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Using the daylight savings clock change to show ambient light conditions significantly influence active travel

Jim Uttley*, Steve Fotios [1]

School of Architecture, University of Sheffield, UK

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ABSTRACT

This article reports a novel procedure used to investigate whether ambient light conditions affect the number of people who choose to walk or cycle. Pedestrian and cyclist count data were analysed using the biannual daylight-saving clock changes to compare daylight and after-dark conditions whilst keeping seasonal and time-of-day factors constant. Changes in frequencies during a 1-h case period before and after a clock change, when light conditions varied significantly between daylight and darkness, were compared against control periods when the light condition did not change. Odds ratios indicated the numbers of pedestrians and cyclists during the case period were significantly higher during daylight conditions than after-dark, resulting in a 62% increase in pedestrians and a 38% increase in cyclists. These results show the importance of light conditions on the numbers of pedestrian and cyclists, and highlight the potential of road lighting as a policy measure to encourage active travel after-dark.

1. Introduction

Encouraging the use of active travel methods such as walking and cycling has a number of benefits. These include improvements in health outcomes such as all-cause mortality (Kelly et al., 2014), obesity (Pucher, Buehler, Bassett, & Dannenberg, 2010) and other health-related measures such as cancer rates and cardiovascular fitness (Oja et al., 2011). Such health improvements can lead to economic benefits (Jarrett et al., 2012). The promotion of active travel can also lead to reductions in the use of motorised transport (Ogilvie, Egan, Hamilton, & Petticrew, 2004), with reductions in CO_2 emissions and improvements in air quality as a result (Goodman, Brand, & Ogilvie, 2012; Grabow et al., 2012; Rissel, 2009). Citizens who continue to use their vehicles for transport may also benefit from the promotion of active transport, due to reduced congestion on roads.

One of the key purposes of road lighting is to create acceptable conditions for people to walk or cycle after-dark (British Standards Institution, 2012), thus encouraging active travel. For example, Kerr et al. (2016) and Giehl, Hallal, Brownson & d'Orsi (2016) both found that road lighting was positively associated with increased walking. Cervero and Kockelman (1997) also suggested that the presence of road lighting and the distance between lamps were significant aspects of neighbourhood design that contributed to encouraging non-automobile travel. Differences in lighting conditions can lead to changes in behaviour. For example, Painter (1994; 1996) found there was an increase in pedestrian use of a crime blackspot after new lighting was installed. Light conditions can also influence the speed with which pedestrians walk (Donker, Kruisheer & Kooi, 2011). Cyclists, as well as pedestrians, are also likely to be influenced by light conditions. For example, the ability to make a trip during daylight hours was found to be one of the top ten motivations in deciding to cycle, whilst using a route that was not well lit after-dark was one of the top ten deterrents (Winters, Davidson, Kao, & Teschke, 2011).

There are several reasons why good light conditions may encourage walking or cycling. First, it allows obstacles and trip hazards to be seen and avoided, and this is a critical task for both pedestrians and cyclists (Fotios, Uttley, Cheal, & Hara, 2015; Vansteenkiste, Cardon, D'Hondt, Philippaerts, & Lenoir, 2013). Lighting characteristics such as illuminance and spectrum can influence the ability of a pedestrian or cyclist to detect an obstacle in the path in front of them (Fotios, Qasem, Cheal, & Uttley, 2016; Uttley, Fotios, & Cheal, 2015) and this may make a person more or less likely to walk or cycle, depending on the light conditions. Second, it may make the pedestrian or cyclist feel safer and less

* Corresponding author. School of Architecture, University of Sheffield, Floor 13, Arts Tower, Western Bank, Sheffield, S10 2TN, UK.
E-mail address: j.uttley@sheffield.ac.uk (J. Uttley).
[1] Postal address: School of Architecture, University of Sheffield, Floor 13, Arts Tower, Western Bank, Sheffield, S10 2TN, UK.

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threatened (Boyce, Eklund, Hamilton, & Bruno, 2000; Fotios, Unwin, & Farrall, 2015). Good light conditions are required to allow a pedestrian or cyclist to see far ahead and have an open view. This is one of the three key attributes an area requires to make it feel safe (prospect, refuge and escape, Fisher & Nasar, 1992). The prospect of an area will be at its highest during daylight, but reductions to this after-dark can be mitigated by road lighting. For example Boyce et al. (2000) asked participants to rate how safe they felt at a number of parking lots in the US during daylight and after-dark. Safety ratings were generally lower after-dark than during daylight, but the difference reduced as the illuminance at the parking lot increased. Feeling safe is particularly important for pedestrians as perceptions of neighbourhood safety have been shown to influence walking levels in that neighbourhood (Foster et al., 2016; Mason, Kearns, & Livingston, 2013). The third and final reason why light conditions may influence the decision of a person to walk or cycle is due to their perceived visibility. Daylight or road lighting may make the pedestrian or cyclist feel more visible and less at risk of being hit by a vehicle as the rate and severity of traffic collisions involving pedestrians and cyclists is increased when there is poor or no road lighting (Eluru, Bhat, & Hensher, 2008), and during darkness (Johansson, Wanvik, & Elvik, 2009; Twisk & Reurings, 2013).

These three factors of obstacle avoidance, perceived safety and perceived visibility suggest light should influence the decision of potential pedestrians and cyclists to travel or not and there should be a link between frequency of active travellers and light conditions. A causal connection between light and active travel has not been shown however. For example, previous work has linked the presence of road lighting with increased walking but it is not clear whether this is due to the light conditions provided or some other factor. This uncertainty is compounded by the fact that previous research related to this question has tended to use subjective methods for assessing the role of lighting, a good example of this being literature on lighting and perceived safety. A common approach is to ask participants to rate how safe they feel under different light conditions using a category rating response scale (Boomsma & Steg, 2012; Loewen, Steel, & Suedfeld, 1993; Rea, Bullough, & Brons, 2015). This approach has some limitations, if not carried out in a systematic way (Fotios & Castleton, 2016; Fotios, 2016). For example, asking for a rating compels a participant to make an assessment of something they perhaps would not otherwise consider relevant (Fotios, Unwin, et al., 2015). Data collected using subjective rating scales may be prone to range bias (Poulton, 1989) and influenced by the phrasing of the question (Schwarz, 1999). Perhaps most significantly, it is not certain that a subjective response by a participant translates into actual behaviour. For example, if light conditions do influence the subjective assessment of safety this may not necessarily be reflected in actual walking and cycling behaviour. Previous research has linked lighting conditions, perceived safety and physical activity (e.g. Weber, Hallal, Xavier, Jayce, & D'Orsi, 2012), but this has been based on subjective responses and is subject to the limitations outlined previously. Objective measures of behaviour could provide stronger evidence.

In the current article we present an alternative procedure to examine whether the amount of ambient light affects the number of pedestrians and cyclists, which is to count the number of pedestrians and cyclists passing a location in the periods immediately before and after daylight savings clock change. This was inspired by the investigation of vehicle collisions reported by Sullivan and Flannagan (Sullivan & Flannagan, 2002).

There are a range of factors that influence the volume of pedestrians and cyclists other than the light conditions, two of the most important being the season and the time of day (Aultman-Hall, Lane, & Lambert, 2009). The biannual changes to clock times resulting from daylight saving time provide an opportunity to control these two variables whilst changing the ambient light condition. This is where clock times in Northern hemisphere countries are advanced in Spring and moved back in Autumn by 1 h, changing the time of day at which dawn and dusk occur. This means that, as an example, a walk to or from work could take place during daylight in one week but after-dark the following week, at the same time of day. That is, an abrupt change of light level for the same journey decision. Counting the number of pedestrians and cyclists passing a particular location at this time of day means that the effect of light on the decision to walk is isolated from potential confounds of journey purpose, destination and environment. A similar approach utilising the daylight savings clock changes was used by Sullivan and Flannagan (2002). They analysed vehicle crash statistics in the US between 1987 and 1997. Their aim was to determine the likely effectiveness of adaptive headlamps in different driving situations, by identifying when dark conditions significantly increased the crash risk compared with daylight. They compared crash frequencies in the nine weeks before and after a clock change to see what the effect of the abrupt change in light conditions was. We use a similar before and after clock change method to compare daylight and dark conditions and their effect on active traveller frequencies. We develop this method further by introducing control periods in which light conditions do not change, against which changes between daylight and dark conditions can be compared.

Pedestrian and cyclist count data collected over a five year period from the Arlington County area of Virginia state, United States, have been analysed using this daylight saving clock change method. Frequencies during a case hour before and after the Spring and Autumn clock changes are compared relative to changes in control periods in which the light conditions do not change.

2. Method

2.1. Arlington pedestrian and cyclist counters

Automated pedestrian and cyclist counters have been installed in a number of locations within Arlington County, Virginia, in the Washington, DC metropolitan area, since October 2009, on both cycle trails and on-street cycle lanes. Arlington County is a 26 square mile area that was formerly an inner ring suburb of Washington DC. Walking and cycling have been regarded as important complements to rail and bus transit by the Local Authority, and led to the development of a healthy active travel infrastructure, matched by investment in active travel count apparatus to support transport planning. By 2016 there were 10 cyclist-only counters and 19 joint pedestrian and cyclist counters. Examples of these counters are shown in Fig. 1. The counters continuously record pedestrian and cyclist volumes and this data is available down to 15-min aggregations via a web service at the Bike Arlington website (http://www.bikearlington.com/pages/biking-in-arlington/counting-bikes-to-plan-for-bikes/data-for-developers/). Separate data for pedestrians and cyclists are provided. The direction of the traveller is also provided, as 'inbound' or 'outbound' relative to the centre of the Arlington area: for the analysis presented in this paper, inbound and outbound volumes were combined.

2.2. Data collation

The dates of Spring and Autumn daylight saving clock changes in the US between November 2011 and March 2016 are given in Table 1. An appropriate 1-h light transition period was identified for each of the clock-change periods, such that it was dark during this hour one side of the clock change date and daylight during the