Cycling, car, or public transit: a study of stress and mood upon arrival at work

Stéphane Brutus, Roshan Javadian and Alexandra Joelle Panaccio
Concordia University, Montreal, Canada

Abstract
Purpose – The purpose of this paper is to investigate the impact of various commuting modes on stress and mood upon arrival at work.
Design/methodology/approach – Data on stress and mood were collected after 123 employees arrived at work by bike, car, or public transit. In order to account for the natural fluctuation of stress and mood throughout the day, the assessment of the dependent variables was made within the first 45 minutes of arrival at work.
Findings – As hypothesized, those who cycled to work were less stressed than their counterparts who arrived by car. However, there was no difference in mood among the different mode users.
Practical implications – A lower level of early stress among cyclists offers further evidence for the promotion of active commute modes.
Originality/value – This study underscores the importance of being sensitive to time-based variations in stress and mood levels when investigating the impact of commute modes.
Keywords Stress, Mood, Work, Cycling, Commuting
Paper type Research paper

Introduction
The time workers spend commuting to and from work has been found to have a significant impact on their physical and psychological states and well-being. Recent data from the UK found that each additional minute spent commuting affected anxiety, happiness, and general wellness (Office for National Statistics, 2014a). Commuting is now recognized as a meaningful and consequential event in one’s daily experience of work. As a result of the overwhelming use of cars in North America, most of the research on commuting has focused on this mode of transportation. However, commuting options are increasing, especially in urban environments. Among these many options, cycling is fast becoming a method of choice. Using a bicycle as a means of transportation to work is economical, eco-friendly, and in many cases more efficient than other commuting modes such as car or public transit. Cycling also involves a level of physical activity that is superior to that of most commuting modes. This unique characteristic of using a bicycle to commute is expected to have positive effects on the perceived stress and mood of employees upon arrival at work.

Cycling as a commuting mode
Mounting evidence suggests that more and more people choose to cycle to work. According to a US Census Bureau report, the number of people who traveled to work by bicycle increased roughly 60 percent over the last decade, from about 488,000 in 2000 to about 786,000 during the 2008-2012 period (McKenzie, 2014). The same report shows that the rate of bicycle commuting for the 50 largest US cities increased from 0.6 percent in 2000 to 1.0 percent in 2008-2012. In the UK, the number of people living in London who cycled to work more than doubled from 77,000 in 2001 to 155,000 in 2011 (Office for National Statistics, 2014b). There were also substantial increases in other cities including Brighton (increasing by 109 percent between 2001 and 2011), Bristol (94 percent), Manchester (83 percent), Newcastle (81 percent), and Sheffield (80 percent). In 2010, 6 percent of Canadians cycled to work (Turcotte, 2011).
The choice of a commuting mode is multi-faceted and complex. The selection of cycling as a way to and from work is linked to a variety of advantages. From an economic standpoint, cycling can be an inexpensive form of transport, and it can sometimes prove to be faster than other commuting modes (Olde Kalter, 2007). The US Department of Transportation (2010) estimates that increasing bicycling and walking could reduce greenhouse gas emissions by 2-5 percent by 2030 and up to 10 percent by 2050. Finally, cycling can help individuals achieve a healthy level of daily physical activity (Dill, 2009). According to Ainsworth et al. (2000), the energy expenditure of cycling places it at least in the “moderate intensity” category of activity. In a study involving a ten-week program of cycling or walking to work, Oja et al. (1991) showed that cycling significantly improved cardiorespiratory and metabolic fitness of commuters, results that were later validated by a meta-analysis (Hamer and Chida, 2008). Besides the favorable effects of cycling on physical health, studies have demonstrated that cycling to work also has a positive impact on the overall mental state of workers (Morris and Guerra, 2015; Ohta et al., 2007). Compared to drivers, cyclists perceive their journey to work to be more relaxing and exciting, are more content with their commute, and are better able to cope with commuting stress (Gatersleben and Uzzell, 2007; LaJeunesse and Rodriguez, 2012; Martin et al., 2014). Research on cycle commuting has shown that cyclists were more likely to say that they simply enjoyed the activity itself, therefore, the intrinsic enjoyment gained from the exercise or relaxation associated with active travel can act as a coping mechanism to deal with commuting stress (Gatersleben and Uzzell, 2007). Moreover, cyclists maintained significantly higher levels of contentment and relaxation while commuting as well as less dissonance between their actual and ideal travel times than other types of commuters (LaJeunesse and Rodriguez, 2012). Despite its many unique benefits, cycling to and from work also has many drawbacks. Cycling is not well-suited for long commutes nor is it convenient when disparate stops are needed (e.g. dropping of children to school or running errands). Also, safety remains a concern, especially in urban environments (Fishman, 2016). In sum, commuting by bicycle is a choice, one that is driven by a variety of variables but the fact remains that, increasingly, commuters are opting to cycle to work.

Relatively few studies have directly compared commuters across multiple modes (e.g. Morris and Guerra, 2015). Most of the research being concerned with comparing car use and public transport (e.g. White and Rotton, 1998; Wener and Evans, 2011). These studies conclude that car drivers experience more negative responses to commuting, as indicated by higher levels of stress and more negative moods, than users of public transport (e.g. Koslowsky et al., 1995; Wener and Evans, 2011). Moreover, authors have taken a rather unspecific approach to the assessment of the dependent variables (i.e. effects of commuting). Both stress and mood are known to fluctuate over time, and recent research has found that the state in which employees start their day has significant influence on the remainder of that workday (Rothbard and Wilk, 2011). Early stress and mood shapes how subsequent events are perceived, interpreted, and acted upon for the rest of the day. The particular focus of this study is on the effects of various commuting modes in the first hour at work. In the next sections, we elaborate on the two dependent variables of interest and how they are influenced by different commuting modes.

**Stress**

Commuting is a well-known biopsychosocial stressor. For many commuters, the ride to work leads to an elevation in levels of stress (e.g. Novaco et al., 1990; Roberts et al., 2011; Schaeffer et al., 1988). This can be triggered by a range of stimuli, from traffic congestion (Schaeffer et al., 1988) and impedance (Gray and Lucas, 2001; Koslowsky and Krausz, 1993; Novaco et al., 1990) to the driving behavior of others (Rasmussen et al., 2000). Drivers’ stress is marked by elevated blood pressure and neuroendocrine hormone levels (Hennessy and
Wiesenthal, 1999) and has been shown to spill over into expressed hostility and obstructionism in the workplace (Hennessy, 2008).

The focus on commuting by car somewhat obscures variations found across different modes, and research on other modes of commuting allows for a more refined analysis of the many factors underlying commuting stress. For example, Evans et al. (2002) studied rail commuters in New York and found that those who perceived their commute as more unpredictable experienced higher levels of stress and showed evidence of higher elevations of salivary cortisol as a response to the experienced stress. In subsequent study, Wener et al. (2005) used an experimental design in order to examine the effects of the introduction of a multi-dimensional improvement of rail service on commuters in New Jersey. The new service had eliminated one transfer and had reduced the total commute by 20 minutes resulting in a shorter trip time and an easier trip. The authors found that compared to commuters who stayed with the previous rail service, those who switched to the improved transit system showed significantly lower levels of stress, as indicated by psychophysiological and self-reported measures.

Evans and Wener (2006) examined the role of commuting duration among suburban train commuters riding into Manhattan and found that the greater the duration of the commute, the more stressful the experience, as indicated by multiple indices of stress, including salivary cortisol and perceived stress. The distance and duration of commute, however, is not always a significant factor in commuting stress. In a study among train commuters in Stockholm it was found that the stress resulting from traveling by trains depends more on the conditions of the train (e.g. crowdedness and availability of seats) than on the distance or duration of the journey (Lundberg, 1976).

**Mood**

Moods are transient states that occupy an intermediate terrain in the range of affective states (Rosenberg, 1998). Moods lie between affective traits, which are enduring aspects of personalities, and emotions, which are acute, intense, and typically brief psychophysiological changes that result from a response to a meaningful situation in one’s environment. Moods wax and wane, fluctuating throughout or across days (Clark et al., 1989; Hedges et al., 1985) but last longer than most emotions (Davidson, 1994; Ekman, 1984; Lazarus, 1991). Research has identified exercise, personality dispositions, and daily stress as some of the key determinants that significantly influence individuals’ mood states. Several studies have found that drivers report more negative mood such as irritability, hostility, and other forms of negative affect after commuting than they do before commuting or on days when they do not commute (Hennessy and Wiesenthal, 1999; Novaco et al., 1979, 1990; Koslowsky et al., 1995). However, research on how various commuting modes affect mood are quite limited. One study on commuters in Dublin found that those who traveled by train experienced lower negative moods on reaching their workplace, followed by car and bus commuters with walkers reporting most positive moods. A more recent study showed that for metropolitan New York residents, train commuting was associated with less negative mood than car commuting (Wener and Evans, 2011). Moreover, the research on the effects of car commuting on mood is quite inconsistent, with some studies indicating more negative mood upon arrival at work or home in drivers using high congestion roads (Koslowsky et al., 1995), while others detected no changes in mood as a result of commuting (Schaeffer et al., 1988; White and Rotton, 1998). It is important to note that none of the studies mentioned have included cycling as a mode of transportation that could have unique effects on mood. The case of cycling to work introduces an element of physical activity to the commute which, in turn, is linked to the increase in endorphin levels (e.g. Markoff et al., 1981) and improved mood and work performance (Coulson et al., 2008). Moreover, the effect of cycling on mood may not simply lie in increased activity...
levels but also in the respite or “time out” that it provides from worrisome thoughts and daily stressors (Bahrke and Morgan, 1978).

Rothbard and Wilk (2011) found that one’s mood in the first few hours of the workday is key to the rest of the workday. Early mood creates a snowball effect that influences mood and productivity throughout the rest of the day. Rothbard and Wilk’s (2011) study demonstrated that early mood was linked to employees’ perceptions of customers and to how they reacted to customers’ mood. Moreover, early mood was linked to employees’ performance (e.g. the number of phone calls they took). While the performance measure in that study may appear questionable, results suggest that starting off the day in a positive or negative mood shapes the way events are perceived and reacted to for the remainder of the day. Rothbard and Wilk (2011) argued that start-of-workday mood is a result of a variety of experiences that happen before one arrives at work. Since journey to work is one such experience that affects start-of-workday mood, a negative commute experience can predict a negative start-of-workday mood, which in turn may adversely impact work performance.

There has been comparatively little research comparing the affective experiences of cyclists to those of car and public transport users. Only a handful of studies have examined and compared the affective responses stemming from multiple commute modes (Gatersleben and Uzzell, 2007; LaJeunesse and Rodríguez, 2012; Martin et al., 2014; Morris and Guerra, 2015). Moreover, a limitation of these studies is that they employed data that come from retrospective self-report measures. Having participants rely on their memories to indicate their feelings of past commutes interferes with the validity of the assessment, because individuals tend to overestimate the intensity of past emotions (Thomas and Diener, 1990). In this sense, the methodology on which this study is based is not a global retrospective assessment but rather focuses on “in the moment” assessment. More specifically, it focuses on mood in the 45-minute period after arriving into work and the specific experiences of how stressful that commute had been before the commuter had arrived at work.

Summary
The present research investigates whether there are differences between commute modes in stress and mood within the first 45 minutes of arrival at work. The methodological aspects of this study are of particular importance. First, the majority of research on this topic has relied on retrospective assessments of stress and mood. In order to increase the validity of the assessment, we measured perceived stress and mood of commuters within 45 minutes of arriving at work. Second, most studies concerned with consequences of commuting have not directly incorporated cycling with car use and public transportation; this paper addresses this gap. Our study uses a cross-sectional design to compare start-of-workday stress and mood of workers in a single organization across different commute modes. The focus on a single organization allows for a natural control of potential confound variables (e.g. geographical location, organizational culture, HR policies, etc.). We propose two mechanisms through which employees’ stress level and mood are related to cycling. First, cycling is a physical activity and leads to a reduced level of stress, at least during the first 45 minutes of arrival at work. Second, cycling, like any physical activity, is a mood-enhancing activity, and it especially elevates one’s start-of-workday mood.

In sum, we conducted a cross-sectional study to investigate the relationship between commuting modes and early-day stress and mood levels of employees. In designing the data collection, special attention was given to the timing of the assessment in order to capture “start of day” stress and mood.

Methodology
Procedure
Participants were recruited from an international software development company located in Montreal, a city with a reputation to be “bike-friendly” (Ogden, 2014). Indeed, Montreal was
ranked 20th in the world by the 2015 Copenhagenize Index; an inventory and ranking of the world’s bike-friendly cities (Copenhagenize Design Co., 2015). First, the human resources director of the company sent all employees an invitation stating the purpose of the project. A few weeks later, another e-mail containing a link to the survey was sent to all employees. To control for weather, this e-mail was sent on a sunny summer day to allow for participation by the maximum number of cyclists. The survey, which was designed for the purpose of the study, contained questions on mood, perceived commuting stress, and mode of travel to work on that specific day. Employees were also asked to provide their names; however, it was emphasized to them that this information would remain confidential and that only aggregated results would be reported. Participants were compensated with a gift card. Note that the research protocol used for this study was approved by the authors’ University Ethics Review Committee.

**Time verification**

Individually’s stress levels and mood fluctuate throughout the day, mainly due to events occurring during a working day. Hence, to measure the stress level and mood state related only to commuting and to avoid the effects of other daily stressors, this study measured stress and mood upon arrival at work. Participants were asked to mark the time of their arrival at work, and the time of filling in the questionnaire was recorded automatically by the online survey software, allowing the research team to differentiate between those who completed the survey within 45 minutes of arriving at work and those who did not.

**Participants**

Out of 634 employees who received the invitation e-mail, 147 (23.2 percent) responded to the survey; of these, 123 (19.4 percent) completed the questionnaire within 45 minutes of arrival at work. The final sample consisted of 61 female and 62 male home-to-work commuters with a mean age of 41.56 years (SD = 7.30). Note that this sample is slightly older (41.56 vs 36.77 years old) and composed of more women than the company’s composition (49.59 percent vs 22.31 percent).

**Measures**

A 31-item questionnaire was designed to measure perceived commuting stress, early morning mood, subjective vitality at the end of commute, and demographic variables. The scales used in this questionnaire are detailed in the following section. Unless otherwise specified, these were measured as continuous variables.

*Mode of commute.* We measured mode of commute by asking respondents how they arrived to work that day. Commuting by car was the most dominant mode of commute on that day, chosen by 54 (43.9 percent) employees. Public transport commute (i.e. train, subway, and bus) was the second main mode of commute (42; 34.1 percent). The number of employees who used a bicycle as their main mode of commute was 25 (20.3 percent) and finally a small number of people used a motorcycle as their main mode of commute (2; 1.6 percent). Note that this latter category was excluded from subsequent analyses due to its size.

*Perceived commuting stress.* Commuting stress was assessed using eight items using a five-point Likert scale from scales developed in previous studies (e.g. Kluger, 1998; Novaco et al., 1990). Sample items are “Commuting to work takes effort” and “Overall commuting is stressful for me.” Three items were reverse coded (e.g. “My commute to work was pretty easy today”) and high scores indicate higher perceived commuting stress. The commuting stress scale yielded an internal consistency of $\alpha = 0.83$ in this study.

*Start-of-workday mood.* We measured a person’s start-of-workday mood at the point at which she or he first sat down to work, prior to engaging in any work activity. We asked
employees to report their mood at the start of the day, using the following phrasing: “Before you begin your day, tell us how you feel. Using the scale below, please indicate to what extent you feel this way right now.” A revised version of the Brief Momentary Mood Checklist (Thomas and Diener, 1990; Van Rooy, 2006) was used to assess affective states. This scale, composed of six adjectives (happy, joyful, pleased, stressed, overwhelmed, confused), is relevant to emotions that commuters might experience. The negative adjectives were reverse coded during the analysis, so that a higher score indicated a better mood and a lower score indicated a worse mood. The internal consistency of this scale was \( \alpha = 0.80 \) in this study.

**Subjective vitality.** We measured subjective vitality as a control variable. Subjective vitality is conceptualized as one’s “health of spirit” and is expected to be affected by both physical health and psychological well-being (Ryan and Frederick, 1997). Not only is subjective vitality related to the individual’s experience of physical health, conscious experience of possessing energy, and aliveness, but it is also associated with personality dispositions of extraversion and conscientiousness (Ryan and Frederick, 1997). The underlying explanation for choosing subjective vitality as a control variable in the study is that it is highly likely that one’s energy level, physical health, and affect might impact one’s choice of commute mode. For instance, it is likely that a person who chooses to cycle to work possesses a higher level of energy in the first place. Subjective vitality was measured using a seven-item scale developed by Ryan and Frederick (1997). Employees were asked to respond to subjective vitality items in terms of how they “apply to you and your life at the present time.” Sample items include: “I feel alive and vital”; “Sometimes I feel so alive I just want to burst”; and “I nearly always feel alert and awake.” The response scale ranges from 1 (not at all true) to 7 (very true), with a higher score indicating more vitality and a lower score indicating less vitality. The internal consistency of this scale was \( \alpha = 0.89 \) in this study.

**Socio-demographic variables and duration of commute.** Gender and age information were collected from all participants. We also measured the duration of the commuting journey in terms of time taken to travel to work using four categories: less than 15 minutes \((n = 14; 11.4\% \text{ of respondents})\), between 15 and 30 minutes \((n = 43; 35.0\% \text{ })\), between 31 minutes and one hour \((n = 47; 38.2\% \text{ })\), and over one hour \((n = 19; 15.4\% \text{ })\). Our decision to categorize duration of commute was based on the fact that prior studies had also split up the duration of commute (e.g. Office for National Statistics, 2014a). Note that it was the authors’ initial intention to also assess distance of commute but, unfortunately, a malfunction in the questionnaire resulted in this variable not being reliably captured.

**Results**

The means, standard deviations, and correlations among study variables are presented in Table I. Duration of commute was positively related to commuting stress. Subjective vitality displayed a positive relationship with mood, and a negative relationship with commuting stress.

We conducted a one-way multivariate analysis of variance (MANOVA) to compare early day levels of stress and mood among cyclists, car, and public transport commuters. The independent variable, commute mode, included three groups of commuters (i.e. car drivers, public transport users, and cyclists), and the dependent variables were early morning stress and early morning mood. Subjective vitality was included as a control variable in the analysis given its theoretical relevance for stress and mood. Results were significant, \( F(4, 110) = 2.99, p < 0.05; \) Wilk’s \( \Lambda = 0.81 \). Furthermore, as Table II shows, mode of commute had a significant effect on stress \((F(2, 56) = 5.94, p < 0.01)\), indicating that after controlling for the effects of vitality, there was a significant difference in stress among the three groups of commuters.

The adjusted means in commuting stress for the three groups of commuters were 2.18 for cyclists, 2.25 for public transport users, and 2.54 for car drivers, on a five-point scale where 5
is the highest level of stress. Follow-up tests were conducted to evaluate pairwise differences among the adjusted means for the three groups. A Bonferroni pairwise comparison detected a significant difference between cyclists and car commuters only ($d = 0.35$). Hence, the hypothesis that different commuter mode users experience different stress levels is partially supported, with cyclists experiencing less stress than drivers upon arrival to work. As there was no significant difference in mood levels of commuters upon arrival at work as a function of their commute mode, the second hypothesis (cycling to work impacts start-of-workday mood) was not supported.

Discussion
The results of this study indicate that mode of commute to work is related to one’s stress level upon arrival at work. Employees who cycled to work showed significantly lower levels of stress compared to those who commuted by car. These findings support previous research by Gatersleben and Uzzell (2007) and LaJeunesse and Rodriguez (2012) who found that cyclists perceived their work commute as less stressful than did car commuters. The present study replicated this finding in the first 45 minutes upon arrival at work. However, contrary to these previous studies, no significant differences were detected between the stress level of cyclists and that of public transport users. This may indicate that the

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>SD</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Mood</td>
<td>3.54</td>
<td>0.86</td>
<td>(0.80)</td>
<td>−0.10</td>
<td>0.67**</td>
<td>0.06</td>
<td>0.13</td>
<td>−0.01</td>
</tr>
<tr>
<td>2. Stress</td>
<td>2.37</td>
<td>0.80</td>
<td>(0.83)</td>
<td>−0.26**</td>
<td>0.58**</td>
<td>0.00</td>
<td>−0.02</td>
<td></td>
</tr>
<tr>
<td>3. Vitality</td>
<td>4.81</td>
<td>1.11</td>
<td>(0.89)</td>
<td>−0.06</td>
<td>0.19*</td>
<td>0.08</td>
<td>−0.04</td>
<td></td>
</tr>
<tr>
<td>4. Commute duration</td>
<td>2.58</td>
<td>0.89</td>
<td>−</td>
<td>0.08</td>
<td>0.04</td>
<td>−</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Gender</td>
<td>1.50</td>
<td>0.50</td>
<td>−</td>
<td>−</td>
<td>−</td>
<td>−</td>
<td>0.15</td>
<td>−</td>
</tr>
<tr>
<td>6. Age</td>
<td>41.56</td>
<td>7.30</td>
<td>−</td>
<td>−</td>
<td>−</td>
<td>−</td>
<td>−</td>
<td>−</td>
</tr>
</tbody>
</table>

Notes: $n = 123$. For commute duration: $1 = 15 \text{–} 30 \text{ minutes}; 2 = 31 \text{–} 60 \text{ minutes}; 4 \text{ > } 60 \text{ minutes}$. For gender: $1 = \text{male}; 2 = \text{female}$. Reliability coefficients are reported in parentheses on the diagonal. *$p < 0.05$; **$p < 0.01$

Table I. Means, standard deviations (SDs), and correlations among study variables

<table>
<thead>
<tr>
<th>Source</th>
<th>Dependent variable</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>$F$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected model</td>
<td>Mood</td>
<td>67.59</td>
<td>66</td>
<td>1.02</td>
<td>2.53***</td>
</tr>
<tr>
<td></td>
<td>Stress</td>
<td>49.35</td>
<td>66</td>
<td>0.75</td>
<td>1.53</td>
</tr>
<tr>
<td>Intercept</td>
<td>Mood</td>
<td>870.73</td>
<td>1</td>
<td>870.73</td>
<td>2,152.14***</td>
</tr>
<tr>
<td></td>
<td>Stress</td>
<td>420.93</td>
<td>1</td>
<td>420.93</td>
<td>860.05***</td>
</tr>
<tr>
<td>Vitality</td>
<td>Mood</td>
<td>49.59</td>
<td>34</td>
<td>1.46</td>
<td>3.61***</td>
</tr>
<tr>
<td></td>
<td>Stress</td>
<td>23.43</td>
<td>34</td>
<td>0.69</td>
<td>1.41</td>
</tr>
<tr>
<td>Commute mode</td>
<td>Mood</td>
<td>0.89</td>
<td>2</td>
<td>0.44</td>
<td>1.10</td>
</tr>
<tr>
<td></td>
<td>Stress</td>
<td>5.82</td>
<td>2</td>
<td>2.91</td>
<td>5.94**</td>
</tr>
<tr>
<td>Vitality × commute mode</td>
<td>Mood</td>
<td>14.45</td>
<td>30</td>
<td>0.48</td>
<td>1.19</td>
</tr>
<tr>
<td></td>
<td>Stress</td>
<td>22.52</td>
<td>30</td>
<td>0.87</td>
<td>1.53</td>
</tr>
<tr>
<td>Error</td>
<td>Mood</td>
<td>22.66</td>
<td>56</td>
<td>0.41</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Stress</td>
<td>27.41</td>
<td>56</td>
<td>0.49</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>Mood</td>
<td>1,632.44</td>
<td>123</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Stress</td>
<td>765.56</td>
<td>123</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected total</td>
<td>Mood</td>
<td>90.25</td>
<td>122</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Stress</td>
<td>76.76</td>
<td>122</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: SS, Sum of squares; df, degrees of freedom; MS, mean square; $F$, F-ratio. For commute mode: $1 = \text{public transit}; 2 = \text{car}; 3 = \text{bicycle}$. ***$p < 0.01$; ****$p < 0.001$
distinction between cycling and public transportation, in terms of their active components, may not be as sharp as what the literature suggests. The fact that public transit users have to walk, climb stairs, and, very often, stand introduces a level of physical activation that makes this mode closer to cycling than car use. Also, it is interesting to note that commuting modes were not related to mood. Mood and stress are interrelated and it is quite possible that stress, a more stable construct, influences the relationship of commuting modes with mood, which is a more transient one.

This research project extends earlier research on commuting by Gatersleben and Uzzell (2007) and LaJeunesse and Rodriguez (2012), in particular by investigating the effects of commuting modes on stress in a different sample of commuters (high-tech employees rather than higher-education employees), and by assessing data based not on individuals’ memories of past commute but on measurements obtained shortly after the commute.

This paper provided insights into the commuting experience across different modes, by finding that commuters’ stress could vary as a function of their commuting mode, such that compared to drivers, cyclists will experience a reduced level of stress. This finding could inform some of the decisions of transportation managers and organizations. Some suggestions are offered in the next section.

Practical implications
Findings that commuting to work by bicycle is less stressful than driving to work have important implications, especially in relation to the promotion of cycling to work. In 2011, 6 percent of Canadians cycled to work (Turcotte, 2011), and even though this number is increasing every year, Canada still falls behind many European countries such as Germany, the Netherlands, and Denmark with respect to the number of people who travel by bicycle (Pucher and Dijkstra, 2003). This paper provides some justification for encouraging the use of bicycles and public transit as commute modes as it is well documented that commuting stress can lead to negative emotional and behavioral consequences upon arriving at home or at work (e.g. Cohen, 1980).

To encourage more bicycling for everyday travel, planners, policy makers, and organizations need to consider investing in bicycle facilities, incentives, and awareness programs. Bicycle facilities that include safe and conveniently located bike parking, on-site bike facilities (e.g. change rooms, showers, and lockers), and areas for basic bicycle repairs have been shown to have an impact on cycling use (e.g. Stinson et al., 2014). Cycling incentives and rewards, such as workshops to raise employees’ awareness of the benefits of cycling, can help make cycling an attractive alternative option for traveling to work. As for public transit, additional consideration as to its inherent physical component may be required by urban planners and transit authorities (e.g. promotion of stair use).

An interesting element in the promotion of cycling is related to multimodality or the combination of two or more modes in one’s commute. Multimodality is predicted to increase in coming decades (Kuhnlimhof et al., 2006) and cycling, by virtue of the ease transport, has the advantage of being easily combined with other modes, such as public transportation (Goodman, 2011). Urban planners could encourage the inclusion of cycling in multimodality by promoting basic elements such as station accessibility and bicycle facilities at public transportation stations (Heinen and Bohte, 2014).

Limitations and future research
Self-reported measures were the only instruments used for measuring stress and mood. Obtaining data from multiple measures – including physiological (e.g. cortisol levels) and behavioral outcomes (e.g. work performance) – might provide additional insights about the impact of commuting on stress and mood. Also, our sample is subject to selection bias, which confounds the results. The choice of commute mode is linked to a variety of factors
such as disposable income, climate, accessibility, etc. While this study incorporated some of these variables (i.e. vitality and weather), there are many that were not addressed. Factors such as the predictability of commute and multimodality, to name just a few, have significant bearing on the quality of commutes. In the same token, our results were obtained under a very specific weather condition (i.e. sunny day), future research should not only assess the many predictors of commute choice but also test these relationships in various settings. A more complex investigation is needed to provide a more comprehensive and detailed picture of the relationships. Another limitation is that the data were collected from a limited sample of commuters. The statistical power of the tests used is limited by virtue of the small sample sizes. Finally, the cross-sectional design of the study precludes us from drawing conclusions regarding the causality of relationships. Future studies with experimental or longitudinal designs are warranted to further our understanding of the causal process between commute mode and the psychological states of employees.

Conclusion
Commuting from home to work is a major part of many workers' everyday life and a source of stress and frustration for many. With growing concerns over traffic congestion and increased air pollution, public policy makers are increasingly promoting non-motorized commuting modes such as walking and cycling as alternative modes of transport, and for an increasing number of workers, the morning commute to work begins with getting on a bicycle and riding to work. This research project was an attempt to broaden range of outcomes that may be influenced by commuting modes. It is also the first attempt to introduce a chronological element in the assessment of these outcomes. By comparing the impact of different modes of commute on stress level and mood upon arrival at work it was revealed that compared to drivers, cyclists, and public transit users reported less stress. Given the increasing attention from policy makers on active transportation modes, more precise and deliberate research attention on this phenomenon can only be beneficial.

References


Further reading


Corresponding author

Stéphane Brutus can be contacted at: stephane.brutus@concordia.ca