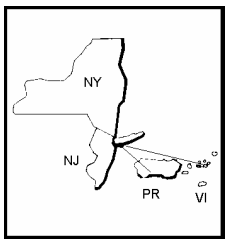

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THE IMPACT OF MODE AND MODE TRANSFER ON COMMUTER STRESS: THE MONTCLAIR CONNECTION

Final Report: FHWA-NJ-2004-005

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16. Abstract

This study was a natural experiment of the effects of a major improvement to the infrastructure of a commuter rail line on commuter stress. The study used a multi-method approach and both cross-sectional and longitudinal data were collection by using a pre-test/post-test design including both within and between group comparisons. On psychophysiological, self-report, well being, and job strain measures those using the new service show reduced stress in the post-change period, while those staying with the previous service did not. Predictability and trip effort did not mediate these effects. Commuters who switched to the new train service experience reduced level of job strain after the implementation of the line. We also founder gender differences on the motivation score (proofreading) and job strain scale for women who had children at home.

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List of Abbreviations and Symbols

PATH – Port Authority Trans Hudson

(nmol/l) - Nanomoles per liter

ns – non-significant

SUMMARY

This study built upon and extended our previous study on the causes and nature of commuter stress. The earlier work found that system improvements (implementing the Midtown Direct service) significantly reduced commuter stress as measured psychophysiologically and psychologically. It revealed that the time of the commute and, possibly, the degree of predictability helps explain why commuting is stressful. That study was limited, however, by a small sample size and a largely homogeneous population. There were, for instance, too few women to adequately examine gender differences and a small range of possible commutes on important variables such as effort and mode changes.

The present study was designed to increase our understanding of the degree of stress experienced by mass transit commuters and the impact of that stressful experience on commuters' lives, psychologically and psychophysiologically, at work and at home. We also sought to better understand the individual and trip factors and conditions that can serve to increase or ameliorate stress from the trip. To accomplish these goals we conducted a natural experiment, and replicated and extended the previous research findings by studying commuters who were affected by another major system improvement on New Jersey Transit train lines - the "Montclair Direct" service offered for Boonton Line commuters.

This study used a multi-method approach, employing self-report and significant other-report data, objective indices of commuting conditions, behavioral measures, and physiological measures of stress. The study made use of both cross-sectional and longitudinal data collection, by using a pre-test/post-test design including both within and between group comparisons. We compared Boonton Line commuters who switched to the new Montclair Direct service with those who did not.

Valid data was collected from 121 commuters. The results on psychophysiological, self-report, well being, and job strain measures supported our hypotheses that those using the new service would show reduced stress in the post-change period, while those

staying with the previous service would not. The study did not find support for our prediction that time of trip, control, predictability or trip effort mediated these effects. This may be due to the fact that variability on these measures remained low.

The results supported our prediction that commuters who were switched to the Montclair Direct services would experience reduced level of job strain after the implementation of the line. The study did not find differences in home stress and measured by spousal ratings.

The study also found gender differences but only for a special vulnerable sub-group of women. On both our motivation score (proofreading) and our job strain scale women who had children at home were especially sensitive to, and helped by, the intervention. This effect appears to be particular to women who are in this life situation and not simply a function of having children at home. The study found no such effect for men who had children at home.

These results, then, replicated the primary findings of the previous study, and extended them (for the first time) to spillover effects in the workplace, and impacts on the vulnerable subgroup of working women with children. The results are discussed in terms of limitations of the study, implications for understanding the nature of commuting stress, and directions for future research.

INTRODUCTION

Research Problem and Background

This study built upon and extended previous research [1-3] on the causes and nature of commuter stress. It did so in a number of ways. First, an important limitation of the earlier of study was that only a small, largely homogeneous (largely white, middle and upper-middle class) sample was available. This sample, limited in size and variability on key dimensions, made it impossible to test for effects of several key variables. For instance, the research literature on stress and commuting suggests that gender and ethnicity may serve as moderators of stress effects. Males and African-Americans reveal greater physiological reactivity to stress. Females react more strongly emotionally and, because of their more typically heavier domestic responsibilities vis-à-vis men, tend to experience commuting as a greater source of stress. The sample in this study provides a more diverse population that makes it possible to test for such effects.

Second, the pilot work revealed that the time of the commute and, possibly, the degree of predictability helps explain why commuting is stressful. If we can better understand what factors account for the ill effects of commuting, we will be in a better position to design and implement public transit improvements that address efficiency, economic and commuter health. To investigate more fully how these underlying mechanisms might account for commuting impacts on riders health and well being, we need a broader range of commuter time and predictability, plus a larger sample size. It is also useful to examine several other characteristics of the commuting experience that may contribute to stress. These include mode of transit, number of stages in the commute, perceived control over the commute, and effect and qualities of the micro-environment of the car (crowding, temperature, noise levels, available seats, etc.). The proposed sample will be selected to include a larger sample size and show a greater range of variation of the commute - time, number of mode changes, etc.

Third, our initial study focused primarily on the experience during the commute. Chronically challenging conditions, however, create situations that can spill-over into

other life domains - work and family in the present case. Do improved commuting conditions that lower stress contribute to higher job satisfaction, longer tenure on the job, enhanced performance? Are happier, more relaxed commuters more patient and socially engaged with their mates and children? Questions such as these are obviously important and have been largely unaddressed until this project.

Research Objectives

The primary objective of this study was to increase our understanding of degree of stress experienced by mass transit commuters and the impact of that stressful experience on commuters' lives, psychologically and psychophysiologically, at work and at home. The study also sought to better understand the individual and trip factors and conditions that can serve to increase or ameliorate stress from the trip.

To accomplish these goals, the study conducted a natural experiment and replicated and extended the previous research findings by studying commuters who were affected by another major system improvement on New Jersey Transit train lines - the "Montclair Direct" service offered for Boonton Line commuters.

Research Plan

The Previous Study

Our earlier research took advantage of the implementation of a major mass transit improvement by New Jersey Transit (known as the "Midtown Direct" service) which provided a "one-seat ride" into New York City for many commuters who previously had to transfer in Hoboken in order to take Port Authority Trans Hudson (PATH) trains into New York City. The creation of this new service provided a natural experiment since some riders switched to the new route, while others continued to use their previous route. The research studied psychological and psychophysiological responses to these commuting options, using a quasi-experimental, pre-post change, field research design. The study found that riders on this new line had reduced levels of stress, measured by multiple methods, whereas riders who continued using the Hoboken-PATH option did not. The stress effects seemed to be mediated by the time of the trip - that is, the reduced trip time of the Midtown Direct Service seemed to be a primary factor in the

reduced stress to riders. Predictability of the trip was also inversely correlated with stress, but did not distinguish between the commuter groups. These results were largely replicated with a student group who were randomly assigned to ride the same lines acting as simulated commuters. Therefore our two initial pilot studies showed that (i) commuting is stressful; and (ii) changes in conditions of the commuting environment affected the degree of stress experienced.

The study of Midtown Direct riders was unusually powerful because it took advantage of a significant change in the mass transit infrastructure to create an experiment without the limits and artificiality of the laboratory setting. The results were powerful even though the data was limited by the small sample size, lack of breadth and diversity among the backgrounds and type of commute of the riders, and the use of a single pre-trial data sample.

The new "Montclair Direct" service provided an unusual opportunity to replicate and extend these findings, and in so doing, learn a great deal more about the relationship of the mass transit commute and rider stress. In this research effort we made use of the same approaches and measures that were used in the previous study - to allow for comparability of results - adding to the data collection in several respects to provide more detailed understanding of these phenomena. For example, the study assessed more carefully conditions on the train cars which should affect stress (such as crowding and noise), and addressed issues of spillover of the commuting experience to the workplace.

METHOD

This study used a multi-method approach, employing self-report and significant other-report data, objective indices of commuting conditions, behavioral measures, and physiological measures of stress, as shown in Table 2. The study makes use of both cross-sectional and longitudinal data collection, by using a pre-test/post-test design including both within and between group comparisons. The independent variable of primary interest is the change and improvement in the commuting route.

This experiment focused on commuters from the Boonton Line, prior to the Montclair Connection traveled to Manhattan via New Jersey Transit, shown in Figure 1, switching in Hoboken to the PATH trains. The Intervention Group consists of those commuters who took advantage of the option to use the new route, transferring to trains that go directly to Pennsylvania Station, New York City. The Comparison Group consists of those commuters who did not change routes, and continued to switch lines in Hoboken. We collected demographic data, job type, and residential data to assure comparability of these groups, even though there is reason to expect these groups to be equivalent.

Pre data was collected from March, 2002 through the end of September, 2002, before the opening of the new Montclair Connection Line. Post data was collected from December 2002 through October, 2003.

Dependent Measures

Psychophysiological Stress Indices .

Both resting and commuting cortisol levels were collected. Cortisol was assayed by salivary measures. Since salivary cortisol peaks within 30 minutes of the onset of a stressor our goal was to measure cortisol 30 minutes after the onset of the commute [(4)]. Salivary cortisol was measured by having the participant chew on a small cotton cylinder (similar to what a dentist utilizes) until it is saturated (typically 90 seconds). Baseline cortisol was also collected at home at the same time of day on a non-work day.

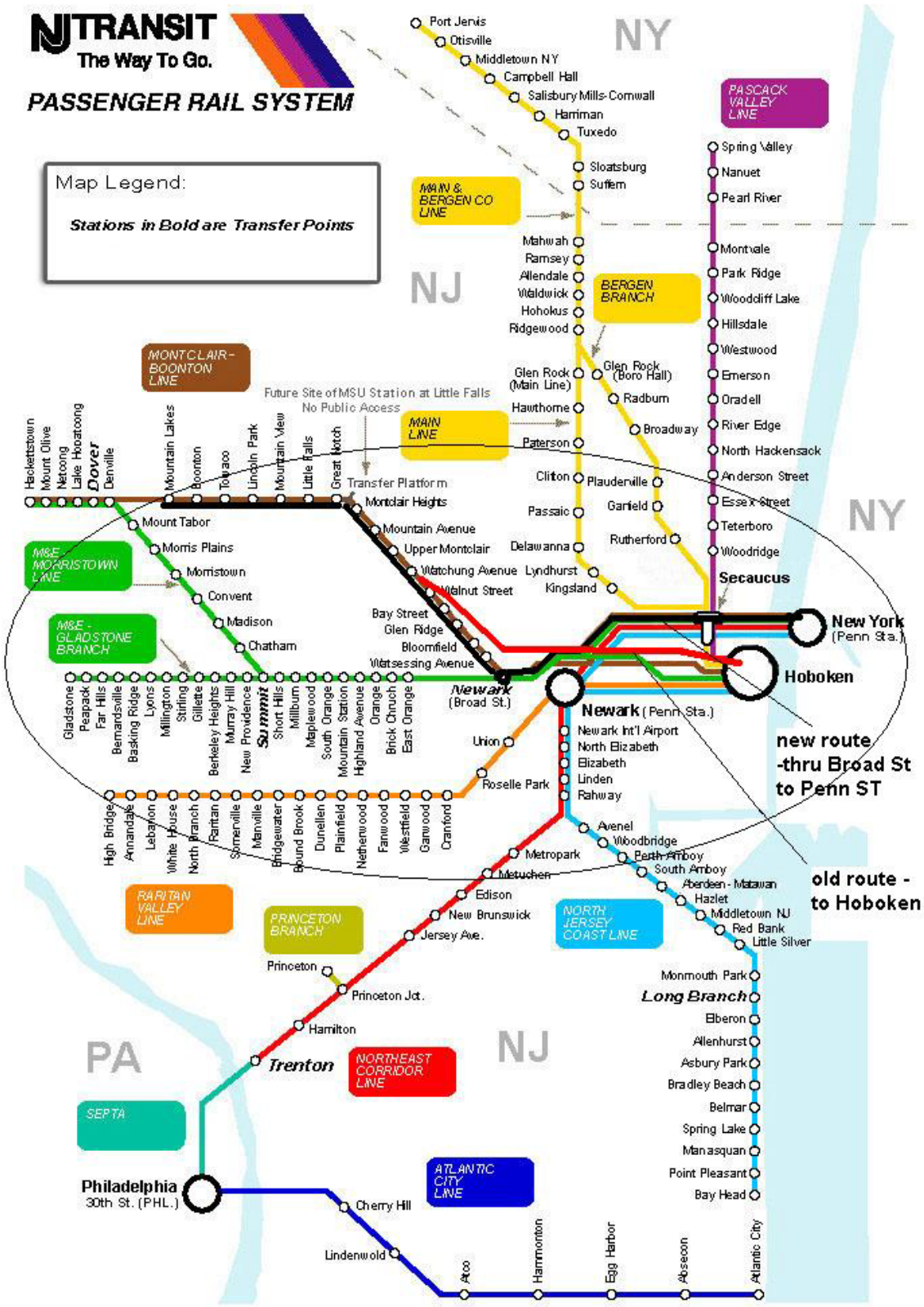

Figure 1 NJ Transit Rail Map

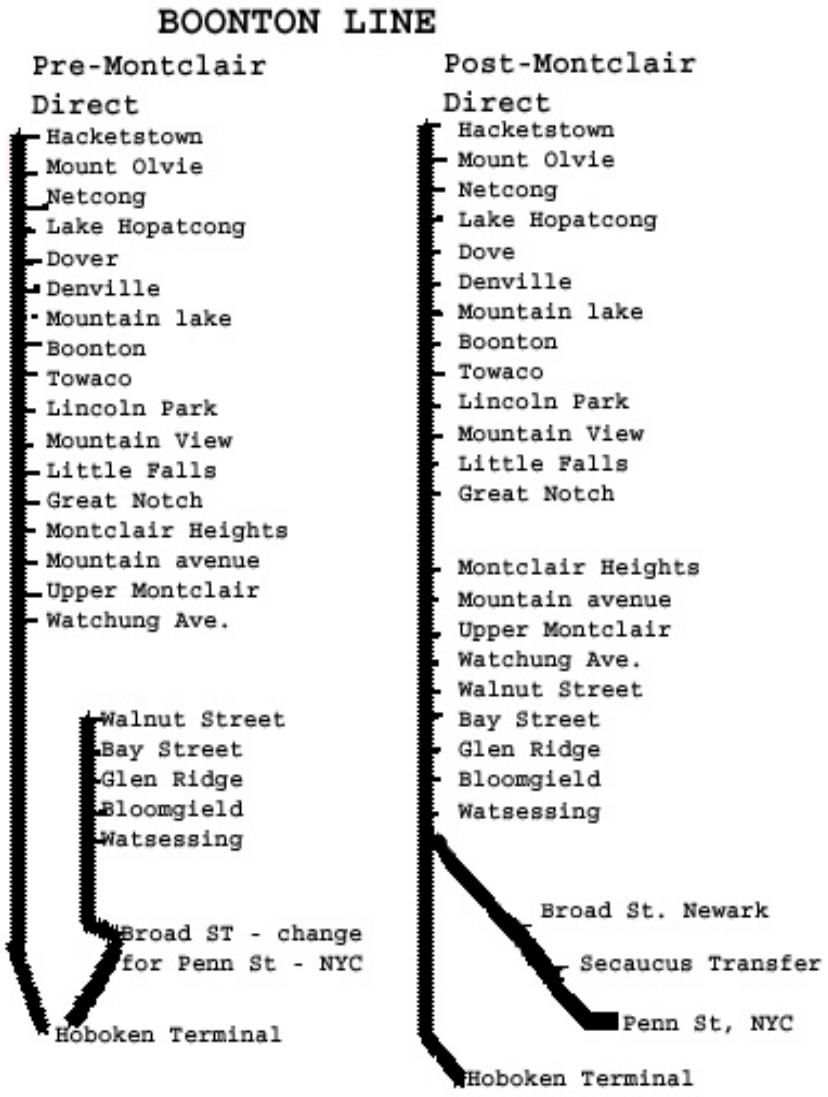

Figure 2 Montclair Direct Stations

Motivation.

Motivation was assessed through use of a proofreading performance task during the last minutes of the commute. Proofreading has been shown to be a sensitive aftereffect index to stress [5, 6]. The proportion of correctly assessed proofreading errors as well as the number of lines proofread will be the primary indices.

Perceived commuting stress. (see Appendix 2 for forms)

We made use of two measures of commuting stress. First, commuting stress was measured by utilizing scales developed and field tested in previous studies of commuting by Novaco et al. [7, 8]. These scales have sensitively discriminated among commutes of varying congestion levels and are internally consistent. The scales consist of seven semantic differential items (e.g., tense-relax, tired-energetic).

The second measure of commuting stress was developed by Kluger [9] and has been utilized in several studies of commuting stress [10]. This four item Likert scale inquires about reactions to particular aspects of commuting (e.g., "I resent the hassles my commute causes me").

Commuting Crowding and Personal Space. (see Appendix 2 for forms)

This study used several indices of crowding. On days of subject monitoring, the subjects were asked to count the number of empty seats and number of standing riders on the cars in which they ride. Subjects were asked to rate levels of density and perceived crowding for each mode of transport. Subjects were also asked to indicate how many people were in their seating row and whether anyone was seated next to them.

Commuting Control and Predictability . (see Appendix 2 for forms)

We used an index of commuting control and predictability from prior work on commuting [7, 8, 10] as well as from research on control and crowding [11, 12].

An objective index of commuting predictability was the variance in commuting times estimated by asking participants to indicate how long their commute takes on a typical day, a bad day, and a good day. The standard deviation of these three measures is an objective assessment of commuting predictability [9]. Perceived predictability of the commute is indexed by asking people to rate a list of factors that affect their commute: extra heavy traffic, weather, time of day, day of the week, time of the year, accidents, choice of routes, and different destinations.

Control over the commute was assessed by a series of questions. Respondents were asked questions about their decision latitude for commuting mode, commuting route, commuting time, arrival and departure time at work. The study also inquired about feelings of control over what happens, the amount of travel time, how other people affect them, interruption, unwanted social interaction, ability to get work done, and feelings of helplessness, during the commute.

Commuting effort . (see Appendix 2 for forms)
The study has developed and tested commuting effort scales. Questions were asked about the degree of effort felt while commuting to work, as well as from work to home, extent of impediments while commuting because of scheduling or because of the location of departure and terminus points, feelings of overload from the commute, amount of spare time, how much concentration is required to reach the commute, to what extent the commute has become automatic and how easily the commute can be accommodated.

Commuting spillover to work/home . (see Appendix 2 for forms)
The study gathered data from two sources to measure possible spillover effects of commuting stress to the workplace and to the home. At the workplace, the subjects rated work stress using scales that have been standardized and are well documented.[13, 14]. We also asked the subject's spouse to complete the Daily Marital Behavior scale [15], which includes items on partner's anger, withdrawal and support. This scale was supplemented with additional items that ask for spousal observations of the impact of the commute on their spouse.

Control factors.

Several variables were measured to help control extraneous sources of variance in the studies proposed. Negative affectivity was assessed by the PANAS [16]. Negative affectivity influences individual reports of both environmental conditions as well as symptoms and affect. Persons who tend to see things in negative terms are likely to evaluate their reactions and environmental conditions more negatively, thus producing exaggerated correlations [17].

All respondents must have been on the commute for a minimum of one year; regularly (at least four days a week) commute to and from the same points; and expect to continue commuting to work in New York City for at least the next year. The study stratified the sample by gender to insure that half of the experimental and half of the comparison commuting groups are female. The sample was also stratified by where in New York City the respondents work. By choosing subjects who work downtown and midtown (near or above Pennsylvania Station) we hoped to create two groups - one likely to switch to the new line and another that will continue using the current route.

All of the participants in the experiment were between ages 25 and 50. Participants in the experiment were commuters who currently travel on the Boonton Line of New Jersey Transit to Hoboken and via the PATH to lower Manhattan. All of the participants in the experiment were living with a significant other and have at least one child living at home.

Basic sociodemographic information was collected of all participants. These data will be used as statistical controls when necessary in the cross sectional, mode shift, and travel mode comparisons. Age, gender, ethnicity, education, income, occupation, family composition, and information about residential location were collected.

Hypotheses

(i) the results of the first study will be replicated. Commuters using the new easy-transfer, faster route will show reduced stress when compared to their previous commute and to others who continue using the previous route.

(ii) These salutary effects will be caused by one or more of several factors:

a. reduced time of travel

b. enhanced perceived control/predictability over the commute

(iii). The study expected there to be significant spillover effects of greater commuting stress on the home (spouse and children) and work (job satisfaction, absenteeism, supervisor ratings).

(iv.) Gender differences are expected. We also expect that women will show more commuting stress overall than men and benefit more from commuting system improvements. The one exception to this is expected to be physiological stress (cortisol) where we expect to see the opposite gender pattern. These predictions are based upon studies on car commuters indicating that the multiple work and family demands weigh heavier on mothers than on fathers [7, 18] whereas men typically evidence more elevated physiological responses to environmental demands [19, 20].

Sampling and Data Analysis Strategy

Train commuters were recruited via notices distributed at stations and handouts on trains. All subjects in the experiment were randomly chosen from those who met the criteria and who indicate a willingness to participate in the study. The study recruited 150 subjects along the train lines.

The subjects were even split - 50% were male, 50% female. 84% were married or living with a partner, and 82% were college graduates. The median family income of our subjects exceeds $95k. Table 1 shows the number of subjects with valid data for each dependent measure.

Table 1. Sample Sizes		
	Period of Measurement	
	Pre-Montclair Direct	Post-Montclair Direct
Cortisol	100	109
Proofreading	120	121
Self stress	111	91
Spouse stress	92	99
Well being	119	116
Mood	119	116
Job Strain	120	120

RESULTS

The results are presented in two parts. In part one, the study provides descriptive and inferential statistics on the commuter's reactions to the NJ commuter transit line intervention. Data are presented before and after the intervention for the two separate groups: the Comparison Group whose commute remained constant and the Intervention Group whose commute was altered by the new direct link to midtown Manhattan.

In part two, the study examines commuter's perceptions of predictability and control of the commute, the degree of effort required to commute, and of objective changes in commuting time as possible underlying mechanisms that might account for some of the expected reductions in commuting stress hypothesized to occur because of the intervention.

Table 2. Measures to be used (see 'Methods' section, page 7, for details on measures)		
Concept to be measured	**Types of information**	
demographic/ personal information as control factors	Self administered survey form: age, gender, race, income, job, type, place of residence, place of employment, family composition, personal and family health history (hypertension/ coronary heart disease), rated negative activity	
commuting information	Self administered survey form: start and end points, mode, times, regularity, likelihood of use of Montclair Direct	
physiological stress indices	Resting & commuting salivary cortisol levels	
motivation	2 proofreading texts	
perceived commuting stress	Standardized Likert scales.	
Crowding, personal space	Rated crowding, estimated number in car, indicating of number in seating row and next seat	
commuting control & predictability	*Objective*: variability of trip time	*subjective*: perceived predictability, choices of route, mode, times
commuting effort	Perceived degree physical & mental effort, impediments,	
spillover	*Home:* spouse ratings of subject's health, attitude, affect, behavior *work:* self ratings of job strain	

Intervention

Psychophysiological .

Salivary cortisol was collected at home on a non-work day and as the commuter disembarked from the commuter train on a workday. This procedure was repeated before and after the completion of the new Montclair Direct commuter line. For each occasion the difference score was calculated by subtracting the resting, home baseline measure from the on-the-train commuting measure. Table 3 and Figure 3 depict the home baseline values, the commuting values, and the difference score for the Intervention and Comparison groups, before and after the opening of the new commuter rail line.

The difference scores for the Comparison Group at Pre-Intervention are equivalent as expected. At the Post-Intervention the differences scores are marginally smaller for the experimental group who benefited from the modifications in service, $F(1, 94) = 2.13$, $p < .07$. The Pre-intervention difference score was co varied to help control for individual differences in stressor reactivity. This analysis was also controlled for gender given its correlation with cortisol secretion. Gender did not statistically interact with the intervention.

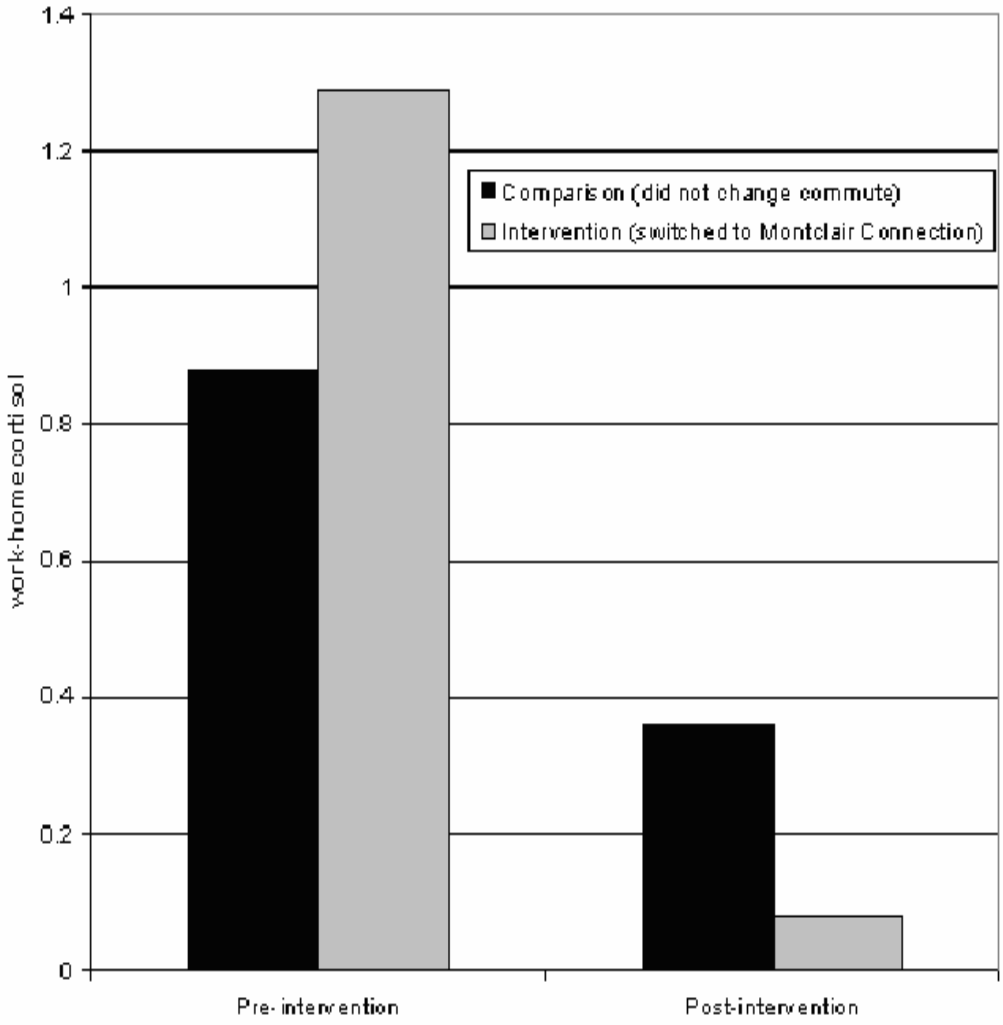

Figure 3 Salivary cortisol (nmol/l) (difference between work and home levels – lower scores indicate less stress)

Table 3. Salivary cortisol (nmol/l) (difference between work and home levels – lower scores indicate less stress)			
Group	Pre-intervention	Post-intervention	Significance
Comparison	.88	.36	p<.07
Intervention	1.29	.08	

Motivation performance

Proofreading accuracy was indexed by the percentage of errors correctly identified. For the Comparison Group 54% correct and 51% proofreading performance were obtained pre- and post-intervention, respectively. For the Intervention Group motivation performance was 55% and 53%, respectively. Neither group of commuters differed before or after the commute. However as inspection of Table 4 and Figure 4 indicate, there was a highly sensitive subgroup of commuters, women with children living at home, who strongly benefited from the commuting intervention, $F(1,117) = 8.82$, $p < .004$.

There was no interaction between commuter gender and child at home status for pre-intervention, motivation performance. We also examined whether the effects were simply due to having children at home. The only subgroup of commuters who significantly improved in motivation performance was female commuters with children living at home. Males, regardless of the presence of children in the home, are the same as females without children at home.

Perceived stress

Both self-reports and spousal ratings of the commuter's perceived stress were collected before and the intervention. Self-reported stress was evaluated at the end of the commute and spousal evaluations were done at home on a non-work day. Initial levels of both indicators of stress were equivalent for the two respective groups of commuters prior to the intervention (see Table 5). However, following the intervention, the two groups of commuters differed significantly in self-reported stress, $b=-.27$ ($SE=.15$), $p<.04$. Gender was included as an additional control in the analysis given its significant relationship with perceived stress. Neither gender per se or gender and children-at-home status interacted with the intervention to influence perceived stress.

Table 4. Motivation performance post-intervention of female commuters with children at home compared to all others (female commuters without children and male commuters at home).			
% correct on proofreading test	Post-intervention		
	Females with Children	All Other Commuters	Significance
Comparison (did not change commute)	41%	54%	p<.004
Intervention (switched to Montclair Connection)	60%	51%	

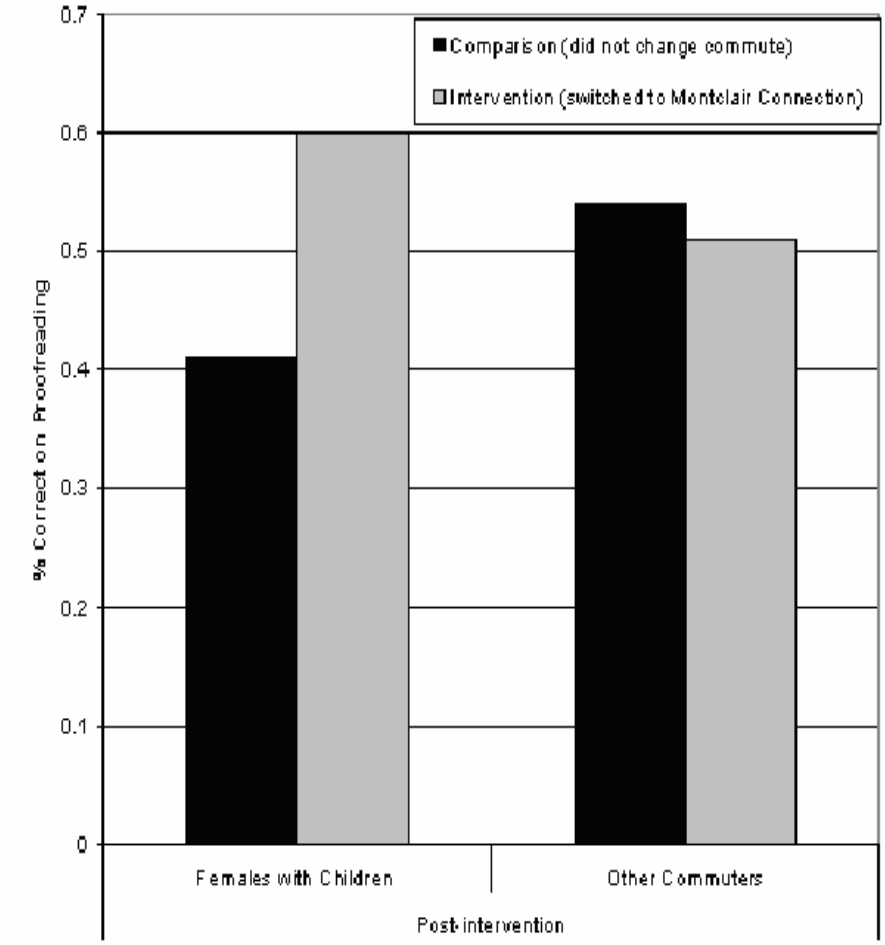

Figure 4 Motivation performance post-intervention of female commuters with children at home compared to all others

Table 5. Perceived stress - 1=low stress and 5=high stress (number of subjects)				
Measures	Group	Pre-intervention	Post-intervention	Significance
Self-rating	Comparison	3.20 (56)	3.32 (41)	p<.04
	Intervention	3.22 (64)	3.07 (50)	
Spousal rating	Comparison	2.11 (41)	2.05 (45)	ns
	Intervention	2.09 (51)	2.04 (54)	

Table 6. Commuter self evaluations of overall well being in past thirty days and mood during the commute, at home on a non-work day, and immediately before the commute home – higher scores represent improved well being/mood (number of subjects)

Measures	Group	Pre-intervention	Post-intervention	Significance
Well being	Comparison (did not change commute)	3.34 (56)	3.20 (49)	ns
	Intervention (switched to Montclair Connection)	3.18 (64)	3.16 (41)	
Mood during commute	Comparison (did not change commute)	2.88 (55)	2.91 (56)	p<.10
	Intervention (switched to Montclair Connection)	2.88 (64)	2.90 (60)	
Mood prior to commute home	Comparison (did not change commute)	2.24 (55)	2.32 (56)	p<.07
	Intervention (switched to Montclair Connection)	2.33 (64)	2.47 (60)	
Mood on non-work day	Comparison (did not change commute)	2.62 (55)	2.61 (56)	ns
	Intervention (switched to Montclair Connection)	2.73 (64)	2.76 (60)	

Table 7. Job strain (demands-control) post-intervention among female commuters with children at home and other commuters higher scores represent increased strain. (number of subjects)

Score on job-strain index (number of subjects)	Post-intervention		Significance
	Females with Children	Other Commuters	
Comparison	1.56 (11)	1.24 (53)	p<.05
Intervention	.67 (10)	.93 (56)	

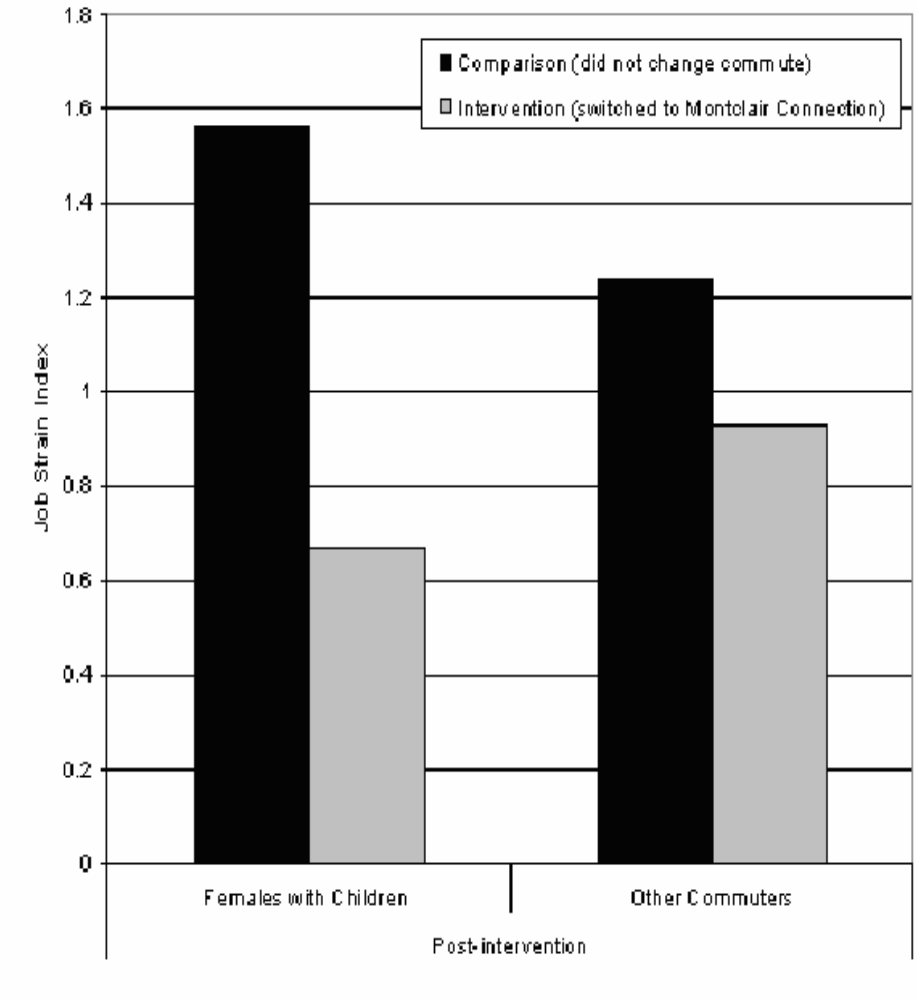

Figure 5 Job Strain - Women with children at home vs. all others

As can be seen in Table 5, spousal evaluations of stress in the commuter while at home were equivalent both pre- and post-intervention. We also evaluated whether gender and child-at-home status interacted with any of the perceived stress measures; it did not. Regardless of gender or whether children lived at home, the intervention significantly reduced self-reported stress but had no impact on spousal ratings of stress in the commuter.

Well Being

Overall self reported well being in the past thirty days as well as mood during the commute, after work just before the commute home, and on a non-work day were assessed pre- and post-intervention. Well being was equivalent before and after the commute (see Table 6). Mood during the commute was marginally higher for those affected by the intervention, $b= -.14$ ($SE=.11$), $p < .10$, as was mood after work prior to the commute home, $b= -.18$ ($SE=.12$), $p < .07$. Mood at home on a non-work day was unaffected by the intervention. These analyses included gender as a statistical control

Job strain

Because of our interest in whether the adverse impacts of commuting spilled over into both the home and the work setting, we also evaluated job stress with a standardized job strain scale. Higher scores indicate greater job strain. There were significant effects of the intervention on job strain, $F(1,118)=6.84$, $p<.01$. Moreover, these main effects were accentuated among female commuters with children at home. This subgroup reaped significantly greater benefits from the intervention. $F (1, 116)=2.96$, $p< .05$. These results are shown in Table 7 and Figure 5.

There were no main or interactive effects between the various groups of commuters prior to the intervention.

Underlying Mechanisms

The study examined whether four different, underlying processes might help account for the apparent salutary impacts of the intervention. These processes were passengers' perceptions of controllability of the commute, predictability of the commute and the degree of effort to commute. The study also examined the actual amount of time the commute took. For each of the prior, significant main and interactive effects of the intervention as discussed above, the analyses were repeated, covarying from the regression equation one of the hypothetical mediators. The four mediators are shown in Table 8 along with their significance in relation to the intervention. From this Table it can be seen that all of the mediators, except perceived controllability of the commute are viable prospects, since each is significantly affected by the intervention. None of these hypothetical mediators differed prior to the intervention between the two respective commuter groups, except for commuting time which was also significantly less in the Comparison Group, $b=9.44$ ($SE=4.71$), $p< .05$.

None of these hypothetical, underlying processes mediated the significant effects of the intervention on cortisol, motivation performance, perceived commuter stress or job strain. All of these significant outcomes of the intervention remained statistically significant after removing the covariation between the hypothetical mediator and both the intervention and the outcome variable of interest.

Table 8. Hypothetical mediating mechanisms in relation to comparison and Intervention Groups at post- intervention (number of subjects).

Measures	Group	Pre-intervention	Post-intervention	b for post-intervention[1]
Controllability of commute	Comparison	3.40 (56)	3.60 (50)	.10 ns
	Intervention	3.36 (64)	3.47 (41)	
Predictability of commute	Comparison	2.13 (56)	2.21 (50)	-.23*
	Intervention	2.18 (54)	2.44 (41)	
Effort on commute	Comparison	3.06 (56)	3.12 (50)	-.27*
	Intervention	3.24 (54)	3.38 (41)	
Duration of commute (min)	Comparison	88.48 (56)	89.43 (56)	11.25*
	Intervention	79.05 (64)	78.17 (63)	

*p < .05

[1] + or – refers to direction of slope

DISCUSSION

The primary objective of this study was to increase our understanding of the degree of stress experienced by mass transit commuters and the impact of that stressful experience on commuters' lives, psychologically and psychophysiologically, at work and at home. The study also sought to better understand the individual and trip factors and conditions that can serve to increase or ameliorate stress from the trip.

This study serves as a replication of our earlier research on commuting and stress. It also extended that work, particularly by investigating the impacts of commuting stress on populations of particular interest, such as women with children, and by assessing important outcomes not previously studied, such as job spillover.

The hypotheses tested in this study were:
Hypothesis I - The results of the first study will be replicated. Commuters using the new easy-transfer, faster route will show reduced stress when compared to their previous commute and to others who continue using the previous route.

Hypothesis II - These salutary effects will be caused by one or more of several factors: a. reduced time of travel; b. enhanced perceived control/predictability over the commute.

Hypothesis III - Significant spillover effects of greater commuting stress on the home (spouse and children) and work (job satisfaction, absenteeism, supervisor ratings) was expected.

Hypothesis IV - Gender differences were expected. It was also expected that women will show more commuting stress overall than men and benefit more from commuting system improvements. The one exception to this is expected to be physiological stress (cortisol) where we expect to see the opposite gender pattern.

Like the previous research, this study had several important methodological advantages over most previous work. First, it capitalized on a natural experiment afforded by the

construction of a major transit infrastructure improvement, the Montclair Direct line. Historically the transit industry and research community have focused such infrastructure improvements on hard endpoint measures such as commuting time, passenger volume and more recently potential impacts on environmental quality. Our work, completed with the support and cooperation of the New Jersey Department of Transportation, New Jersey Transit, and, the University Transportation Research Center, serves as an important reminder that transportation systems are about moving people, not vehicles. The human beings who use transit systems and highways, are affected physically and psychologically by commuting. The research shows that these effects are not transitory, and carry over into home life and to the work setting.

A second important advantage of the present study is the use of a within subject design with measurements taken over two time periods. By examining the same person before and after the inauguration of the Montclair Direct line, the study overcame concerns that the effects of different commuting environments are confounded with individual differences among users and non-users.

Moreover having a well-matched Comparison Group increases confidence that the pre and post-intervention results are not attributable to external events coincident with the passage of time. Even without random assignment of subjects to conditions, it appears that people who were in the Intervention Group were, for all intents and purposes, essentially from the same population as were people in the Comparison Group, before the intervention. There were no differences between subjects retrospectively assigned to these two groups on demographic variables or on our dependent measures. The only important difference that could be identified between groups was that those in what turned out to be the Intervention Group voluntarily chose to switch their commute to the new route directly into Penn Station, NY, while the others (retrospectively designated the Comparison Group) chose to maintain their earlier route. These were, then, the same people from the same towns with the same range of jobs and income and the same commute. They are distinguished by the fact that one subset of subjects chose, largely because of the location in New York City of their place of work, to change to the

Montclair Direct service, while the other chose to remain with the Hoboken service, largely because they worked in lower Manhattan.

Therefore for multiple reasons, this study has been able to conduct a very rigorous, natural experiment that maintains a degree of precision and accuracy typically available only in a laboratory, while studying an important environment in situ.

Secondly, this study used a multi-method approach, employing self-report and significant other-report data, objective indices of commuting conditions, behavioral measures, and psychophysiological measures of stress. This made it possible to look at the full spectrum of possible effects of commuting and changes in the commute on stress. Correspondence among multiple measures provides a level of convergent validity that is not possible with more limited measurement. In addition, cortisol, as a basic marker of the hypothalamic-pituitary neuroendocrine response system, is a known biological mechanism linking environmental exposure to stressors to physical morbidity.

Assessment of Hypotheses

Hypothesis I was supported by results in several, though not all, of our dependent measures. The Intervention Group and Comparison Group showed no difference in the pre period but only the Intervention Group showed a marginally significant decline in stress on psychophysiological measures. Commute-related elevations in cortisol (on the train minus day at rest, at home) are smaller for those able to take advantage of the new Montclair Direct line relative to their commuting counterparts who continue to ride to New York City by their previous routes through the PATH station at Hoboken.

The same patterns held for self-report measures of stress. There was no difference between groups in the in pre-change assessment of stress, but stress was significantly reduced ($p<.05$) for the Intervention Group at the time of the post-change assessment. The study also found a similar effect on the well being scales and for job strain measures - there were no differences between groups during the pre-change period and but significant improvement only for the Intervention Group at the time of post change measurement. Similarly, on our measure of well being scale, there were no

differences between groups during the pre-change period or post-change when the scale was completed at the end of the work day, before the commute home. When the scale was completed at the end of the morning trip to work, post-change, however, there was a significantly improved mood for the Intervention Group.

There was not support for Hypothesis II in the data for predicted impacts of any of the anticipated mediators of commuting stress. Neither total time of trip, control, predictability or trip effort significantly reduced or eliminated the effects of the intervention when entered into the regression analyses as covariates. As discussed below, lack of natural variability in these hypothetical, underlying explanatory variables may account for these null findings.

Hypotheses III predicted home and office spillover effects. We did not find any significant main or interaction effects on our measure of home spillover - the spousal ratings. We did, however, find a significant main effect for our measure of job strain. Those commuters who were in the Intervention Group had a significantly reduced level of job strain after the implementation of the Montclair Direct line.

The job strain results are potentially very important for two reasons: 1) for the first time there is a documented, adverse impact of commuting conditions on the work setting. People who have more stressful commutes have more job strain at work; 2) the measure of job strain incorporated in the research has undergone extensive development and testing. It has well documented concurrent and prospective relationships to health and job satisfaction, across a wide range of jobs.

Hypothesis IV was supported by results on two variables, but only for a special vulnerable sub-group of women. On both the motivation score (proofreading) and the job strain scale women who had children at home were especially sensitive to, and helped by, the intervention. This effect appears to be particular to women who are in this life situation and not simply a function of having children at home. No such effect for men who had children at home was found. One possible explanation is that working women with children at home effectively have jobs at both ends of the commute. For

others (men and women without children at home) the benefits seem to be more in terms of reduced stress at work than at home. They may be more concerned about getting to work on time, and a better morning commute may leave them more relaxed at work because of it. They may be less concerned about the evening commute. However, women commuters with children at home have pressures at the home end of the commuting trip in the evening, so they may feel the benefit of the intervention both ways. The data, however, did not support the prediction that males would reflect significantly greater physiological stress reactivity to the commuting experience.

CONCLUSIONS

These results, then, support prior research findings on commuting stress. The primary research results from our previous study [2, 21] were replicated in demonstrating that infrastructure improvements which change the nature of the commutes (that is eliminate transfers, reduced the time of trip) reduce commuter stress, as multiply measured, when compared to a comparison group who were tested at the same time and who continue to take their normal route.

The data also support findings [22, 23] that commuting affects psychophysiological functions. Given the connections that have been demonstrated in the literature between stress and cardiovascular health, it is not unreasonable to suggest that significant long term improvements in commuting of the sort demonstrated here can have important and beneficial health consequences [24, 25].

The data also support and extend previous work in indicating that stressors from outside the work situation, in this case commuting, can have an impact on stress at work [10]. Finally, the data support and extend previous findings [7, 18, 19] that women, particularly those with an extra load outside of the workplace (young children in the home) may be particularly vulnerable to stress from other sources such as commuting, and might particularly benefit from improvements in the commuting situation.

Limitations and Future Research Priorities

Is important to note that this study, as is the case often in field research, was not unaffected by the important events of our day. In particular, the study was impacted by the attacks of September 11, 2001. As commuters in New York settled back into something approximating their normal routines in the months after Sept. 11th, many who had previously taking trains to Hoboken and from Hoboken to the World Trade Center had to involuntarily alter their trip. Some, for instance, became regular riders of the ferry service from Hoboken to New York City. Others took the PATH trains on the 33rd Street line. Still others may have changed to buses are cars. It was much more difficult to recruit commuters who traveled through Hoboken to downtown New York - those most likely to be in the comparison group - then it was in 1995 when the previous study was conducted. Other impacts of September 11th, such as continuing and residual levels of stress felt by those who traveled regularly to New York City were undoubtedly real but beyond the scope of this study to assess.

We also found it difficult to recruit subjects with sufficient variability of experience on several key factors to allow assessments of the impact of these variables. In particular the range of the number of modes taken in the trip to work was very small - in most cases either three or four. Perceived controllability and predictability of the commute also indicated a lack of variability across commuters. Use of a homogeneous travel corridor (one line) undoubtedly contributed to the truncated variance in potential, underlying explanatory processes to account for the salutary effects of the infrastructure improvements.

Also, although we succeeded in obtaining an even split of male and female subjects, we had only a very small sample of single parents. This is potentially relevant because of the results as suggested that women with children were particularly affected by the improvements in the commute.

Another limiting factor that should be noted is that the intervention itself, though structurally identical to the past change that was studied, was for some of our subjects actually a smaller improvement in service for most commuters than was the Midtown

Direct. The Midtown Direct service provided direct access to Penn Station and midtown New York for the first time. Montclair riders from some stations (between Denville and Walnut St.) were also able to access the Midtown Direct service by transferring at Newark-Broad Street Station. This was an easy transfer - the rider simply disembarked and waited on the same platform for the next Penn Station train to arrive. Schedules were coordinated by NJT so that these waits, in rush hour, were usually brief. The advantages for these Montclair Direct riders to using the new service were real - they were more likely to get a seat than they were getting on the train at Broad Street, the last stop before Manhattan; and they had a one seat, no transfer trip. It was, however, not as dramatic a change as that for Midtown riders.

This difference in level of the intervention for some riders was both a disadvantage and an advantage for this study. The disadvantage was that the less intense improvement in the commute probably made it more difficult for the study to uncover significant effects. With a larger intervention we might have seen effects across more measures and had a chance to observe the mediating effects of other variables. The advantage is that this study, along with the past study, gives us a chance to see the impact the various levels of the independent variable - the improvement in the commute. Like a drug dosage study, it helps us learn the effect of different levels of interventions. In this case it demonstrated that even a smaller scale of improvement in the commute had significant and important psychological and psychophysiological benefits for the commuter.

All this suggests interesting directions for future research. Spillover effects of the commute to both home and work are potentially important and deserve further and more detailed inspection. More detailed analyses at work might incorporate measurement of physiological stress at arrival at work and during the day, evaluations of worker emotional affect and performance by self and coworkers during the day. Archival indices of physical health as well as productivity are also of potential interest. Among families with children, it might be illuminating to examine childrens' perceptions of the commuter's interpersonal relations with the family plus examine outcomes such as fatigue or irritability.

Similarly, it is important to study in greater detail the manner and degree to which commuting stress affects particularly vulnerable populations. In this study the group identified as most affected was working women with children at home, but potential other groups include single working parents of both genders and people of lesser financial means. Lastly, there is a need to study populations with a wider range of experience in the number of modes and level of effort taken in their commute so that the impact of these variables can be properly assessed.

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APPENDIX 1

LITERATURE REVIEW

Human Health and Behavioral Consequences of Commuting

There are a small number of studies of commuting and human health and well being. Most of the research has focused on what characteristics of commuting, particularly traffic congestion, influence human well being. A few studies have also examined commuting mode and the number of stages or mode transfers as potentially critical factors in the commuting experience. Following a review of these studies, problems with this literature and the need for greater conceptual clarity in building a model of what makes commuting stressful are presented in greater detail.

Several studies have demonstrated that commuting by car [26-29] and by train [22] elevates psychophysiological parameters like blood pressure and neuroendocrine processes (e.g., epinephrine, cortisol) indicative of stress relative to resting baseline comparison. Several studies also show that operating a bus in an urban setting elevates both cardiovascular and neuroendocrine markers of stress [30].

These markers of psychophysiological stress are important for at least two reasons. First, they provide objective evidence that the commuting experience is stressful. Second, these psychophysiological measures have been directly implicated in the development of cardiovascular disease and in suppressed immune functioning [24, 31]. The potential links between commuting conditions and morbidity are also shown by work indicating that psychophysiological reactivity to driving is accentuated among those with prior cardiovascular vulnerability (e.g., angina patients) [32]. The psychophysiological data on driving are complemented by extensive epidemiological work showing elevated risk for cardiovascular morbidity among bus drivers [30, 33].

While these studies and others like them [see 10, 34 for reviews] clearly show that commuting, whether by train or car, elevates cardiovascular and neuroendocrine parameters, they beg the question of what factors in the commuting experience explain its harmful effects.

Most attention has been paid to traffic congestion as the primary causal factor leading to elevated stress from commuting. Unfortunately although the data are clearly supportive of this hypothetical explanation, all of the field studies completed to date are weak cross sectional designs, comparing individuals commuting to work under variable levels of congestion. Furthermore, all are limited to auto commuters. Several studies have shown correlations between levels of traffic congestion and elevated blood pressure *(35-37)* among automobile commuters. Evans and Carrere [23] found elevated blood pressure and neuroendocrine hormones (catecholamines) among urban bus drivers as a function of traffic congestion.

One very important exception to the above cross sectional studies is an experiment in which the same person drove different road stretches for short time periods. The road stretches varied both in traffic volume levels and in number of intersecting roads. Both of these factors elevated skin conductance, a marker of psychophysiological stress [38]. This is the only longitudinal investigation of commuting stress and as such counters criticisms that the prior field investigations suffer from confounding variables. In particular, a plausible confounding variable is self-selection (that is, differences in outcome could be the result of systematic differences of who chose different routes to work).

Both Knox [39] and Novaco and colleagues [40] showed that traffic congestion is also related to absenteeism at work. Furthermore, Koslowsky et al [41] have linked traffic congestion during the work commute to job satisfaction. Greater congestion is also associated with more negative emotions, including feelings of irritation, frustration, anxiety, and general annoyance [23, 35, 37, 42, 43] and reduced job satisfaction [41] and residential satisfaction, particularly for women [7].

Several investigators reasoned that since commuting is stressful, adverse effects might also be manifested immediately following the commute in tasks known to measure motivation or persistence. Measures of stressor aftereffects have long been employed in the psychological stress literature [5] and are believed to index deficits in motivation

or helplessness, following exposure to a negative, uncontrollable event [44]. Commuting whether by car or by bus increases behavioral aftereffects [29] relative to individuals not commuting in a true experiment in which college students were randomly assigned to either drive, take a bus, or relax indoors. Greater traffic congestion has been associated with decreased task motivation following exposure by [35-37].

Because commuting by mass transit frequently exposes people to crowding, Lundberg investigated what role crowding on passenger trains might have in influencing the stressfulness of the commute experience. Similar to laboratory and field studies of crowding (see *45 for a review)* the higher the level of density on the train, the greater the levels of both perceived stress and neuroendocrine indicators [46]. Singer et al. [22] replicated these effects.

Another manifestation of stress associated with commuting may be hostility and aggressive behavior, more recently dubbed "road rage" in the popular media. Possible linkages between aggressive behavior and driving are not new having been documented over at least a forty year period by scholars (see *47 for a fascinating overview of this topic)*. There is solid scientific evidence that exposure to physical stressors such as noise, crowding, pollution, and moderate elevations in temperature can potentiate aggressive behaviors when people are already angry. For example exposure to violent stimuli or personal provocations that increase feelings of hostility and aggression lead to greater overt aggressive acts if they occur in noise versus quiet [48, 49].

Estimates on the prevalence of road rage vary widely but there is consensus that the phenomenon is increasing over time within the U.S. [50]. There is evidence that road rage is related to frustration, anger, and time pressure created by traffic congestion and long commutes [51-54]. There is also evidence that more aggressive driving is a contributor to traffic accidents [55, 56].

Aggressive drivers also drive faster, commit more errors, and execute more high risk overtakes in a driving simulator compared to non aggressive drivers [56]. More aggressive drivers also tend to see other drivers as hostile and cope in a more

confrontational manner when driving [56]. Interestingly these traits only manifested under congested driving conditions. When driving on a simulated open road, aggressive and nonaggressive drivers behaved similarly. Evans and colleagues in a multimethodological study of Type A and Type B male bus drivers found that Type A individuals who are characterized among other things as high in hostility and time urgency drove more aggressively in India but not the United States [57].

Some insight into road rage can be derived from the application of theory and research on aggression which is a well developed topic in social and clinical psychology. Frustration produced by long, tedious driving conditions, particularly on congested roadways causes irritability and other negative emotional feelings. Another important contributor to roadway aggression may be the anonymity of driving conditions, particularly in larger metropolitan areas [47].

Although the topic of driving conditions and altruism has not been explored, it is also worth noting that several other environmental stressors including noise, crowding, heat, and pollution depress helping behaviors [49, 58].

Differences among Modes of Transport

Another characteristic of commuting that may impact its stressfulness is mode of transport. Two studies have compared car pooling to solo driving, finding that driving a car pool leads to the greatest level of stress, comparing solo drivers, car pool passengers, and car pool drivers [59]. Car pool passengers also experience somewhat greater stress than car pool drivers [36]. Taylor and Pocock [60] found greater levels of absenteeism among car drivers relative to users of mass transportation in London. Both number of days as well as the number of absence spells were greater among car drivers.

Unfortunately, the results on mode of transport are difficult to interpret since people usually choose transport mode. It is difficult to disentangle individual characteristics from mode of transport. White and Rotton [29] addressed this difficulty by randomly assigning college students to drive 45 minutes in their car, ride the same route by bus,

or to rest quietly while reading in the laboratory. Behavioral aftereffects were greater among the two driving groups relative to the resting comparison group but only car driving elevated physiological stress. Riding on a bus showed similar physiological profiles to those in the resting comparison groups. The bus commuter physiological data differ from earlier work showing that train commuting can elevate physiological stress among passengers *(22, 46)*. At least two possible explanations for this difference are possible.

One, *(22)* showed that people who embarked early on the train who had a choice of where to sit, manifested little physiological stress reactivity to commuting. All of White and Rotton's [29] subjects had a seat on the bus. Two, the passenger train studies were not simulations and thus indexed people who were regularly commuting whereas the White and Rotton study was a simulation with college student participants.

The artificiality of the commute may have weakened the physiological impacts of commuting. Given the critical role of psychological variables in stress responses (e.g., perceived threat or challenge, uncontrollability), the artificiality of the simulation may have played been an important role.

A final factor that may contribute to the stressfulness of commuting, particularly mass transportation, is the number of stages of the commute. A stage is defined as any change in the mode of transportation or having to move from one vehicle to another even if within the same mode (e.g., changing trains). Walking for some minimum period (e.g., five minutes in one study) is also considered a stage.

In the most extensive investigation of this topic, Taylor and Pocock [60] examined a large number of office workers in the same London firm. Absenteeism from work was significantly correlated to the number of commuting stages. Those with more than two stages had increased health risk. The average number of stages among this one group of London commuters was 2.84 stages. Similarly, car drivers who had to make more road changes or who used a larger number of highways, had greater absenteeism at work [40].

Perceived Stress and Control

Underlying explanations of commuting impacts have focused on the concepts of perceived stress and control. Novaco and colleagues have shown that objective traffic congestion significantly overlaps but is not isomorphic with perceived traffic congestion; that subjective traffic congestion and objective traffic congestion have varying effects on stress outcomes; and that some of the effects of objective levels of traffic congestion on symptoms are mediated (i.e., explained) by perceived traffic congestion [7, 40, 41]. Koslowsky and Krausz [41] found similar effects, utilizing a different measure of perceived congestion and job satisfaction as the outcome variable. These findings while interesting are limited to self-report measures which is a major shortcoming in the test of the model.

Singer et al. [22] in their study of train commuters found that the longer someone was on the passenger train in the morning commute, the less their stress levels. This paradoxical finding actually makes sense when one considers that the earlier the passenger gets on the train going to work, the greater the degree of choice s/he has about where to sit. More direct evidence for the role of control comes from studies showing that persons with greater levels of residential choice were less negatively impacted by traffic congestion [37] and that individuals with expectations that they can control their environment (internal locus of control) were less negatively impacted by traffic congestion on their daily commute [35, 61]. Evans et al. [61] found that Type A bus drivers perceived their jobs as more stressful, and were observed while driving to manifest more overt, behavioral indices of stress. Type A personality includes hostility, time urgency, and high needs for environmental control.

These authors reasoned that the apparently greater vulnerability to occupational stress among Type A compared to Type B drivers was likely a result of greater frustration from dealing with the largely uncontrollable workload demands and low decision latitude (i.e., high job strain) that well characterizes urban bus driving. Schaeffer et al [36] also

interpreted their finding that congestion had more negative physiological impacts on car poolers than drivers in terms of controllability of the commuting experience. The person who could control the commute was less negatively impacted than the one who could not. Finally, Kluger [9] found a significant interaction of commute predictability and perceived traffic congestion on psychosomatic symptoms. Those with more predictability in their commute (e.g., less variance in daily commute time) were less symptomatic when under heavy congestion than those in unpredictable, congested conditions.

In the above studies, control operates as a moderator, an exogenous factor that alters or moderates the relationship between commuting stress and some outcome measure. Residential choice [37], greater seat selection [22], and more predictability in the commute [9] were each shown to significantly buffer the adverse impacts of commuting. Although these findings suggest that control is an important component of the commuting stress process, they do not directly show that control is an underlying mechanism that explains why commuting stress causes psychophysiological stress or diminished well being. Looking at this issue specifically, Evans and Carrere [23] found that higher traffic congestion directly related to less control. Moreover, when they examined the previously significant relationship between traffic congestion and neuroendocrine elevations on the job, statistically partialling perceived control significantly attenuated the congestion-health link, especially in the case of norepinephrine.

Wener et al. [2] demonstrated a reduction in commuting stress as a function of an improved mass transit route, and showed convergence among psychophysiological data (salivary cortisol), motivation measures (proof reading); rider self-report scales, and (marginally) home spillover ratings (spousal assessments). Stress was reduced among riders of this new route as compared with pre-change data and compared with contemporaneous data from riders who maintained use of the old route. Time of trip was the only significant mediator variable. Predictability was significantly and inversely correlated with stress [21] but there was little variability of predictability ratings between the original and modified passenger train commuting conditions, precluding an adequate test of its explanatory power. In other words, although predictability of the

commute as perceived by the commuters significantly predicted stress outcomes, the reduction in commuter stress caused by improved mass transit services could not be explained by changes in perceived predictability.

Another potential mechanism for explaining commuter stress is effort. Although prior studies have not examined this variable, a parsimonious explanation of the commuting stages effects could simply be effort expenditure. It takes more effort, physical and cognitive, to change trains, park and ride, take a train and then walk several blocks, than it does for example to get in one's car and drive to a lot or take a train directly to work. Several studies of noise and crowding [(62)] have shown that effort expenditure during exposure to these stressors, potentiates the adverse effects of the stressor, particularly on psychophysiological outcomes.

There may be underlying psychophysiological mechanisms related to effort for explaining commuting effects. Individual differences in circadian rhythms moderate perceived stress among automobile commuters. Persons commuting in the morning experience greater stress levels if their alertness levels peak in the evening compared to those who are more alert in the morning [(63)]. There is also evidence that persons who are more neurotic experience elevated stress when commuting relative to their more well-adjusted counterparts [(56, 63)].

Spillover Effects

Spillover refers to the conditions in one life sphere influencing well being in another setting. For example stressful working conditions can elevate fatigue as well as negative interpersonal relationships between spouses and between parents and their children [(18)]. The fact that commuting is rated as less stressful among workers on flex time schedules compared to fixed hours [(64)] is also consistent with the interpretation that one of the negative impacts of commuting stress may be manifested in home life interferences. Not only did flex time workers feel less stress from commuting, this relationship was largely mediated by reduced time pressure.

Novaco and colleagues in two sets of studies [8, 47] found the more stressful driving conditions spilled over into home life creating more negative mood at home in the evening. The latter study indicated that the negative spillover from congested commuting to home appeared somewhat stronger among women than men. Both Novaco et al. [7] and Wener et al. [2] in their respective studies of car and train commuters failed to find differences in perceived levels of conflict at home. Scale floor effects and lack of statistical power, however, may partially account for these nonsignificant results.

Moderators of Commuting Stress

In addition to attempts to understand potential underlying explanations or mechanisms to account for why commuting can be stressful and lead to adverse health and behavioral outcomes, scholars have also begun to investigate factors that might alter individual vulnerability to the stress associated with commuting. In other words, instead of asking why or how does commuting negatively impact people, research on moderators of commuting stress asks a different question: Are there individual differences in susceptibility to the adverse impacts of commuting? The two variables that have examined the most scrutiny to date are gender and coping processes.

Gender .

In addition to examining potential, underlying psychological processes such as perceived commuting stress or control, a small amount of attention has been directed at gender differences in reactions to commuting. For both objective and subjective reasons, women may experience greater psychological stress than men when commuting. However women's psychophysiological reactivity to commuting may be more muted than men's.

Psychophysiological reactivity to acute stressors generally shows that men respond with greater levels on various measures but careful analyses of this consistent pattern

indicates that it is limited to achievement situations [65]. In fact, when men and women are put in a stressful situation that is more aligned with traditional sex roles (taking a child to the hospital), women showed greater physiological reactivity [66].

Research on commuting stress and gender has not carefully examined psychophysiological responses but occupational stress research indicates that after work, at home in the evening women employed outside the home take much longer to return to resting baseline levels of neuroendocrine [19] and cardiovascular functioning [20] in comparison to employed men. These results have been interpreted in light of research suggesting that employed women have higher total workloads than employed men because of their greater proclivity to have to fulfill multiple roles vis a vis domestic, family, and work responsibilities [18]. Women are also believed to have much greater fluidity between work and home, whereas males as the principal breadwinner are traditionally protected from many domestic demands.

Novaco et al. [47] uncovered greater commuting stress in employed women compared to employed men. Women in more congested commutes perceived their commute as more stressful than men on the same routes. Overall women also felt much more rushed to get to work on time, were less satisfied with their commuting experiences, perceived less choice in route selection and felt they had more traffic to contend with vis a vis men. Commuting also had more negative impacts on women than on men. Greater congestion had a stronger impact on women's psychological distress levels, their desires to change residential location and marginally impacted negative mood after work and residential satisfaction. Novaco and colleagues did not collect any physiological data. Wener et al. [2] did not find significant differences between genders on any measures in their evaluation of alterations in train commuting infrastructure, although their small sample made it difficult to do an adequate test on this variable.

Coping

Obviously one potential reason why individuals may vary in their stress responses to different driving conditions is because of differences in how they cope with the environmental demands related to driving. This perspective has not received much

attention to date in work on commuter stress. Koslowsky et al. [10] in their book on commuting stress devote two chapters to individual and organizational strategies for coping with commuting. Interestingly, no data are presented in either chapter which are focused on suggestions for how to make commuting less stressful by drawing upon lessons learned from other arenas of coping and stress research. Matthews in a series of studies [summarized in 56] has developed a set of scales to assess individual differences in perceived stress from driving as well as driver coping strategies. Car drivers who dislike driving, perceiving the experience as more anxiety provoking and worrisome, tend to cope by focusing on their negative emotions ("Criticized myself for not driving better"). These drivers experience greater stress and make more errors compared to others while driving especially when demands are low.

Under high demands the subset of drivers who rely principally on emotion focused coping appear to rise to the occasion, performing equally to others who do not rely on emotion focused coping strategies. Other drivers who cope more by becoming task oriented ("Made an extra effort to drive safely") deal significantly better with driving conditions under low task load than those who dislike driving. Interestingly, task oriented drivers also perform similarly under high and low driving demand conditions. As noted above in our discussion of aggressive driving behavior, Matthews [56] has also found that drivers who perceive other drivers as more aggressive and annoying tend to be more susceptible to aggressive driving, especially under more congested driving conditions.

In a fascinating study of auto commuters and traffic congestion effects of perceived stress, Hennessy and Wiesenthal [52] used cell phones to collect data while people were driving under high or low traffic congestion conditions. In addition to the expected main effect of traffic congestion on self reported stress, these investigators found an interaction between traffic congestion and trait driver stress. The subset of commuters who tend to be more vulnerable to driving stress (e.g., "I get annoyed by driving behind another vehicle") reacted more with greater perceived stress to high traffic congestion.

Coping with occupational stress associated with professional driving has been examined as well. Kuhlmann [67] reported that professional drivers (bus and tram) who coped with job stressors by resignation and submission reported greater levels of job stress, experienced more psychosomatic symptoms, and felt more exhausted and took longer to unwind after the work day. Winkleby et al. [68] uncovered an increased association between job strain levels and hypertension. Bartone [69] compared urban bus drivers with high job stress who did or did not have significant levels of physical illness. Three individual factors emerged as significant buffers of the job stress-illness link: regressive coping style (denial and avoidance), familial history of chronic illness, and low hardiness. Hardiness subsumes appraisals of commitment, challenge, and control over the work environment. Meijman and his colleagues [70] in a program of research have identified how bus drivers cope with time urgency as a key element in their reactions to driving conditions. Individuals who prioritize adherence to the schedule over traffic safety and relationships with passengers suffer greater negative affect and psychophysiological stress responses.

Methodological and Conceptual Issues

Research on naturalistic stressors such as commuting conditions always faces difficult methodological challenges. The biggest issue is separating out environmental factors, in the present case commuting characteristics, from individual variables that may covary with them. Car commuters or professional drivers may select into certain driving conditions. For example perhaps more neurotic or anxious drivers wind up with more arduous commuting conditions. The best way to handle this problem is generally not practical, randomly assign individuals to different commuting conditions. However driving simulation studies both in the laboratory [56] and in the field [2] are possible and at least in these two cases largely replicated prior field work.

Another approach to the selection bias issue is to take advantage of natural experiments wherein a group of drivers are monitored before and after major changes in commuting infrastructure. Research by Rydstedt, Johansson and Evans in Stockholm illustrates this approach with urban bus drivers. They evaluated changes in driving conditions created by alterations in traffic flow, passenger delivery, and information

systems [71]. Wener and colleagues took advantage of a natural experiment afforded by the re-design of major passenger commuting lines from suburban areas into Manhattan in New York City. In each instance, changes in commuting conditions were related to changes in pre to post-intervention measures of stress and well being. At the same time, well matched comparison groups remained relatively stable over the same time period in the stress outcome measures.

An additional methodological strategy to improve the causal validity of real world stressor research is to incorporate assessments of theoretically meaningful, underlying explanations of differences in commuting conditions and stress. In other words, one can strengthen research designs by measuring changes in underlying psychosocial processes that may help explain how or why commuting characteristics influence human health and well being. Wener et al. [2] tested but failed to find support for their prediction that improved commuting predictability would explain the beneficial effects of improved, suburban passenger commuter routes into New York City. Instead, their analyses indicated that the duration of the commute appeared more important.

The use of theoretically meaningful mediator variables also ties into another important methodological limitation of commuter stress research - the general absence of theory. Too much of this research looks for a simple ecological linkages between an environmental condition and one or more health or behavioral outcomes. This approach neglects the potential reasons for why and how aspects of the commuting environment affect people. Better understanding of these intervening processes is valuable in at least two respects. One, it provides insight into possible intervention strategies when dramatic changes in the physical qualities of commuting are not possible. The fact that control over commuting conditions appears to be very important in accounting for adverse effects lends itself to intervention strategies related to choice, and better information for commuters. Two, as shown above, there are clearly individual differences in commuter responses to poor commuting conditions. Identification of vulnerable subgroups is useful in showing what subsets of commuters are susceptible to adverse driving conditions and by pointing towards potential explanations of why certain characteristics are stressful. For example, if it turns out to be correct that

mothers of young children suffer more from poor commuting conditions compared to other commuters, then investigation of issues like time urgency and workload pressures because of greater domestic responsibilities could help uncover why this subgroup of persons may be at greater risk and potentially lead toward effective amelioration strategies.

Another methodological and conceptual challenge in research on commuting and human response is the delineation of appropriate outcome measures. One of the key features of conceptualizing commuting conditions as a stressor has been the development of a wide array of stress-related outcome measures. The theoretical insight has greatly strengthened commuter and behavior research, moving it beyond over reliance on self report measures of satisfaction or negative affect. Conceptualizing commuting as a stressor also has policy importance since several of the stress indicators sensitive to commuting are early warning signs of more serious problems if left unchecked (e.g., elevated stress hormones and the development of coronary heart disease). Measures such as behavioral aftereffects in task motivation may also be more sensitive indicators of performance than more traditional but relatively insensitive indices such as job productivity. One important development in commuting research that remains unfulfilled is more long term monitoring of some of these types of outcome variables. Given the chronicity of commuting for many individuals, outcome measures need to be incorporated over longer periods of time. The measurement implications of spillover from commuting to other life realms remain underdeveloped as well. Fatigue, interpersonal relationships, exercise and other forms of physical activity, are prime candidates for additional research.

Summary

There is clear evidence that commuting conditions can cause psychological stress. The long-term health consequences of adverse commuting conditions is less well understood with suggestive evidence in the bus driver literature of adverse cardiovascular outcomes related to poor driving conditions (in particular high time pressure coupled with traffic congestion). Quicker, more direct transit service significantly reduces multimethodological indices of stress including physiology, task

performance, and negative affect. There are cross sectional data showing linkages between traffic congestion, crowdedness on trains, mode of commuting, and number of commuting stages with multiple indices of stress, and longitudinal research showing a link between time of trip and stress. Traffic congestion research indicates that with greater congestion when driving, cardiovascular and neuroendocrine parameters are elevated, negative affect is heightened, and motivation to persist in problem solving is diminished. Limited data on commuting mode suggests that when more than two stages or mode shifts occur when commuting, absenteeism at work increases.

Research is needed that examines more direct, sensitive indices of stress such as psychophysiological parameters or task persistence in relation to commuting mode characteristics. There is reasonable evidence that driving conditions contribute to aggressive driving. There appear to individual characteristics of drivers that heighten the risk of such behaviors. Another aspect of commuting stress warranting more scrutiny is spillover. Poor commuting conditions appear to generalize from the commuting experience itself into home life. Fatigue and negative interpersonal interactions at home appear to rise in relation to more adverse commuting conditions.

Research on underlying mechanisms to account for commuting stress suggests that perceived stress related to traffic congestion may mediate some of the associations uncovered between objective indices of traffic congestion and self reports of negative affect. Duration of commute could be a mediator of commuting stress. Both direct and indirect evidence point to a key role of perceived control in linking commuting to stress. Environmental or programmatic changes that enhance perceived control over the commute generally ameliorate negative impacts. More directly, congestion itself deteriorates perceived control which, in turn, accounts for some of its negative impacts.

Predictability of the commute, which can be construed as a form of cognitive control, also appears to play in role in commuting stress. Although not as well developed as the control mechanism, another mediator of commuting conditions on human health and well being may be effort. Some of the adverse consequences of commuting may reflect adaptive costs associated with efforts to cope.

Finally, commuting research has begun to focus on the joint contribution of commuting conditions and individual characteristics as they interact to produce stress. Gender and coping processes have received some attention. Women, particularly mothers of young children, may experience more psychological stress than men on comparable commutes. Psychophysiological stress in reaction to commuting, however, may be greater in men than women during the commute, given the tendency of men to physiological respond to acute, achievement-related challenges more dramatically than women. At present, insufficient data exist to support either of these theoretically cogent predictions. A few findings indicate that coping strategies for dealing with the strains of commuting can also have health and behavioral consequences. Several studies indicate more emotion focused strategies such as resignation appear counterproductive. Individual drivers who are more sensitive to scheduling issues, i.e., time urgent, appear more vulnerable to ill effects from difficult driving conditions.

APPENDIX 2
SURVEY INSTRUMENTS

BACKGROUND INFORMATION FORM

This form asks for basic background data of persons who have volunteered to be subjects in the **University Commuting Experience & Health Study.** We realize that some of these questions repeat items you have answered in the past, but ask your cooperation in completing the whole form during this phase of the study. All of the information collected in this scientific study is held strictly **CONFIDENTIAL.** Information will not be made available to anyone that could link a response or set of responses to any individual. The answers from this section are necessary to show that we have a representative sample of commuters.

1. **Name** _____

2. **Marital/living situation** *(check one)*
   ☐ living alone ☐ living with significant other

3. **Do you have children living at home?** ☐ YES ☐ NO
   If YES: How many children are living at home _____ children

4. **Your Education Level** (check highest level completed)

☐ some high school	☐ some college/AA	☐ advanced degree
☐ high school	☐ college (BA/BS)	
☐ technical school	☐ some graduate work	

5. **Occupational field** _____ **Job title** _____

6. **Check the category** that describes your gross **household income**.

☐ $15,000 - $25,000	☐ $45,001 - $55,000	☐ $75,001 - $85,000
☐ $25,001 - $35,000	☐ $55,001 - $65,000	☐ $85,001 - $95,000
☐ $35,001 - $45,000	☐ $65,001 - $75,000	☐ > $95,000

7. **Race/Ethnicity:** *(check one)*
   ☐ African-American ☐ Asian American ☐ Caucasian ☐ Latino/Chicano
   ☐ Native American ☐ Other (please describe)

8. How many hours do you **actually work** each week, including overtime? _____ hours/week

9. Do your have a **second paid job** in addition to your main one? *(check one)* ☐ YES ☐ NO

   If yes, how many hours do you work in the second job in an average week? _____ hours/week

10. On average, how **long does it take** you to from work? *To work* _____ *minutes* *From work* travel to & _____ *minutes*

11. On average **how many weekends** do you

have off *per 28 days*? _____ weekends

DESCRIPTION OF *TODAY'S COMMUTE*

For **each leg or segment** of your commute **to work *today*** indicate the **mode or way of travel** (such as car v. bus v. train v. walking) and the **time it took.**
Please remember that:

- **Walking *is* a mode** if you walk more than 50 feet (for example, walking to your car parked in your driveway *is not* a mode. Walking to the train station or a bus stop *is* a mode).

- Each train transfer represents a separate mode.

1. What time did you **leave home** today for your morning commute to work?
   __ __ : __ __ AM

2. How did you **travel today *to*** your local **NJ Transit train station** *(use all that apply).*
   "I…

…drove/parked a car at/near station."	approx time of trip	_____min
…was given a ride in a car to station."	approx time of trip	_____min
…rode in a car pool to station."	approx time of trip	_____min
…walked to station."	approx time of walk	_____min
…bicycled to station."	approx time of trip	_____min
...took a **bus** to station."	approx time of trip	_____min

Other or additional modes used to get to station_____

3. Morning NJ Transit **train to work**.
   Name of departing NJ Transit Station: _____

4. ***Scheduled* departure time** of your NJT train __ __ : __ __ □AM □PM this morning from your home station

5. ***Actual* departure time** of your NJT train __ __ : __ __ □AM □PM this morning from your home station

6. ***Scheduled* place and time of arrival** of this NJT train.

   Arrival station: (*Check one*) □ Hoboken station □ NY Penn Station

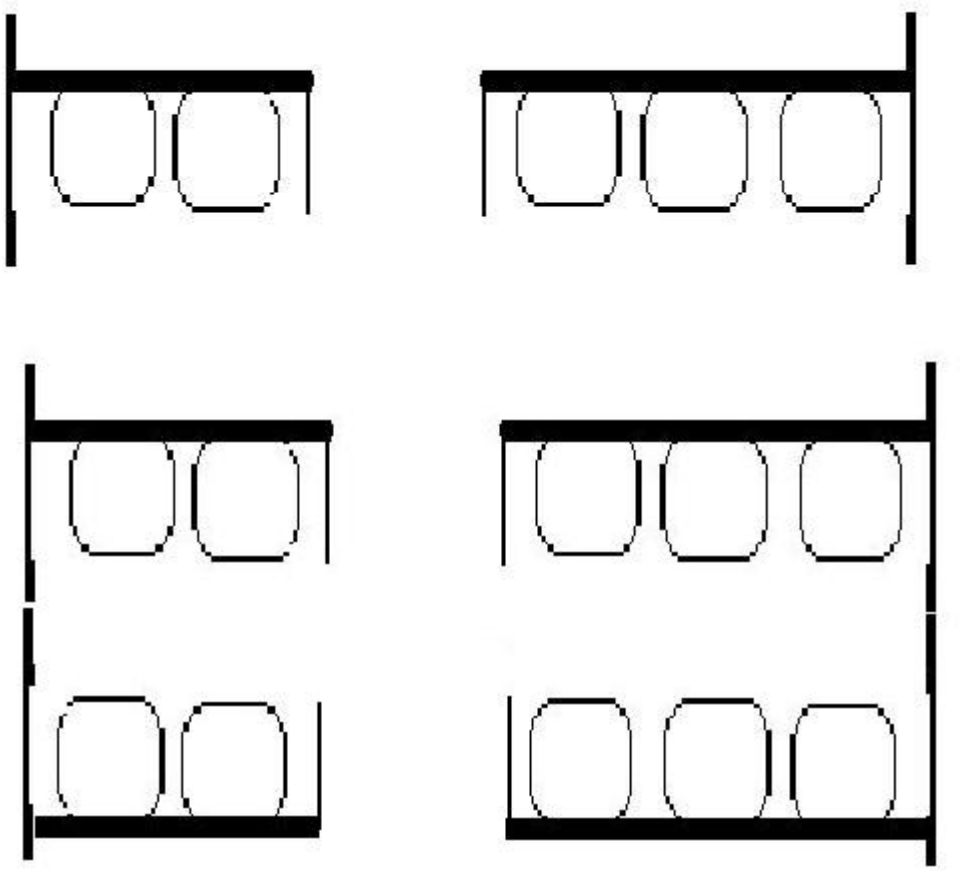
   Arrival time: __ __ : __ __ □AM □PM

7. Approximate **# seats** your train car **holds** _____ seats

8. Approximate **# seats available** when you got on _____ seats

9. Did you **get a seat**? □ YES □ NO

10. If **YES**, please indicate where you sat on the drawing below that most closely resembles your seating.
First…Mark the seat ***you were in*** with an ***"X"***
Second…Mark ***all other occupied seats*** in your row with an ***"O"***



11. **How crowded** is the NJ Transit train you are on? *(Circle one number below)*

Very Crowded (Standing room packed)	**Somewhat Crowded**	**Neither Crowded or Uncrowded**	**Somewhat Uncrowded**	**Very Uncrowded (Many available seats)**
1	2	3	4	5

ANSWER THE FOLLOWING QUESTIONS BASED ON YOUR ***TYPICAL*** EXPERIENCES COMMUTING

If you travel through Hoboken, answer questions 23 through 26...

From **NJ Transit's Hoboken Station** to NYC via **PATH**

12. How long do you **usually wait** for a PATH Train? _____ minutes

13. Do you usually **get a seat** on the PATH Train? *(check one)* □ YES □ NO

14. To **what station** do your you usually take the PATH train *(check one)*
    □ Christorpher St □ 9th St □ 14th St
    □ 23rd St □ 33rd St

15. What is your **typical total travel time** from **Hoboken to your PATH stop**? _____ minutes

==========

16. What is **the *next mode*** you usually take ***after arriving in New York City*** (via PATH or NJ Transit at NY Penn Station)? *(check one)*

□ I Walk my approximate walking time is… _____ minutes

□ I take subway my approximate travel time is... _____ minutes

□ I take bus my approximate travel time is… _____ minutes

□ Other (explain _____)

17. What is **the *next* mode** you usually take after that? *(check one)*

□ I walk my approximate walking time is… _____ minutes

□ I take subway my approximate travel time is... _____ minutes

□ I take bus my approximate travel time is… _____ minutes

□ Other (explain _____)

□ None – my trip is complete

30. If you take any additional modes or segments beyond those mentioned above, please describe them here.

31. Please tell us if **anything unusual** (stalls, delays, incidents, etc.) happened on your commute **today** that might have affected how your answered this questionnaire.

□ Nothing unusual happened today.

32. **How long** have you been **traveling the route** that you presently take to work?
Years___ Months ___

33. If you wanted to relocate to avoid a long commute or heavy traffic, how feasible would it be for you to: *(circle one number for each)*

a. change your place of residence

1	2	3	4	5	6	7
not at all feasible						quite feasible

b. change your place of work

1	2	3	4	5	6	7
not at all feasible						quite feasible

COMMUTING EXPERIENCE RATING FORM

As previously indicated all of the data you provide us is completely **CONFIDENTIAL** and **ANONYMOUS**. There are no 'correct' answers to any of these questions. What we care about is your honest evaluation. Thank you.

Please answer the following questions in terms of your ***trip to work***.

Please indicate your degree of agreement/disagreement with each of the following descriptions of your typical commute to work.

Please circle **one** answer for each question.

1. My commute to work is congested.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

2. When I am driving to work, I feel crowded.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

3. My commute to work is stop-and-go.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

4. The route I take to work is usually crowded.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

5. My ride to work is often cramped.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

6. I have plenty of room in the car when I commute to work.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

The following questions refer to your commute *to* work. We care about your opinion. There are no right or wrong answers.

Please circle **one** answer for each question.

7. Overall, commuting is stressful for me.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

8. I feel there is little or nothing I can do to control the way in which I commute to work.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

9. It takes a lot of effort to commute to work.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

10. I resent the length of my commute to work.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

11. My commute to work rarely varies from day to day.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

12. My commute to work is pretty easy.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

13. I can control how long it will take me to get to work.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

14. My commute affects my productivity on the job.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

15. My commute to work each day takes a lot of effort.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

16. Commuting to work is consistent on a day to day basis.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

17. I can choose what time I commute to work.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

18. My daily commute takes little effort.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

19. I resent the hassles by commute causes me.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

20. In my daily commute to work, I typically know how long it is going to take.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

21. There is essentially nothing I can do to affect my daily commuting experience.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

22. In general, I feel positive about my commute to work.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

23. My commute to work is unpredictable.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

24. I can usually predict what time I will get to work.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

25. Commuting to work takes effort.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

26. For the most part, I have no choice about how I commute to work.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

COMMUTING EXPERIENCE RATING FORM

As previously indicated all of the data you provide us is completely **CONFIDENTIAL** and **ANONYMOUS**. There are no 'correct' answers to any of these questions. What we care about is your honest evaluation. Thank you.

Please answer the following questions in terms of your ***trip to work***.

Please indicate your degree of agreement/disagreement with each of the following descriptions of your typical commute to work.

Please circle **one** answer for each question.

1. My commute to work is congested.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

2. When I am on the train, I feel crowded.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

3. My commute to work is stop-and-go.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

4. The train I commute on is usually crowded.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

5. When I am commuting, people are standing or sitting too close to me.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

6. My ride to work is often cramped.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

7. I have plenty of room on the train when I commute to work.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

8. There is not enough space on the train for commuters.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

The questions below refer to your commute *to* work. We care about your opinion. There are no right or wrong answers.

Please circle **one** answer for each question.

9. Overall, commuting is stressful for me.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

10. I feel there is little or nothing I can do to control the way in which I commute to work.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

11. It takes a lot of effort to commute to work.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

12. I resent the length of my commute to work.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

13. My commute to work rarely varies from day to day.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

14. My commute to work is pretty easy.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

15. I can control how long it will take me to get to work.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

16. My commute affects my productivity on the job.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

17. My commute to work each day takes a lot of effort.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

18. Commuting to work is consistent on a day to day basis.

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Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

20. My daily commute takes little effort.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

21. I resent the hassles by commute causes me.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

22. In my daily commute to work, I typically know how long it is going to take.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

23. There is essentially nothing I can do to affect my daily commuting experience.

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Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

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Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

27. Commuting to work takes effort.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

28. For the most part, I have no choice about how I commute to work.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

COMMUTER MOOD SCALE

Mark each line below with an X at the point that reflects how you feel right noW.
Remember…your answers will remain **anonymous** and **confidential**.

	VERY	**SOMEWHAT**	**NEUTRAL**	**SOMEWHAT**	**VERY**	
Tense	_____	_____	_____	_____	_____	relaxed
Friendly	_____	_____	_____	_____	_____	irritable
intolerant	_____	_____	_____	_____	_____	tolerant
tired	_____	_____	_____	_____	_____	energetic
happy	_____	_____	_____	_____	_____	sad
carefree	_____	_____	_____	_____	_____	burdened
contented	_____	_____	_____	_____	_____	frustrated