Commuting and Well-being

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Abstract

Commuting stress, whether associated with driving on congested roadways or with strains in public transit, has much relevance for the health and social sciences, urban planning, engineering, economics, and business management. We provide an overview of research on commuting stress and its impact on physical health and psychological adjustment. Historical developments in automobile commuting and technologically driven alternatives to cope with commuting stress are presented, pertinent to personal health, work performance, and family relationships. The subsidiary subject of driver stress is addressed in its association with violations and accidents. Comparative studies across commute modes and information age innovations are also discussed. There is some evidence in support of telecommuting as a coping strategy, as the convergence of technological, economic, social, and psychological factors have made work less place-dependent. Variables that moderate commuting stress, such as personal control, commute predictability, and gender, are reviewed, as well as environmental factors affecting commuting stress and coping. Despite the adversities of commuting, some of its elements can serve as enhancements to well-being, such as privacy, protected time, and the symbolic value of personal vehicles and freedom. We conclude with a discussion of adaptation as an overarching concept.

Commuting and Well-Being

The progress of human societies has always been associated with mobility and transportation. Since the earliest homosapiens migrated from their cave dwellings over 100,000 years ago to establish civilizations in the valleys of the Tigris and Euphrates, human achievement and societal well-being has been dependent on our ability to transport ourselves and the goods that we produce. While the information age has radically modified both work products and the means of transportation, physical mobility on roadway systems remains fundamental to our commerce, recreation, and other life-sustaining activities. Indeed, mobility is very much associated with well-being, but the relationship is not uniform, as higher levels of travel may be reflective of constraints on opportunities, depletion of resources, and impairments to personal health and job performance.

Contemporary urban societies are fraught with stressful environmental conditions, among which traffic congestion features prominently. Remaining attached to the mode of private automobile travel and constrained by the availability of affordable housing, workers endure congested commutes and absorb the stressful consequences. As Dubos (1965 & 1969) observed about human adaptation, we seem to develop tolerances to aversive environmental conditions and apparently function effectively in these less than healthy environs; however, as he also asserted, such adaptations in the present will be paid by misery in the future. Although potentially harmful urban conditions, such as exposure to noise, air pollution, and traffic congestion, become acceptable through habituation, the adaptive adjustments are achieved at the price of physical or psychological disturbances later in life. Adaptations to chronic stressors have costs, as was famously established for noise and social stress by Glass and Singer (1972). Because routine exposure to high density traffic has become normative in urban areas

worldwide, attention to the strain of commuting on congested roadways and long distance commuting is important for both researchers and professionals in health and social sciences, urban planning, engineering, economics, and business management.

In this chapter we will provide an overview of research on commuting stress and its impact on physical health and psychological adjustment. Our focus is on work travel, although we include some relevant stress research on driver performance and the psychological characteristics of drivers found in studies conducted outside of the commuting domain. We will also discuss what has been learned about technologically driven alternatives to cope with commuting stress as it bears on work performance and family relationships as important domains of personal well-being.

At the outset, we acknowledge that there is a diverse array of stress-related research connected with driving and commuting, much of which falls broadly under the rubric of the psychology of transportation -- a field of applied psychology that entails the study of human behavior and well-being in conjunction with the regularized movement of people, goods, and services regarding work, personal life, and community activity systems. That general field also involves the interface of humans with transport vehicles and facilities, including their design for optimal operation, provisions for human needs, forms of utilization, road design, and social impacts (cf., Rothengatter & Vaya, 1997). Another related area is driver stress research, which is part of the human performance field of applied psychology.

Our focal domain of commuting has salience in the routines of daily life, and its importance bears on personal, family, and organizational well-being. Because various elements of transport systems are operated by people, understanding the stress-related dimensions has wider relevance for system development, efficiency, and safety -- in transit vehicles, as well as

automobiles, human cognitive, personality, and performance factors affect vehicle operation. Transport systems shape the structure of our communities, and the experiences we have while using them spill over to home and work domains. People respond to environmental constraints on mobility and strive to enhance well-being. What happens on a particular journey depends on many intertwined psychological elements, including personality disposition, attitudes about the origin and destination of the trip, and resources for choosing alternative travel modes and schedules, including telecommuting. The topic of commuting stress, while centrally focused on health and performance impairments resulting from commute travel impedance is also inclusive of travel mode decisions, driver attitudes and performance, the interplay between work and family, emotional well-being, as well as major societal issues such as the needs of special populations, the definition of the workplace, and the provision of transportation facilities.

Some Historical Background

The field of transportation has been dominated by engineers, urban planners, and economists; but the contributions of psychologists and sociologists have been integrated into this arena (e.g., Altman, Wohlwill, & Everett, 1981; Wachs & Crawford, 1992). Discussions of the social costs of transportation are now common, and psychological elements are given weight in such considerations. Because individuals, families, and work organizations recognize that they absorb hidden costs associated with traffic congestion, air pollution, and traffic noise, Stokols and Novaco (1981) argued that there was considerable merit in understanding how to optimize transportation systems and to assess the consequences of travel constraints.

Involvement by psychologists in the field of transportation began in the 1920's when transport companies and government agencies sought to improve the selection of drivers of

public transport vehicles, and psychometric testing became used in choosing the operators of buses, trams, and trains. A central concern was to minimize accident risk, and psychological tests were used to screen applicants who could be anticipated to be accident-prone. Wartime studies of adjustment among military personnel and the early psychological formulations of stress, adaptation, and coping that resulted from observations made by psychological researchers working with the military extended quite nicely to the subject of driver performance demands and safety risk. As well, industrial psychology research on fatigue at the workstation transferred to the issue of vigilance in professional train and road drivers (Barjonet, 1997).

As the motor car progressively came to dominate travel in Western societies in the 1950s and 60s, car ownership grew dramatically; and accident rates and road deaths became serious public health problems. For example, in most European countries, the number of road death doubled between 1955 and 1970. Public safety policies, such as speed limits, penalties for drunk driving, and ultimately seat belts, were instituted to curtail casualties, and research into the human causes of accidents came into play. Social psychological knowledge was used in public persuasion efforts, and theories and techniques of learning found fertile ground in driver education and rehabilitation. As the advent of the computer augmented the capacity to analyze and integrate data, the approach in the 1970s and 80s to understanding driver-based safety risk often took the form of psychological modeling that incorporated personal background, attitudinal, motivational, and emotion variables, on top of ergonomic factors.

The growth in automobile commuting that occurred between 1960 and 1980, especially in the United States, prompted interest in modeling how trips were generated, how they were distributed across travel zones, and how trips split across available transportation modes (car, bus, train). The boom in automobile commuting followed from substantial growth in the number

of jobs, in the working age population, and in the number of women in the labor force. In addition, homes and jobs shifted to suburban locations. Because neither highway nor transit systems were designed for suburb-to-suburb commuting, traffic congestion in metropolitan areas became a salient issue. In the U.S., the use of private vehicles between home and work nearly doubled from 43 million users in 1960 to 83 million in 1980. At the same time, alternative modes of travel declined, vehicle occupancy declined, and national investment in highway infrastructure fell far behind the demand for road use (Pisarski, 1987).

European cities, with their treasured historic centers having limited road space and parking facilities, became concerned about the detrimental effects of traffic congestion and pollution and were keen to impose access restrictions. These trends spurred interest in the travel behavior of individuals. Computer-analytic methodology spurred development of travel demand modeling, which blended consumer theory in economics with choice theory in psychology, which assume that people use some utility or value function in assessing choice alternatives.

Attention to the transportation needs of special populations, such as working mothers, the elderly, and those affected by physical disabilities, also came into focus during the 70s and 80s. An important component of the auto-commuting boom was a large increase in the number of women in the labor force (Grieco, Pickup, & Whipp, 1989; Pisarski, 1987). Single women with children who lived in suburbs were very dependent on the automobile (Rosenbloom, 1991). In the U.S., most trips made by working mothers and their children cannot be made by transit, and the impact of travel constraints on the quality of family life is an important topic. Indeed, Novaco, Kliewer, and Broquet (1991) found that high levels of home environment stress linked to traffic congestion exposure among women in high impedance (long distance/long duration) commutes, independent of income and job satisfaction. In the 1990s, telecommuting emerged,

partly as a way to reduce strain on family life. The convergence of technological, economic, social, and psychological factors made work less place-dependent, and telecommuting was heralded as a viable alternative to auto commuting (Mokhtarian, 1990).

In the most recent analysis of long term commuting trends in the US, Pisarski (2006) shows that the booms in suburbanization, in commuting from suburb to suburb, in vehicle ownership, and in commuting by private vehicle that were evident from 1960 through 1980 have continued through the year 2000 census. Half of the US now lives in suburbs, and from 1990-2000, 64% of the growth in metropolitan commuting was associated with suburb to suburb commutes. The next largest growth share (almost 20%) was from central city to suburbs. Such travel patterns intensify congestion, as they are not efficiently accommodated by existing radial road design networks. Strikingly, comparing 1980 with 2000 percentages of modal use share, driving alone increased from 64.4 % to 75.7%, carpooling decreased from 19.7% to 12.2%, and transit use declined from 6.2% to 4.6%. Travel time in getting to work is now more than 60 minutes for 8% of workers in the US. Increasing numbers of workers are starting their commute before 5:00 AM.

Similar trends have occurred in Europe. Since 1970, there has been a 145% increase in the transport of people, and 87% of that growth has occurred in the road passenger transport sector (European Commission, 2006). The automobile share of passenger travel increased from 74% in 1970 to 79 % in 2003. In comparison, the rail transport share of passenger travel declined from 10% to 6% in that same period, and the bus/coach share of passenger travel dropped from 13% to 8%. "The emergence of the information society has not limited the need for mobility -- quite the contrary ... every European citizen travelled 17 kilometers a day in 1970. Today that has risen to 35 km. Against this backdrop, traffic congestion has reached disturbing

levels" (European Commission, 2006, p. 7). Costa, Pickup, & Di Martino (1988a), noting the European trend in suburban growth, combined with reduction in the inner cities, called attention to commuting as a stress factor due to its interference with living and working conditions, such as diminished leisure time and work absenteeism.

Population growth in metropolitan areas worldwide clearly has exacerbated traffic congestion as an international problem. Jones's (2002) account of mega-urban regions in Southeast Asia indicate that public transport problems are immense, with travel times to work of 2 hours being normal, as is the associated lost productivity and poor quality of life. Shimomitsu (1999) reported that 48.2% Japanese workers in major cities spend two or more hours commuting every day (12.7% spend three or more hours) and refers to the commuter train experience as "commuting hell". Studies of stress associated with traffic congestion in Asian cities are sparse, but the Matthews, Tsuda, Xin, & Ozek (1999) study with Japanese drivers found some comparability with British studies on "driver stress", although we discuss below some issues in this genre of research. Overall, it is clear that traffic congestion and the strain of commuting through it is a problem worldwide.

Stress, Driving, and Commuting

There are a variety of domains that might be subsumed under the rubric of commuting stress, including studies concerning driver stress measurement, driver performance and safety, and factors influencing mode choice decisions. In this chapter, we focus on the stress of commuting, as opposed to driving per se that is not done on one's commute to work. For example, driver personality variables or other individual difference factors that are associated with driving behaviors or accident risk are excluded, as are ergonomically-oriented studies and

driving simulator research. Also outside of our present scope is research on the stress experienced by professional drivers, such as research conducted with urban bus drivers (e.g., Evans, 1994; Evans & Carrere, 1991), long distance coach drivers (e.g., Raggatt, 1991; Sluiter, van der Beek, & Frings-Dresen, 1998), truck drivers (e.g., de Croon et al., 2004; Hentschel, Bijleveld, Kiessling, & Hosemann, 1993; Vivoli, Bergomi, Carrozzi, & Vezzosi, 1993), and company car drivers (e.g., Cartwright, Cooper, & Barron, 1996).

One does find in the "driver stress" literature a research segment concerning violations and accident involvement that is relevant to our commuter stress topic. Such driving behavior indices legitimately constitute stress-related outcomes, and we review findings from studies in this area later. However, because of its bearing on the framing of the commuter stress concept, we note at this juncture that many “driver stress” designated studies come up short on construct validity, because they have been restricted to limited questionnaire assessments. For example, in many studies of "driver stress", the criterion variable has been a single measure, the "Driving Behavior Inventory" (DBI; Gulian, Matthews, Glendon, Davies, & Debney, 1989). The DBI items are in large proportion about annoyance, irritability, anger, and aggressiveness, and in that regard, its assessment of stress is truncated. The experience of stress involves much more than an antagonistic sentiment, mood, or inclination. In the affective sphere, in addition to anger-related dispositions, it entails anxiety, depression, and demoralization. Moreover, the environmental factors that induce stress, such as the physical environmental conditions associated with traffic exposure, merit objective assessment.

To properly assess stress as a condition of the human organism, one must get beyond self-report measures; and, when one must rely on self-report procedures, multiple instruments should be utilized. Stress has cognitive, affective, and behavioral disposition dimensions, as well

as task performance, physiological reactivity, psychological adjustment, and personal health components. The stress concept has had extensive elaboration since the landmark writings of Selye (1956) and Lazarus (1966), so much so that the three-volume *Encyclopedia of Human Stress* (Fink, 2000) has now gone to its Second Edition. A formulation of psychological stress pertinent to the general domain of transportation is given in Stokols and Novaco (1981).

Our principle focus here will be on automobile commuting, although we will give attention to mass transit users. We examine factors bearing on the stress of commuting as it interfaces with the home and work domains, review findings regarding the psychological and physical manifestations of commuting stress, identify moderating variables, and discuss what has been learned about how people cope with the stressful aspects of commuting.

Conceptualizing Commuting Stress

The topic of commuting stress is given a very fine exposition in the book by Koslowsky, Kluger, and Reich (1995), who provide an engaging mix of the environmental, psychological, personal health, and organizational factors involved. They offer an elaborate structural model and provide a rich discussion of coping at both the individual, organizational, and governmental levels. One springboard for their view of commuting stress is the impedance concept, which has guided our understanding of the subject and is embedded in broader ecological models (Novaco, Stokols, & Milanesi, 1990; Stokols and Novaco, 1981).

Exposure to traffic congestion can be understood as being stressful in terms of the concept of impedance – the blocking or thwarting of movement and goal attainment. The impedance conceptualization of commuting stress was introduced to capture the obstructive, frustrating aspects of road traffic that interfere with behavioral objectives, evoke unpleasant

emotional states, and detract from efficient performance and personal satisfaction (Novaco, Stokols, Campbell, & Stokols, 1979; Stokols, Novaco, Stokols, & Campbell, 1978; Stokols & Novaco, 1981). It was principally operationalized as a three-level factor defined by the conjunction of the distance and duration of the commute, although other objective indices such as road exchanges later served as supplementary indices (Novaco et al., 1990). The greatest impedance would result from traveling long distances slowly, and, conversely, the least impedance occurs when short distances are traveled in small amounts of time. Validation for the impedance concept was first demonstrated in the above studies, which were quasi-experimental investigations involving criterion measures of physiology, task performance, mood states, subjective distress, and physical health problems and involving repeated measures on each day of a week at company sites, plus questionnaires and travel logs. Generally, higher (physical) impedance was associated with higher blood pressure, lower frustration tolerance, more negative mood, more work absences, more colds and flu independent of work absences, and lower residential and job satisfaction. Evans and Carrere (1991), examining a three-level traffic congestion exposure variable with urban bus drivers, reported progressively higher adrenaline and noradrenaline levels and lower perceived job control.

In subsequent studies in our research program, travel impedance was conceptualized as having both physical and perceptual dimensions (Novaco et al., 1990; Novaco, Kliewer, & Broquet, 1991). "Physical impedance" can be objectively measured by the distance and time of the journey, along with the number of road exchanges, which represent nodes of congestion. Time of day is also relevant, as congestion is objectively greater in the evening, and commuting stress is compounded by strains from the workday. "Subjective impedance" is the person's perception of commuting constraints, assessed in this research by 17 questionnaire items. A

structured interview could also be done to ascertain this perceived dimension of travel impedance. Subjective impedance overlaps with physical impedance but is not isomorphic with it. Some commuters who have high physical impedance commutes are low in subjectively experience impedance, whereas others who have low physical impedance routes perceive their commutes to be high in impedance. Subjective impedance was found to be significantly related to evening home mood, health problems job satisfaction, and residential satisfaction. In testing the conjecture that subjective impedance mediated the relationship between physical impedance and stress outcomes, confirmatory evidence was obtained for a multivariate cluster of personal affect measures but only for some residential satisfaction measures (Novaco et al. 1991).

Because the commute is sandwiched between the home and the job, the demands and affordances of each of these domains, as well as personality factors, bear on the commuting experience. A useful concept in understanding commuting stress is "inter-domain transfer effects", whereby the psychological consequences of environmental conditions in one life domain (home, commuting, work, or recreation) transfer to another, either positively or negatively (Novaco et al. 1990 & 1991). An empirical example of a positive transfer effect is that a high level of residential choice was found to buffer commuting stress. Empirical examples of negative transfer effects are that exposure to commuting stress affected negative mood at home in the evening, controlling for a great many other relevant variables (e.g., income, education, residential choice, months in residence, residential satisfaction, job satisfaction, work social relationships) and that commuting stress was found prospectively to be associated with change in commuters' job location, independent of job satisfaction and residential location and satisfaction (Novaco et al. 1990 & 1991).

The impedance findings from the measurement-intensive quasi-experimental studies in field settings were extended in a large survey study by Novaco & Collier (1994), conducted with a representative sample of southern California commuters. Commuting stress was found to be significantly associated with distance and duration of the commute, controlling for age and income. Independent validation for the impedance conception of commuting stress occurred in research by Koslowsky and his colleagues. In a survey study with nurses at several hospitals, Koslowsky and Krause (1994) found that automobile drivers' employee stress was linked to commuting time (they did not assess distance) and that stress mediates employee job satisfaction, commitment, and intention to leave. Unfortunately, they did not assess whether their measure of employee stress, a 20-item self-report questionnaire, was related to individuals' perception of their commutes. Subsequently, Koslowsky, Aizer, & Krausz (1996), in a survey study of commuters in Tel Aviv, operationalized commute impedance as a three-level physical dimension and found it to be significantly related to subjective stress. They also found that higher levels of commuting impedance were associated with much lower levels of perceived control.

Perceptions of control and predictability were important themes in the nascence of the stress field (e.g., Averill, 1973; Folkman, 1984; Glass & Singer, 1972; Lefcourt, 1973) and remain so (e.g. Bollini, Walker, Hamann, & Kestler, 2004; Frazier, Steward, & Mortensen, 2004; Troup & Dewe, 2002). In the commuting stress domain, these themes have also emerged, as has a related concept of commute variability (Kluger, 1998). Environmental controllability is a core property of the Stokols and Novaco (1981) ecological model of commute travel impedance, as it bears on both exposure to commute travel stressors and the person's level of need facilitation in the commuting context vis-à-vis expected or preferred outcomes.

The relevance of perceived control for commuting stress surfaced in the Singer, Lundberg, & Frankenhauser (1977) study of train commuters, where it was found that perceived control (associated with getting on the train at the start of the transit line and getting a desired seat) was inversely related to psychophysiological stress (urinary secretion of catecholamines). For automobile commuters, Novaco et al. (1979) examined personal control expectancies ("locus of control") as a personality variable and situational control dimensions (residential choice and type of car), finding strongest support for the situational control variables on task performance (frustration tolerance in puzzle tasks and digit symbol recall). The control theme for automobile commuters was pursued by Schaeffer, Street, Singer, and Baum (1988), as they investigated differences in blood pressure, heart rate, mood, and task performance between drivers as a function of degree of route choice and whether the person drove alone or was a carpool driver. Having route choice did not buffer stress, and the results for being a solo driver (car environment control) were mixed. Carpool drivers had significantly higher blood pressure and heart rates, but solo drivers had higher hostility and anxiety scores. Also in that study, impedance, indexed by average speed, was significantly related to systolic blood pressure and to proof-reading errors. Novaco et al. (1990) found a set of choice variables (concerning car selection, commuting route, and residential selection) are significantly related to perceived commuting impedance -- the higher the degree of choice, the lower the subjective impedance.

Evans and Carrere (1991) deftly uncovered the stress mitigating effects of perceived control in their urban bus driver study, showing that perceptions of control (a 4-item measure concerning work decisional latitude, control, and freedom) was significantly related to adrenaline and noradrenaline, after accounting for exposure to traffic congestion. As they found that perceived control decreased with higher levels of traffic congestion, Evans and Carrere

conjectured that congestion curtails drivers' ability to adjust driving speeds to stay on schedule and to maneuver the bus to pick-up and drop-off passengers.

In this context, Koslowsky et al. (1995) put forward the "predictability" of the commute as an important moderator between subjective impedance and stress, preferring this concept to "control". For example, while having route choice might be thought to reflect control, they did not find it to moderate the number of stress symptoms reported -- this is consistent with what occurred in the high impedance condition in Schaeffer et al. (1988). Koslowsky et al. assert that having route choices will not amount to having control when those choices are low in quality. "The commuter put into a situation of choosing between undesirable alternative may indeed experience more, not less stress" (p. 100). Thus, Koslowsky and his colleagues proposed predictability as the hypothetical moderator. For example, a person who can simply predict the duration of his or her commute may thereby have the perception of control. Kluger (1998) sought to sharpen this further by proffering the concept of "commute variability". When a commute has low variability across days, the aversiveness of the commute is predictable and uncertainty is low, hence the commuter can maintain a sense of control. Variable commutes, even if predictable, are thought by Kluger to limit the cognitive ability of the commuter to control the environment. Testing this commute variability concept in conjunction with the impedance model, Kluger's study, involving a questionnaire given to graduate student commuters, found support for the impedance model -- commute length was related to perceived commuting strain and to somatic and affective symptoms. While commute choice had some effect, variability (a composite of three indices) had a much stronger effect in relationship to the strain and symptom measures. Variability had the highest correlation with perceived commuting

strain. Both commute length and variability had significant partial correlations with symptoms, controlling for perceived commuting strain.

Building on these ideas concerning predictability and variability of Koslowsky et al. (1995) and Kluger (1998), Evans, Wener, & Phillips (2002) investigated whether commute predictability for train passengers affected perceived stress of the commute, salivary cortisol, and performance on a proof reading task. They trichotomized predictability, which was indexed by a 5-item scale, and found that with increasing levels of unpredictability, perceived stress increased, as did salivary cortisol. Proof-reading was unaffected.

Taken together, this body of research points to the scientific value of understanding commuting stress in terms of the impedance and that predictability or variability is an important moderator. The best way to index impedance remains to be ascertained, and not all studies that have employed that concept have fully operationalized its physical and subjective dimensions. In some cases, what Novaco et al. 1990 & 1991) termed subjective impedance, is treated in its operational forms by other investigators as a stress measure, thus confusing independent with dependent variables -- i.e., treating antecedent conditions as outcome criteria. As well, the concept of control -- whether in the form of choice, predictability, or variability -- has been shown in various studies to have empirical and theoretical value. Costa et al. (1988) note that uncertainty of travel time was often a source of anxiety for their large sample of long distance commuters in various travel modes. The control concept has also not been sufficiently operationalized, particularly when one considers the ecological context of commuting and the relevance of the home and work domains.

Another potential moderator is time urgency as a personality factor (e.g. Stokols et al. 1978), which would seem to merit further examination than it has received. Feeling "rushed" in

getting to work served to distinguish the highly stressed long distance females in Novaco et al. (1991), and being "in a hurry" was found by Gulian, Glendon, Matthews, Davies, and Debney (1990) to be very significantly related to multiple stress indices. In a fuller analysis, Hennessy & Weisenthal (1999) and Hennessy, Weisenthal, and Kohn (2000) found that time urgency (operationalized by a 3-item rating scale) was significantly related to driver stress assessed on time in the vehicle (see procedure described below). Although their time urgency index was not a personality measure, their results lend support to the prospective merit of examining this factor more fully, so as to sharpen conceptions of commuting stress. The suggestion here is for investigators to consider time urgency as a personal disposition variable that affects how commuting experiences, including the anticipation of stressors on destination, are processed by the individual.

Adverse Impacts of Commuting Stress: Additional Moderators

The various quasi-experimental and survey studies discussed above have shown that commuting stress is associated with elevated physiological arousal, negative mood on arrival at work, negative mood at home in the evening, lowered frustration tolerance, cognitive performance impairments, illness occasions, work absences, job instability, lowered residential satisfaction, and decrements in overall life satisfaction. As it is easily argued that such investigations suffer from differential selectivity in sample composition (i.e., self-selection into commuting conditions), one must be cautious in suggesting causal connections between commuting strains and stress outcomes. The problem of course for an experimental investigation is that it is not feasible to randomly assign people to commutes of varying degrees of impedance and have them endure those journeys as routine. However, an experimental study by White and

Rotton (1998) did randomly assign participants to conditions (either car, bus, or control) for a single commute (travel between two campuses) and obtained stress measures. Those who drove had a significant higher blood pressure change than the other two conditions and a significantly greater increase in heart rate and lower frustration tolerance compared to controls. The findings of White and Rotton (1998), while limited in ecological validity -- students in an experiment sent on a journey between two campuses, as opposed to workers on daily commutes -- does provide support for the various field research studies finding physiological (cardiovascular and hormonal) and task performance effects for commuting stress.

At this juncture, we must mention that gender seems to be an important moderator of commuting stress. Novaco et al (1991) found that female solo drivers in high impedance commutes were the most negatively affected commuters, independent of job-involvement and household income. Because women tend to have more logistical responsibilities for home and family, they are perhaps more sensitized to stress on high impedance routes. The gender moderation effect (females showing higher stress) was also obtained by Novaco & Collier (1994), as women in the long distance commutes (greater than 20 miles to work) perceived greater commuting stress spillover to work and to home. Koslowsky et al. (1996) found a near significant moderation effect for gender on subjective stress, but they only report the main effect testing, not in interaction with impedance. However, they did find that women commuters had significantly lower levels of perceived control. In studies with rail commuters, Evans et al. (2002) and Evans & Wener (2006) found that gender did not interact with commute variables in relationship to stress measures. However, the ecology of commuting by train is quite different than that by automobile, including margins of departure and arrival, intermediate stops, and tasks that can be done during the commute. Hennessy et al. (2000) found no gender differences in

driver stress, but their participants were on single trips on their routine commutes. In the large sample survey study of Italian factory workers by Costa et al. (1988), women across commuting modes had significantly shorter duration commutes than did men, but they had significantly higher psychological stress, family problems, illnesses, and work absences and lower job satisfaction. Those authors conclude that (long) commutes accentuate the problems that working women face.

In our preceding discussion, we have given some attention to commuting stress involving public transport, although automobile commuting features more prominently. Comparative analyses of modes of commuting on stress dimensions are sparse, particularly if one looks for measurement intensity. A recent study by Gatersleben and Uzzell (2007) compared drivers, cyclists, walkers, and public transport users on questionnaire measures, and their discriminant analysis show that car drivers have the most stressful commutes, but public transit users had the most negative attitudes toward their travel mode. Parallel to automobile commuting studies, Evans and Wener (2006) found that the duration of the commute is related to salivary cortisol elevation and proof reading errors. Unfortunately, the latter study did not track the predictability or control dimension of earlier train passenger studies (e.g. Evans et al. 2002; Singer et al, 1977). The large sample survey study of Italian factory workers by Costa et al. (1988) examined differences between commuters have long duration (45 minutes or more) versus short duration (20 minutes or less) journeys to work -- they oddly termed the former "commuters" and the latter "non-commuters" -- but did not disentangle modes within these conditions. The long distance commuters (especially the females) did, however, report significantly more discomfort, distress, and somatic complaints, as well as a higher rate of illnesses and sickness absences. McLennan and Bennetts (2003) found that reported stress and productivity decrements varied with length of

journey and travel mode. For those in long journeys, car drivers reported more stress, whereas, in short journeys, public transit users were more stressed.

A commute occurs in two directions, but in the vast majority of studies the measures obtained have been in conjunction with the morning commute. In the impedance studies conducted by Novaco et al.(1990, 1991) we separately assessed morning and evening commute dimensions. The evening commute is objectively more stressful than the morning commute, it is subjectively perceived as more stressful, and the relationship with residential domain stress outcomes measures is stronger for the evening commute impedance than that for the morning. The results of the diary study by Gulian et al. (1990) converge in this regard. Daily driving stress scores were significantly higher across days of the week. The stress reported on daily diaries was significantly related to health complaints, relationships at work, and cognitive failures. Guilian et al. also found that driving stress was inversely related to age and driving experience.

Pertinent to moderator variable analyses are ideas introduced by Hennessy and Weisenthal (Hennessy & Weisenthal, 1997, 1998; Hennessy et al., 2000) a concern state and trait conception of driver stress. They developed a 26-item State Driver Stress Inventory and a State Coping behavior Inventory relevant to driving (Hennessy & Weisenthal, 1997), involving a small sample of student and community drivers in York, Canada, who made telephone calls to the investigators at journey landmarks points, at which time the state stress and coping measures were administered. Trait stress scores were computed from a general driving behavior inventory, and trait coping behaviors from another separately administered inventory. The drivers commuted on either low or high congestion routes. The state driver stress varied significantly as a function of both trait driver stress and level of congestion. Hennessy & Weisenthal (1999)

extended this line of research to aggressive behavior, using a larger sample in the same region. Driver aggressive behavior, assessed verbally by the telephone call procedure, was predictive of state driver stress, especially in the high congestion condition. Subsequently, Hennessy et al. (2000) replicated their previous findings that state driver stress is a function of level of traffic congestion, time urgency, and trait susceptibility toward driver stress. They also found that daily hassles were carried forward into the driving environment, amplifying driver stress levels among high trait stress drivers. This lends support to the notion of "interdomain transfer effects" (Novaco et al. 1990), with results obtained from on line assessments in the vehicle. While this research by Hennessy & Weisenthal has been conducted on single trips, these did occur on the person's routine commute route. Their use of a state/trait distinction for driver stress and their innovative measurement of the state variables offers promise for future research discoveries.

Driver Stress, Violations, and Accidents

Beyond more the health and psychological indicators of stress reflected in the studies we have heretofore discussed, psychological stress variables affect the operation of transport vehicles, as can be seen in studies of driver error and performance decrements (cf. Rothengatter & Vaya, 1997). Fatigue has been the most researched topic in this regard. Ordinarily understood as physical exhaustion, it can also involve conditions characterized by boredom, task aversion, uncontrollable sleepiness, hypnotic trance-like states, or loss of alertness. Driving performance decrements occur before the driver is subjectively aware of the fatigue. Fatigued drivers become complacent and underestimate the effort needed to maintain driving performance. This issue is of course most applicable to professional drivers, for whom hours of service limitations are implemented to guard against fatigue-related safety errors, but it also has relevance to stress

spillover from the workday on the commute home. However, we here turn to driving violations and accidents as additional stress criteria.

"Driver stress" has received considerable research attention as a focal topic (e.g. Hartley & Hassani, 1994; Kontogiannis, 2006; Simon & Corbett, 1996; Westerman & Haigney, 2000). Studies have typically included one, or both, of two self-report measures: the Driving Behavior Inventory (DBI; Gulian, Matthews, Glendon, Davies, & Debney, 1989) and the Driving Behavior Questionnaire (DBQ; Reason, Manstead, Stradling, Baxter, & Campbell, 1990; Parker, Reason, Manstead, & Stradling, 1995). Despite the extent of their use, their construct validity is not so well established. For example, most of the DBI items are not about behaviors, but rather concern emotional reactions and cognitions. There is a driver stress subscale within the DBI measure, but this scale is heavily loaded with items having anger/frustration/aggression content. In contrast, the Hennessy and Weisenthal (1997) state driver stress measure samples a much wider range of affects. Moreover, many of the dimensions of human stress reflected in the studies discussed above, such as dysphoric mood, cognitive interference, dissatisfaction in various life domains, health complaints, etc., are not incorporated in the DBI. Nevertheless, these instruments have had extensive use, and the research involved merits our attention.

Kontogiannis (2006) proposed a model of accident causation in which distal factors (e.g. driver stress) create a disposition to exhibit risky driving behaviors (e.g. errors and violations), which in turn predict actual accident involvement. High driver stress, measured by the DBI, was associated with higher levels of errors and violations measured by the DBQ. However, item inspection of the DBI and DBQ draws out two serious caveats. First, as we indicated, the DBI captures not only driver stress (a state of physical or emotional strain), but also driver aggression

(driving behaviors). Second, both instruments share content related to driver aggression. The fact that both distal and proximal factors measure aggression is methodologically muddled.

The DBQ (Reason et al, 1990) has been repeatedly translated, factor analyzed, and applied in a range of cultural settings. The study that brought forth the DBQ aimed at investigating the probable differentiation between errors and violations while driving. A sample of drivers from the UK anonymously completed and returned the questionnaire by mail. Three distinctive factors were identified: violations, dangerous errors, and relatively harmless lapses. Thereafter, the study was replicated in a Western Australian sample (Blockley & Hartley, 1995) and in a Swedish sample, (Aberg & Rimmo, 1998) yielding somewhat similar results.

There have been moderately consistent findings for the DBI. For demographic variables, the number of driving violations decreases with age; regarding gender, males report more violations, traffic accident involvement (as drivers), license suspension, and convictions for speeding than do females (Aberg & Rimmo, 1998; Blockley & Hartley, 1995; Reason et al., 1990). Not unexpectedly, roadway exposure, in hours of driving and distance driven per week, is a significant predictor of dangerous violations (Blockley & Hartley, 1995; Reason et al., 1990).

Consistent with the concept of interdomain transfer effects, stressful life circumstances outside the context of driving are associated with errant driving behaviors. Veneziano, Veneziano, and Fichter (1994) found that driving while intoxicated (DWI) arrestees were more likely to endorse stressful life events (e.g. job loss and unemployment, financial difficulties, divorce and separation) and being in an accident, than would be expected in the general population. Nearly a quarter of the sample (23.9%) indicated traffic accident involvement within the last year. The cross-sectional design of this study does not entail directionality, so our ability

to draw inferences of causality is restricted. An increase in stressful circumstances could lead to alcohol abuse, or alternatively, increased drinking can lead to stressful circumstances.

Getting beyond cross-sectional design limitations, Lagarde and colleagues (2004) conducted a prospective investigation over an 8-year period, exploring the association between stressful life events, namely marital separation and divorce, and traffic accidents in a large cohort of French workers. Consistent with previous findings, those with higher annual driving mileage, men and younger drivers, reported more accidents. Remarkably, separation or divorce was strongly associated with higher risk of serious accidents and even more strongly with at-fault status. Other potentially stressful life events, such as a child leaving home and an important purchase, were also associated with serious traffic accident involvement.

Corroborating evidence supports the notion that negative emotions and stressful life events can adversely affect driver performance. Negative mood has been found to predict violations, hazardous errors, and non-hazardous errors (Reason et al., 1990). Similarly, Legree, Heffner, Psotka, Martin and Medsker (2003) found that the negative emotional state preceding an accident (e.g. stressed versus calmed, stressed due to life event, fatigue, sleep deprivation, being disturbed by a passenger) predicted at-fault status. When combined, results of these studies suggest that elevated stress while driving is a risk factor that increases the likelihood of driving errors, violations, and traffic accident involvement.

Environmental Conditions Affecting Driver Stress and Coping

Although stress has been defined in many ways, at its core, stress is grounded on the relationship between the person and the environment (Lazarus & Folkman, 1984). Research on how stressors (environmental demands) affect perception and information processing during

tasks, including driving, is not new (Brown, 1962, Brown, Tickner, Simmonds, 1966; Moscowitz, 1973; Finkelman & Glass, 1970; Plutchik, 1959). Given that excess stress and strain can hinder driving performance and increase accident likelihood during commute, the study of stressors in the roadway environment is obviously important. Only a fraction of the numerous environmental stressors present while driving have been systematically researched.

Finkelman, Zeitlin, Filippi, and Friend (1977), examining the effect of noise on driver performance, hypothesized that drivers allocate their perceptual and information processing capability to the demands of the immediate driving tasks and use the remaining capacity on subsidiary tasks. Their study assessed the demands of separate and conjoint task (driving and delayed digit recall) coupled with environmental stress (nonperiodic noise) on driver's perceptual and processing capacity. Nonperiodic noise significantly increased driving task time, but only degraded performance under the highest load condition (conjoint task). A remarkable finding was that in this condition, drivers were much more likely to reduce accuracy than speed. We are inclined to mention that small rubber pylons, used to marked driver accuracy, may not attract the same amount of attention than real world markers (e.g., center lane dividers and guard rails).

Like noise, heat is a potentially aversive environmental element. Wyon, Wyon, and Nordin (1996) investigated whether moderate heat stress (21º or 27ºC compartment temperature) reduced individuals' vigilance for a set of onboard signals while driving in actual traffic in Sweden. Average response times, across all signals, were significantly increased in the higher heat condition. Interestingly, data analysis revealed no significant differences until the second half hour of the driving task. Six of the 18 female subjects in the high heat condition erred by a lapse of attention, while no such errors were recorded for females in the low heat condition. The manipulation of cabin temperature was not confounded by external weather, and none of the

subjects guessed that thermal conditions were under investigation. Consistent with previous research (Bursill, 1958; Mackie, O'Hanlon, & McCauley, 1974), findings suggest that even moderate increases in compartment temperature, insufficient to cause observable sweating in all but a few subjects, could adversely affect driver vigilance.

Hill and Boyle (2007) recently explored how different tasks and roadway conditions influence the amount of stress perceived by drivers. A factor analysis of 18 driving scenarios from a nationally distributed survey yielded four factors. The first factor was weather related stress (e.g. heavy rain, snow). The second factor involved stress resulting from interactions with other drivers (e.g. driving behind a vehicle that is constantly braking). The third factor accounted for stress related to performing driving tasks (e.g. merge into heavy traffic). Finally, the fourth factor accounted for stress from conditions related to limited visibility (e.g. night driving). Analyses showed that that females were much more likely to be stressed by adverse weather conditions, and other drivers. Increases in age were associated with increases in driver stress. A significant interaction effect between age and gender revealed that as age increased among women, lower stress levels were reported when compared to men. Females, older drivers, and drivers with more crashes reported higher stress levels of visibility-related stress. No significant differences were found when taking into account freeway versus non-freeway driving.

Contrasting the previously reviewed studies, a smaller amount of research has explored factors in the roadway environment that might potentially reduce stress and/or ameliorate well-being. Parsons, Tassinary, Ulrich, Hebl, and Grossman-Alexander (1998) examined whether stress recovery and /or immunization varied as a function of the roadside environment. This was attempted by showing participants one of four different video-taped simulated drives, varying in natural vegetation and appeal, immediately after and preceding mildly stressful events (passive

or active). Stress responses were captured by a number of physiological measures including: electrocardiogram (ECG), skin conductance, facial electromyogram (EMG), and electrooculographic (EOG) signals. There was some evidence suggesting that exposure to artifact-dominated roadside environments both slowed down and impeded recovery from laboratory stressors relative to exposure to nature-dominated roadside environments. In contrast, exposure to the nature-dominated condition decreased the magnitude of the autonomic response to the lab stressors and concomitantly increased coping ability, as reflected in task performance.

More recently, Cackowski and Nasar (2003)similarly explored the potential mitigating effects of highway vegetation on drivers' anger and frustration. After exposure to a 10-minute stressor (a timed addition task with random noise), participants were given the State-Trait Anger Expression Inventory (STAXI; Spielberger, 1996). They then randomly viewed one of three videotapes of highway drives, varying in the amount of vegetation and man-made material, followed by a second stress-inducing task (timed anagrams, some unsolvable). The time spent on the unsolvable anagrams served as a measure of frustration -- more frustration inferred from less time spent. Unfortunately, anger dissipated substantially across conditions during the short video, precluding a test of changes across roadside conditions. However, results for frustration tolerance supported the hypothesis: respondents viewing roadways with more vegetation worked almost a minute and a half longer than respondents who viewed other videos consistent with previous findings (Parsons et al., 1998).

An environmental variable naturalistically associated with driving and driver efforts to cope with stress is music. Wiesenthal, Hennessy, and Totten (2000) examined the efficacy of music in dealing with stress while driving by randomly assigning commuters to either a music or non-music group. State measures of driver stress (Hennessey & Weisenthal, 1997) were obtained

via their cellular telephone procedure, during a single commute in low- and high-congestion conditions. A significant interaction was obtained between congestion level and music groups. As in their other studies discussed above, greater stress was reported in high congestion, with the highest stress in the non-music group. This finding supports the notion that music could have stress-reducing effects in high congestion commutes.

The hypothesized benefits of reducing stress while driving range from increased processing capacity and attentiveness to reduced negative emotional states. Hypothetically, stress ameliorating environmental factors might indirectly reduce traffic accident incidence. Relatively little attention has been given to stress-mitigating roadway/driving conditions or to commuters' efforts to cope with the stress experienced while driving. However, one of the ways of coping with commuting stress is avoid the commute itself, and technological innovations that have moved the workplace have made this possible.

Commuting as Enhancement to Well-Being

The view that commuting is an unhealthy, derived demand (Mokhtarian & Salomon, 2001; Mokhtarian, Salomon, & Redmond, 2001) has been the subject of much empirical work, as our discussion of commuting stress has documented. However, commuting is not intrinsically harmful nor is it a uniformly unwanted activity pattern. The popular notion of our "love affair with cars" (cf., Marsh & Collett, 1986; Wachs & Crawford, 1992) has corroboration in Steg's (2005) factor-analytic identification of symbolic and affective motives for car use (along with instrumental ones). Also, qualitative studies suggest that commuting might be understood as a gift rather than as a curse (e.g., Jain & Lyons, 2008; Mann & Abraham, 2006).

Despite the widespread increase in traffic congestion and the associated intensification of travel impedance that we have portrayed, most individuals do want some commuting time, many are relatively satisfied with their commute, and a few actually prefer an increase (Redmond & Mokhtarian, 2001). Many commuters may very well choose to drive more than is needed, and few individuals view car ownership as a burden (Handy, Weston, & Mokhtarian, 2005). Commuting is indeed seen as having positive utility by both automobile drivers and transit users, as shown in multiple studies by Mokhtarian and her colleagues (Mokhtarian, et al. 2001; Ory & Mokhtarian, 2005; Redmond & Mokhtarian, 2001), identifying a plethora of utility dimensions, from mobility to lifestyle. Beyond the obvious utility of reaching a destination, people find utility in the commuting domain for doing work tasks, social networking, personal isolation/relaxation, and daily activity planning. Travel time has many information age utilities, as suggested by Lyons and Chatterjee (2008) and Lyons and Urry (2005).

The affinity for automobile commuting entails more than utilities. For example, when making choices about vehicle type, destination, route, and risk-taking, commuters often willfully disregard objective, instrumental considerations. While a wide range of objective variables (e.g., trip frequency, distance, duration, destination, and vehicle type) influence commuters' judgments of travel, various person-determined factors (e.g., attitudes and personality) are also operative (Collantes & Mokhtarian, 2007). Some drivers want and enjoy commuting, as illustrated by the qualitative studies by Gardner and Abraham (2006) and Mann & Abraham (2006), and private automobile transport is endorsed by commuters as conveying greater psychosocial benefits (e.g., mastery, self-esteem, protection, autonomy, and prestige) than does public transport (Ellaway, Macintyre, Hiscock, & Kearns, 2003).

It has long been considered that the psychological reasons for car use (e.g. emotional attachment, habit-formation, prestige) outweigh the practical ones (e.g., Stokes & Hallett, 1992). Research by Steg and colleagues (Steg; 2005; Steg, Vlek, & Slotegraaf, 2001) has found that car use is more strongly related to symbolic (status and prestige) and affective motives (freedom, fun, love of driving) than to instrumental ones (transportation characteristics) and that drivers make a clear distinctions between these categories.

While investigation of the potential psychosocial benefits of commuting is in its nascence, we suggest that studies in this regard get beyond the all-to-easy self-report questionnaire mode. The physiological, work performance, and physical health aspects should be examined. As transport policies sometimes aim at reducing vehicular use to increase public health, physical well-being criteria should be utilized. Epidemiological research by Macintyre, Hiscock, Kearns, and Ellaway (2001) found that car access/ownership is associated with better physical health, controlling for age and sociodemographic variables (social class, marital status, housing tenure, and income). Given that other studies (e.g., Hiscock, Macintyre, Kearns, & Ellaway, 2002) have found psychosocial benefits associated with car use, the interrelationship of the psychological and physical health benefits, and the mechanisms involved, merit examination.

Telecommuting and Well-being

Telecommuting, a term coined by Nilles (1975) in the early 1970's, refers to "travel" to the office by way of telecommunications. Recent estimates indicate that the number of telecommuters has risen to over 28 million in the United States (WorldatWork, 2007). This figure reflects a growing recognition of communications, especially computer technology, as an existing alternative capable of significantly reducing commutes.

Motives for telecommuting are bountiful, but, since telecommuting leads to commute reduction, it is not surprising that many telecommuters find value in this result (Hartig, Kylin, Johansson, 2007; Stephens & Szajna, 1998). Stephens and Szajna (1998) found evidence confirming that commute reduction implies less driver frustration and stress, as conjectured by Trent, Smith, and Wood (1994). Other widely reported motivations for telecommuting are: flexibility, relaxed atmosphere, cost savings, increased family-time, and avoidance of office politics. Telecommuting enables workers to maximize control over their work schedules and transportation modes; and an abundance of research on human stress in the past two decades has shown that personal control mitigates stress. Such beneficial effects of control have been found with regard to noise, crowding, air pollution, institutionalization, surgery, and stressful life events (Cohen, Evans, Stokols, & Krantz, 1986), as well as in the commuting studies previously discussed. A number of reviews concerning telecommuting, motivations, and psychological well-being have been published in recent years (e.g. Andriessen, 1991; Baruch, 2001; Konradt Schmook, & Malecke, 2000). As motives and circumstances for telework vary, telecommuting can affect well-being in different ways.

The relationship between telecommunications and transportation can be seen to be symbiotic (Mokhtarian, 1990), and it is quite possible that advances in telecommunications technologies will result in travel increases. As Mokhtarian states, the most important impact of telecommunications is in the reduction of constraints. At the psychological level, this has important implications for the well-being of workers, consistent with the broader issue of "personal control". Within most work organizations, issues of personal control are recurrent themes (Greenberger, Porter, Miceli, & Strasser, 1991); workers generally seek to enhance control, and traditional management routinely attempts to maintain control over subordinates.

Kossek, Lautsch, and Eaton (2006) reported that employees who perceived greater job control (the degree to which an individual perceives control over where, when, and how work is done) had significantly lower turnover intentions, family-work conflict, and depression. Kossek et al. expand on the personal control and work flexibility theme in Chapter X.

Although management preference for line-of-sight supervision is a commonly noted institutional impediment to telecommuting, it is noteworthy that not everyone capable of telecommuting chooses to do so. An inspection of the literature reveals numerous reasons why telecommuting can be disadvantageous, including: decreased social interaction, lack of career visibility, the need for direct supervision, and a desire to separate home and work life. Numerous theories propose that telecommuting can be disadvantageous. Standen, Daniels, and Lamond (1999) suggest that the erosion of boundaries (the structural and psychological divide between life and work) negatively affects well-being. Much attention has also been given to the potential consequences of overlap between work and non-work domains (Ellison, 1999; Hill, Hawkins, & Miller, 1996), where a home becomes negatively isolating (Lundberg & Lindfors, 2002; Ellison, 1999) and individuals perceive less social support (Trent, Smith, & Wood, 1994). Some have contemplated how telecommuting may undermine restorative functions of the home (Hartig, Kylin, & Johansson, 2007) and considered how family related stressors can spillover to the work domain (Baruch & Nicholson, 1997; Lewis & Cooper, 1995, Standen, 2000).

Telecommuting is viewed as a coping strategy to enhance congruence between demands and resources. However, only a handful of studies have examined personal outcomes of telecommuting by comparing telecommuters versus commuters, and the results are inconclusive. Belanger (1999) found that telecommuters report greater productivity and personal control than commuters but obtained no significant differences in either satisfaction or performance, whereas

Kossek, Lautsch, and Eaton (2006) found telecommuters had higher performance ratings by supervisors (although that did not result from flexibility control; see Chapter X). As periodic telecommuters and regular office workers have been found to have higher rates of social support than full telecommuters (Trent, Smith, & Wood, 1994), the relationship between telecommuting and social isolation requires examination. Golden (2006) did find a higher degree of teleworking to be associated with more organizational commitment and less turnover intentions, with work exhaustion partially mediating the relationship between degree of telework and organizational commitment and fully mediating the relationship between telework and turnover intentions.

Concerning psychological well-being and the family home environment, in Kossek et al. (2006), telecommuting was related to higher depression, except for women with children, who had lower depression. Not surprisingly, the amount of hours of telework was positively related to work-to-family conflict. They asserted that "all forms of flexibility are not necessarily good for individual well-being" (p. 363). In the Swedish study by Hartig, Kylin, and Johansson (2007), teleworkers and non-teleworkers both experienced the home as a place of restoration far more than as a place of demands. However, as overlap became higher, the teleworkers' evaluation of the home shifted from positive to negative. Working at home facilitates interdomain transfer effects, and the outcomes are not straightforward. That can be seen in Golden, Veiga, and Simsek's (2006) results that the more extensively individuals telecommuted, the less their work interfered with their family (WFC), but the more their family interfered with their work (FWC). Job autonomy and schedule flexibility positively moderated telecommuting's impact on WFC, but household size was found to negatively moderate telecommuting's impact on FWC. In a similar vein, Konradt, Hertel, and Schmook (2003) found that home-centered telecommuters reported significantly lower task-related stressors (interruptions, concentration demands, time

pressure, and uncertainty) but higher non-job-related stressors (strains due to restricted material resources, burdened duties at home, and social factors) than office-centered telecommuters and regular office workers. Kossek, Lautsch, and Eaton (Chapter X) expand on the boundary management issue (see their excerpts of participants' reports regarding family and friends, p. xx).

Forecasts of the diffusion of the telecommuting innovation have projected significant benefits in personal well-being and in reductions in traffic congestion, but outcomes are far from clear. The personal privacy and control afforded by the automobile, as well as its embeddedness in Western societies, suggest that it will be quite difficult to dislodge solo drivers from their private cars without imposing economic penalties or governmental regulations.

In addition to telecommuting, the information age had many effects on transportation systems. The development of intelligent transport systems, such as in-vehicle devices to aid navigation (e.g., route guidance and congestion warnings), as well as the increased sophistication of driver panel displays, raised the importance of driver control, visual search efficiency and mental load on driving proficiency. On the horizon of advanced technologies are Intelligent Vehicle Highway Systems that automatically control steering, speed, and spacing. However, having a vehicle travel under the control of a computerized system raises psychological issues of personal control and freedom, which have been themes intrinsic to car ownership and driving.

Adaptation: An Over-Arching Concept

Dissatisfaction with the commute is a cost the employee absorbs, often with delayed effects on health and family life, as well as on work organizations -- commuting stress can be manifested in illness-related absences from work and with impaired work performance. People will change jobs, commuting modes, vehicles, or commuting schedule to cope with traffic congestion, but such adaptations are a function of coping resources.

A core concept in the psychology of transportation is behavioral adaptation. Drivers and transport users will adjust to conditions in the transportation environment, whether that be in their overall commuting scheme, roadway or transit conditions, vehicle conditions, or changes in skill level or state of functioning in order to enhance their well-being. Thus, adaptation occurs at different levels of analysis, ranging from “high level” trip and travel mode decisions to “low level” vehicle control behaviors that maintain safety margins. When behavioral adjustments involved in adaptation are unsuccessful in the long term, more substantial behavioral coping can be expected, as when someone changes jobs to reduce commuting strain or stops driving because of age-related driving skill decrements. Innovations in information technology, by decreasing the need for vehicle trips, progressively may facilitate adaptation to travel constraints imposed by congested roadways and to unwanted reductions in mobility for some populations. The commuting stress model presented in Novaco et al. (1990) incorporates the transportation environment, commuting stress (physical and subjective impedance), and cognitive and behavioral coping, as well as stress and resource factors in the home, commuting, and work domains. The interdomain and longitudinal complexities remain to be empirically examined.

We should stay mindful of the wisdom of Rene Dubos: "Admittedly, human beings are so adaptable that they can survive, function, and multiply despite malnutrition, environmental pollution, excessive sensory stimulation, ugliness and boredom, high population density and its attendant regimentation. But while biological adaptation is an asset for the survival of *Homo sapiens* considered as a biological species, it can cause a progressive loss of the attributes that account for the peculiarities of human life" (Dubos, 1969, p. 80)

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