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Investigating urban route choice as a conflict between waiting at traffic lights and additional travel time

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Abstract

The aim of this study was to analyze urban route choice as a conflict between waiting at traffic lights on a main route and additional travel time when using an alternative route. The effect of varying waiting times and time pressure was investigated in a mixed experimental design with 64 participants in a driving simulator. Besides accepting routes with longer distance, one third of participants also chose routes with longer travel times to avoid red light. Results can be used for road traffic control to guide drivers to less frequented roads without traffic lights which can improve overall traffic flow.

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Keywords: queue length; red-light duration; driving simulator; time pressure; travel time; decision-making; traffic psychology; main road

1. Introduction

The limited capacity within urban areas requires sustainable traffic management in order to enhance overall traffic flow (e.g. by providing green waves) and to reduce emissions. This could be achieved by guiding drivers while taking their individual route choice preferences into account. Considering the huge number of selectable routes in cities, this could result in a distribution of traffic and thus in a better usage of the existing road network and the prevention of traffic jams. In order to achieve this, it would be especially useful to lead drivers away from congested roads onto less-used roads. By means of Car-to-Infrastructure communication, travel information on urban traffic obstructions could be communicated faster and more efficiently to the drivers. For this reason the question arises under which circumstances drivers would switch to less frequented roads.

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A large number of studies have been conducted to understand the determinants affecting individual route choice (Ben-Elia and Avineri, 2015; Bovy and Stern, 1990; Chorus et al., 2006). The most important aspect of drivers' route choice is certainly the travel time. Besides this, other route attributes and additional factors like situational aspects, driver experience and personality factors influence the decision-making process as well. Various research groups investigated the impact of travel time reliability (Ben-Elia et al., 2013; Katsikopoulos et al., 2000), personality traits (Bekhor and Albert, 2014; Tawfik and Rakha, 2012), trip purpose (Ramaekers et al., 2013) and traffic disturbances like congestion and waiting at traffic lights and stop signs (Palat et al., 2014; Papinski et al., 2009). Concerning data collection, route choice is either examined by asking drivers what they would do (stated preference) or by observing their behavior (revealed preference). To assess stated preferences, 'artificial' route choice scenarios are presented to the drivers in questionnaires (paper-pencil, online) or travel/driving simulations. Observed behavior is assessed either using GPS-tracking or license plate recognition (e.g. Ramaekers et al., 2013; Zhang and Levinson, 2008). Both approaches have advantages and disadvantages regarding internal and external validity. The results from the first approach (e.g. Abdel-Aty et al., 1997; Abdel-Aty et al., 1993; Wardman et al., 1997) may differ from reality if drivers do not have to drive the route of their choice and thus do not experience the consequences of their decisions. For example, Hölscher et al. (2011) showed that planned routes of pedestrians differ strongly from the ones actually walked and Papinski et al. (2009) showed the same effect for drivers. In a direct comparison, Di Pace et al. (2011) revealed that participants were more risk-averse when comparing the decision-making situation in a driving simulation with a travel simulation. Thus, it would be preferable to not only present some information and then letting drivers chose between virtual alternatives but to actually let them drive different routes. For this reason, driving simulators, originally used in safety research, have been recently used more widely to assess the influencing factors of route choice with a more realistic feeling for the drivers (e.g. Ardeshiri et al., 2015; Tawfik et al., 2010)

Although many studies have been conducted to analyze the impact of route attributes, most of them have focused on long-distance trips. However, in urban areas, drivers are confronted with more complex traffic situations such as intersections (Werneke and Vollrath, 2012) and a higher number of possible routes. Due to the increased number of stops at intersections in cities, Palat et al. (2014) revealed in a questionnaire based study, that drivers prefer routes with fewer traffic lights. However, they concluded that the red-light duration is another interfering factor when routes do not differ much regarding the number of traffic lights. Therefore it is necessary to investigate also the impact of varying waiting times at a red traffic light. In addition to this, the urban road network consists of main roads being regulated with traffic lights and other roads in residential areas without traffic lights. These factors might also contribute to the individual drivers' utility and cost function. Besides these route attributes, characteristics of the driver should be taken into account. For example, Ramaekers et al. (2013) showed that the trip purpose (work, leisure, shopping, and home) influences the preferred road category. However, from a psychological view it is not clear what exactly causes this effect. Time pressure may be important, as Cœugnet et al. (2013) showed that mostly work-related trips are associated with time pressure. How this factor influences route choice in combination with different route attributes is still unclear.

Therefore, the objective of this paper is to analyze urban route choice behavior as a conflict between waiting at traffic lights on a main route and additional travel time when using an alternative route. This is examined with and without time pressure.

- First, we quantified the influence of varying waiting times at traffic lights, the increasing duration of an alternative route and of time pressure on decision-making and decision-making times.
- Second, we determined the threshold up to which point drivers would accept a gradually longer lasting alternative route in order to avoid waiting at a red traffic light.

2. Methods

2.1. Participants

In line with our objectives we conducted an experiment in a driving simulator so that the waiting times could be experienced. A total of 78 drivers participated in the study. Seven datasets had to be removed from the analysis because of simulation sickness. The decisions of another seven participants were not recorded due to technical