notably, Iwarsson et al. [14] had earlier developed an instrument named "The Travel Chain Enabler" and combined it with "The Critical Incident Technique". This new instrument has been used for researching accessibility to urban public bus transportation for persons with functional limitations [15]; see also [16,17].

2. Theoretical model for accessibility

In Fig. 1, we have developed a theoretical person-environment-interaction model for accessibility to railway transport [18–20]. Model A presents perceived accessibility as a function of travel behavior and of barriers (constraints) for persons with *functional limitation(s)*. A functional limitation is regarded as a *person factor*, inherent in the person. It will affect what *barriers* are encountered during whole-trip traveling as well as what *travel behaviors* are provoked. For example a broken leg would make climbing stairs more difficult. Notably, for different persons, the identical functional limitation may create different travel behaviors, e. g., one person may avoid stairs (=barrier) altogether, another may choose to climb the stairs more carefully (travel behavior in interaction with barrier). Moreover, depending on situation and occasion, the same barrier may be perceived differently by the same person and thus result in various travel behaviors. Please observe that even if barriers are reduced or removed, the functional limitation would still be the same; the causation is one-sided.

As proposed in Model B, it is fruitful to focus on persons' functional *abilities*, rather than merely on their functional limitations (Model A). In the case of functional ability, the causation turns into a three-way reciprocal relationship. Model B exhibits accessibility to the whole trip as (a) travelers' functional ability, (b) their perceived barriers in the travel environment, and (c) their travel behavior. Functional ability is a feature that emerges in a person's *encounter with her/his environment*. If barriers are reduced or removed, the functional ability may increase (and travel behavior may become more independent). The causation may also work the other way around; the barriers may change because of a person's level of ability (bi-directed interaction). Consequently, the travel environment may change because of a person's particular level of functional ability. That is, not only does the barrier influence a person's ability, but the person may also influence the barrier. The staff may treat a person with low ability differently than a person with high ability. For example, before driving off, a bus driver may kneel the bus or wait until a person with seemingly low ability has found a seat. The low ability here resulted in a reduction of the barrier. A more common situation would be that a person with a low ability encounters more barriers than a person with a high ability.

Although functional ability is regarded as a feature appearing in the person-environment interaction [21], it is grounded in person factors such as functional limitations and physical characteristics but also in intra- and interpsychological factors such as personality, self-perception, and attitudes towards others. In addition, functional ability