# DEVELOPING TAILORED INTERVENTION TECHNOLOGY FOR ALTERNATIVE TRANSPORTATION

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PREPARED FOR

UNIVERSITY OF RHODE ISLAND
TRANSPORTATION CENTER

**Technical Report Documentation Page**

| 1. Report No. | 2. Government Accession No. | 3. Recipient's Catalog No. |
|---|---|---|
| 4. Title and Subtitle<br>Developing Tailored Intervention Technology For Alternative Transportation | | 5. Report Date |
| | | 6. Performing Organization Code |
| 7. Author(s)<br>Norbert Mundorf, Colleen Redding, Andrea Paiva, James Prochaska | | 8. Performing Organization Report No. |
| 9. Performing Organization Name and Address<br>University of Rhode Island<br><br>Department of Communication Studies<br><br>10 Lippitt Rd, Kingston, RI 02881 | | 10. Work Unit No. (TRAIS) |
| | | 11. Contract or Grant No. |
| 12. Sponsoring Agency Name and Address<br>University of Rhode Island<br><br>Transportation Center<br><br>Carlotti Building, Kingston, RI 02881 | | 13. Type of Report and Period Covered |
| | | 14. Sponsoring Agency Code |
| 15. Supplementary Notes | | |

16. Abstract


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Single Occupancy Vehicle (SOV) transportation is a key contributor to climate change and numerous other environmental impacts. Alternative Transportation (AT) or Sustainable Transportation (ST), i.e. commuting by means other than SOV, represents one important step toward slowing climate change, improving communities and enhancing health. Communication and behavior change approaches can play a key role in encouraging commuters to choose more sustainable modes of transportation. The Transtheoretical model of behavior change (TTM) is a useful framework for understanding Transportation Behavior and ways to encourage sustainable alternatives. Few systematic applications of TTM to sustainable behavior exist to date. This report explains assessments and interventions designed to encourage Alternative Transportation. While the TTM Stages of Change Model is well established and world-renowned in the field of health promotion and related areas, very limited systematic work has been done related to transportation behavior. To develop tailored interventions, key TTM measures had to be developed: Stages for ST, Decisional Balance, and Self-Efficacy. These measures then became the cornerstone of TTM based interventions.

Short and reliable measures for decisional balance and self-efficacy, and their associations with *Stage of Change*were examined. University student volunteers (n=588) participated in this cross-sectional study. Through measurement development analyses using split-half cross validation procedures, we developed two internally consistent measures: a 20-item *Decisional Balance* measure with four hierarchically organized scales (Pros, Specific Pros, Cons, and Climate Change Doubt) and an 8-item *Self-Efficacy* scale. Both Decisional Balance and Self-Efficacy confirmed predicted associations with *Stage of Change*, supporting the application of TTM to Sustainable Transportation.

| 17. Key Word | 18. Distribution Statement | | |
|---|---|---|---|
| Sustainable Transportation, Alternative Transportation, Behavior Change, Stages of Change | | | |
| 19. Security Classif. (of this report) | 20. Security Classif. (of this page) | 21. No. of Pages | 22. Price |

**Form DOT F 1700.7** (8-72) Reproduction of completed page authorized

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## Table of Content

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Single Occupancy Vehicle (SOV) transportation is a key contributor to climate change and numerous other environmental impacts. Alternative Transportation (AT) or Sustainable Transportation (ST), i.e. commuting by means other than SOV, represents one important step toward slowing climate change, improving communities and enhancing health. Communication and behavior change approaches can play a key role in encouraging commuters to choose more sustainable modes of transportation. The Transtheoretical model of behavior change (TTM) is a useful framework for understanding Transportation Behavior and ways to encourage sustainable alternatives.

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# Introduction

Prevalence of overweight or obesity and global climate change represent major public health concerns facing American society today. According to the Intergovernmental Panel on Climate Change (2007), transportation, especially by automobile, is one main contributor to greenhouse gas [GHG] emissions and the depletion of fossil fuel sources. A range of transportation conservation strategies will be needed to mitigate climate change (Pacala&Sokolow, 2004). Population-based strategies to improve energy balance must increase levels of physical activity, among other things (Kumanyika et al., 2008). In developed countries like the U.S., alternative, or sustainable transportation (AT or ST), defined as commuting by any other means than a single occupancy vehicle (SOV), represents one potentially effective way to reduce GHG emissions as well as to increase physical activity (Dora, 1999; Kwaśniewska et al., 2010; Woodcock, Banister, Edwards, Prentice, & Roberts, 2007). Despite many synergistic benefits, nearly 90% of Americans commute by driving alone.

Communicating the impacts of climate change and encouraging more sustainable behaviors have met with limited success in the face of indifference and climate change denial. Some authors attribute the resulting inaction to two major psychological factors—which might also help explain the reluctance to change transportation behaviors*: Limited Pool of Worry* and *Single Action Bias* (Center for Research on Environmental Decisions, 2009). In other words, we tend to be overwhelmed with (seemingly) more pressing concerns, and we often engage in only one or two sustainable behaviors (often the 'low hanging fruit' like recycling) and feel that we have done enough.

One widely discussed approach to improving public responsiveness to environmental communication is *Framing* (Lakoff, 2010). Due to their complexity, climate change and sustainable behaviors can be discussed on the basis of different mental models, frames (or schemata). For instance, Climate Change deniers have successfully capitalized on *Doubt* as a key mental *frame: doubt about climate change itself* (in reference to the cyclical nature of weather events, for instance) or doubt about the anthropogenic nature of climate change. Another common frame is 'job loss' as the result of

government intervention to mitigate climate change—which resonates with emotionally charged debate about high unemployment. Lakoff points out that recent cognitive science has increasingly underscored the importance of emotion in decision making; and much Climate Change communication has failed to appeal to emotions and to develop theappropriate frames, while Climate Change deniers have successfully triggered emotional responses and appealed to deeply rooted frames established over decades. In addition, there are limited possibilities for changing frames (p. 72). Just giving people the facts will not necessarily lead them to the right conclusion—unless these facts are framed properly. Framing is often misunderstood as a short-term activity, but to be effective, the right frames have to be built over time. Clearly, there is no popular frame for public transit, or walking and biking as transportation in most parts of the U.S. We tend to lack appropriate frames considering the complexity of issues surrounding environmental behaviors ("Environmental Hypocognition," p. 76), especially since they tend to be systemic, global, and political in nature. In order to reach people, framing issues in terms of moral values is important. Stories used should exemplify values and rouse emotions, rather than merely statistics and facts.

Skannell and Grouzet (2010) also address the cognitive complexity involved in thinking and acting related to climate change. They address three areas of metacognition: Metacognitive knowledge, certainty, and importance. *Knowledge* about Climate Change tends to provide a readily available heuristic "that guides intention and behavior." Since Climate Change effects are often remote both in location and time of occurrence, *Certainty* (or removal of doubt) about such effects is an important influence in promoting behavior change. Communicating climate change risk is a challenge because media and politics often portray such risk as a debate with both sides having equal weight (in spite of prevailing scientific evidence), or tend to dwell on isolated research findings which appear to point in the opposite direction of prevailing data. Perceived *Importance* of this issue relates to the idea of a *Limited Pool of Worry* mentioned above. Specifically, certainty about the impact of SOV driving is lacking as drivers observe this behavior to be the societal norm, and the environmental impact of driving is seen as

an area of limited importance. Communicators need to find a way to make it urgent by emphasizing local, current, and tangible threats. Nerlich, Koteyko and Brown (in press) attempted a comprehensive analysis of variables relevant for climate change related communication, along with a discussion of extant research findings in light of the complexities of multiple impacts and uncertain time frames. In addition to the complexity of Climate Change (capitalized as opposed to the physical phenomenon of climate change), this work also relates to different types of communication (e.g. Risk, Health, and Science Communication) as well as social and cognitive psychology, including behavior change science.

Recently, interdisciplinary teams from psychology, communication, decision science, and the natural sciences have addressed factors influencing the propensity towards sustainable behavior. A key finding is the segmentation of audiences according to their willingness to accept anthropogenic climate change, and by implication to support or engage in actions, which may mitigate its impact. An influential study was conducted by Maibach, Roser-Reneuf,Leiserowitzand their research team(2009),which resulted in six distinct segments of the American public according to Climate Change knowledge and attitudes. In related work, Leiserowitz and Smith (2010) conducted a large-scale survey and applied the segmentation into *The Six Americas* to knowledge of Climate Change. The six segments were labeled: Alarmed, Concerned, Cautious, Disengaged, Doubtful and Dismissive. They found that respondents' position along this continuum correlatedwith their knowledge of Climate Change scientific information. Presumably, Climate Change beliefs and knowledge werealso related to behavioral propensities as well as support for sustainable policies. This work lays an important foundation towards understanding behavioral dispositions. *The Six Americas*segmentation correlates with readiness to change and the propensity to sustainable behavior alternatives.

Technological, economic, and regulatory approaches will be necessary to address these complex issues, but a key element of any mitigation strategy must include population-based changes in individuals' transportation-related knowledge, attitudes, and behaviors. Model-based research and intervention efforts to increase sustainable transportationuse can contribute to mitigation. Although both

research and intervention development are important, it is first necessary to identify modifiable psychological constructs or determinants which influence transportation choices (Merom, Miller, van der Ploeg, & Bauman, 2008).

The Transtheoretical model of behavior change (TTM; Prochaska&DiClemente, 1983) is an influential model in the field of health behavior change, with a strong scientific record of research and effective intervention development across a range of diverse behaviors (Prochaska, Redding, & Evers, 2008). The TTM describes behavior change as progressing through a series of five stages of change: precontemplation (not ready), contemplation (getting ready), preparation (ready), action (change occurred), and maintenance (change preservation). The TTM also includes three key constructs that drive the change process: processes of change, decisional balance and self-efficacy. Importantly, different constructs have been found to be important and are therefore emphasized in interventions for people at different stages of change. Decisional balance reflects the individual's relative weight of the advantages (the Pros) and disadvantages (the Cons) of the target behavior. Self-efficacy reflects the individual's level of confidence that they can practice the target behavior across challenging situations.

Stage of change has been found to be systematically related to decisional balance and self-efficacy. For decisional balance, the Cons outweigh the Pros in the precontemplation stage, while the opposite is true in the action stage (Prochaska et al., 1994a). Comparisons of those in the precontemplation and those in the action stage involved approximately one standard deviation (SD) increase in the Pros of change and approximately one-half SD decrease in the Cons of change across 48 health-related behaviors (Hall & Rossi, 2008; Prochaska, 1994b). Generally, self-efficacy consistently increased across the stages (Prochaska, DiClemente, and Norcross, 1992).

One previous intervention study to increase active commuting using the TTM was reported to be effective. Mutrie and colleagues (2002) demonstrated that a self-help intervention based on the TTM did effectively help those people who were either in the contemplation or preparation stages to initiate active

commuting to work (walking or bicycle riding). This supports the idea that the TTM can be a useful framework for understanding and increasing AT.

Others have applied some constructs from the TTM to AT or active commuting (Gatersleben& Appleton, 2007; Shannon, Giles-Corti, Pikora, Bulsara, Shilton, & Bull, 2006). Gatersleben and Appleton (2007) examined the stage distribution for commuting to school by bicycle in British university students, and reported that the majority who commuted by car had little or no intention to switch to cycling. Shannon and colleagues (2006) examined stages of change for using public transportation, walking, or cycling and evaluated associations with motivators (pros) and barriers (cons) in Australian university students and staff. They found that remarkably few individuals were in the precontemplation stage. Furthermore, those in the action or maintenance stages rated the barriers (cons) lowest, while those in the precontemplation stage rated the motivators (pros) lowest. These findings support the application of the TTM to this new area, however, measures are still lacking.

One first step toward evaluating how well the TTM applies to transportation behavior in the U.S., is measurement development for decisional balance and self-efficacy scales. Once scales are developed, theoretically predicted relationships between stage of change and each of these constructs can be evaluated (Redding, Maddock& Rossi, 2006; Velicer, Prochaska, Fava, Norman, & Redding, 1998).

First, this research discusses the development of measures for decisional balance and self-efficacy for AT as well as examining relationships between stage of change and each construct in a sample of university students. This study will provide an initial important test of validity of the application of the TTM to this new behavior (O'Hea, Boudreaux, Jeffries, Taylor, Scarinci, & Brantley, 2004).

Based on these measures, an individualized intervention was developed which utilized an expert system to encourage behavior change among respondents at different stages of change. This computer tailored intervention (CTI) was developed using the Transtheoretical Model (TTM)to assess people's readiness to engage in sustainable transportation.

The current study examines intervention effects of a CTI, the Sustainable Transportation Expert System, aimed at promoting sustainable (or alternative) transportation in a sample of students, faculty and staff at the University of Rhode Island. Meaning of the terms 'sustainable' and 'alternative' transportationare comparable and are used interchangeably in the current work.

While the TTM is well established in the field of health promotion, very limited systematic work has been done related to transportation behavior. In order to develop tailored interventions, key TTM measures had to be developed: Stages for ST, Decisional Balance, and Self-Efficacy. These measures then became the cornerstone of the intervention development, including both a brief video and the CTI. Also, a multimedia pilot study of the brief video was conducted to test the initial effect of a one-time cross-sectional intervention. In a related project supported by NEUTC (Fu et al., 2012), the TTM measures were applied at two comparable university campuses with divergent public transit infrastructures and 'sustainability cultures' in order to assess the impact of these factors and assess the relationship of travel distance, stage of change, demographic factors (age and employment status) and transit infrastructure on the likelihood of using sustainable transportation.

# Measurement Development

## Method

### Participants

Participants were n=588 undergraduate student volunteers from a Northeastern university setting. About 54.5% of students lived off-campus, while the remaining 45% lived on-campus. This sample included 70.1% women, and 84.4% Whites, 5.8% Black/ African Americans, 5.8% Hispanics, and 2.2%

Asians. The mean age was 20.6 years (SD=3.98). Within the sample, 65.2%, 15.8%, 13.6%, and 5.4% were freshman, sophomores, juniors, and seniors, respectively.

### *Measures: Decisional Balance, Self-efficacy, Stages of Change*

**Decisional balance.** For the decisional balance measure, 30 items were included in the initial item pool. About half of the items reflected pros, with remaining items reflecting cons of using AT. Based on Stern (1992) who argued that pro-environmental behaviors, including AT, differ from other behaviors in that such behaviors influence ecosystems as well as people, our initial items included positive and negative aspects of AT for the environment, as well as for the individual and others. Consistent with other decisional balance measures, respondents rated the importance of each statement to their own AT decision making on a five-point Likert scale (1 = not important to 5 = extremely important).

**Self-efficacy.** For the self-efficacy scale, 17 items were included in the initial item pool. Each respondent rated their degree of confidence that they could/would use AT in each specific situation on a five-point Likert scale (1 = not at all confident to 5 = very confident).

**Stages of change.** The stages of change for AT were assessed using the following self-classification item. First, this definition of AT was provided: "Alternative transportation includes any way of getting to [school] other than driving by yourself (single occupancy vehicle use). So walking, biking, public transportation (bus/subway/train) and carpooling are all means of Alternative Transportation." Then, participants were asked to choose one statement best reflecting their situation: (1) “I do not regularly use alternative transportation and I do not intend to start within the next six months” (precontemplation); (2) “I am thinking about regularly using alternative transportation within the next six months” (contemplation); (3) “I am planning to regularly use alternative transportation within the next 30 days” (preparation); (4) “I regularly use alternative transportation and have been for less than 6 months” (action); or (5) “I regularly use alternative transportation and have for 6 months or more” (maintenance).

### *Procedure*

All surveys and procedures for this study were reviewed and approved for human subjects protection by the University Institutional Review Board. This online survey was conducted in December, 2010. Students were invited to participate in the online survey by their instructors for extra credit. Participants read an online informed consent form explaining the study.

## Analyses

**Measurement development.** For both scales, the study cohort of n=588 participants was randomly split into two subsamples for exploratory principal components analyses (n=280), and confirmatory structural equations modeling analyses (n=280). The goals of these analyses were to examine psychometric structures and internal consistencies, resulting in development of brief and reliable measures for decisional balance and self-efficacy.

**Exploratory analyses.** With the first half of the sample, we carried out a series of exploratory principal components analyses (PCAs) with varimax rotation on each set of items. The number of components to retain was based on the minimum average partial procedure (MAP; Velicer 1976) and parallel analysis (Horn 1965). The aims of these analyses were to: 1) determine the number of components present and estimate the correlation between them; 2) provide estimates of the component loadings; 3) estimate internal consistency for each component using Cronbach's alpha. Item selection was an iterative process, in which items with loadings on multiple factors and items with poor loadings (<.40) were removed, and analyses were repeated. Final item selection was also determined on the basis of item clarity, lack of redundancy, and conceptual breadth.

**Confirmatory analyses.** Structural equation measurement modeling on the remaining confirmatory subsample for both scales was then conducted. Five fit indices were calculated, including: 1) the likelihood ratio chi-square statistic; 2) the goodness of fit index (GFI); 3) the comparative fit index (CFI); 4) the average absolute standardized residual statistic (AASR); 5) the root mean squared error of approximation (RMSEA). Traditionally, values of GFI and CFI above .80 indicate good fit, while values

above .90 indicate excellent fit (Hu &Bentler, 1998). For the AASR and RMSEA, values below .06 indicate excellent fit (Tabachnik, 2001; Kline, 2005).

**External validation.** The TTM hypothesizes that individuals in different stages of change will differ significantly on their scores for the Pros, Cons and Efficacy scales. In order to facilitate comparison of the magnitude of differences in scale scores among the subscales and between these results and other studies examining TTM scales, raw scores were converted to T-scores (M=50, SD=10). We plotted T-scores of pros and cons by the stages, and then examined patterns graphically, consistent with Prochaskaand colleagues (1994a). Then, to examine whether the strong and weak principles would be confirmed, we first conducted a multivariate analysis of variance (MANOVA) and follow-up ANOVAs with Tukey post-hoc tests, using stage of change as the independent variable. Based on the studies of Prochaska (1994b) and Hall and Rossi (2008), we calculated maximum differences of pros and cons scores across the first four stages, and compared those between pros and cons.

We conducted an ANOVA using stage of change as the independent variable and self efficacy scores as the dependent variable to examine relationships between these constructs.

## Results

**Stages of Change.**The stage of change distribution of these participants is shown in Table MD1. We found 57.9% in precontemplation, 10.8% in contemplation, 3.7% in preparation, 13.7% in action, and 13.9% in maintenance. Not surprisingly, students living on-campus showed a different staging distribution compared to students living off-campus.

### *Measurement Development*

**Decisional balance.** The thirty items were subjected to the initial PCA. A total of three PCAs were carried out, and the initial 30 items were reduced to 20 items. Both MAP and parallel analysis indicated a four factor solution in the second PCA (Table MD1). Item evaluation suggested that two factors reflected AT Pros while the remaining two reflected AT Cons. The first 6-item Pros factor

involved items reflecting general positive evaluations of AT, and was labeled, "Pros". The second 4-item pros factor included items reflecting more specific positive aspects of AT, and was labeled, "Specific Pros". The first 6-item Cons factor included items reflecting general negative aspects of AT and was labeled, "Cons". The second 4-item Cons factor included items reflecting doubts about climate change and the need to use ATand was labeled, "Climate Change Doubt." All items showed loadings higher than 0.5. Internal consistencies were good for Pros (6-item $\alpha = 0.86$), Specific Pros (4-item $\alpha = 0.74$), Cons (6-item $\alpha = 0.77$), and Climate Change Doubt (4-item $\alpha = 0.75$). These four factors accounted for 55.8 % of the total item variance.

**Self-efficacy.** The initial 17 items were reduced to eight through a series of 3 PCAs, with items removed because of either poor loadings or repetitive content. Remaining items captured the desired breadth of challenging situations. The final PCA showed a single factor structure (Table MD2), that all item loadings were >.70, internal consistency was high ($\alpha = .90$), and this factor accounted for 54% of the total item variance.

### *Confirmatory Analyses*

In the confirmatory subsample, a confirmatory factor analysis examined the validity of a four-factor correlated decisional balance model. Fit indices for the Decisional Balance scale (Figure MD1) were good, with CFI = .876, GFI = .863, and AASR = .054. The correlation between the two higher order factors (Pros and Cons) in the confirmatory sample was r = -.05. Standardized path coefficients were very similar to PCA loadings obtained in the exploratory analysis. Internal consistencies were also comparable to those found in the exploratory sample($\alpha = 0.85$, 0.76, 0.78, and 0.71 for Pros, Specific Pros, Cons, and Climate Change Doubt, respectively). This measure showed an interpretable factor structure with a desired breadth of construct, as well as good factor loadings and internal consistencies.

On the second half of the sample, the confirmatory factor analysis was carried out to examine the validity of the one-factor model. Fit indices were low (GFI = 0.78, CFI = 0.79, and RMSEA = 0.13).

Standardized path coefficients were very similar to the PCA loadings found in exploratory analyses and the internal consistency was also comparable ($\alpha = 0.87$).

### *Relationships with Stage*

Table 1 summarizes the means and SD of the four subscales of the decisional balance measure and the self-efficacy measure by stages.

**Decisional balance.** Figure 1 and 2 show the mean scores of Pros, Specifc Pros -, Cons, and Climate Change Doubt by AT stages. As predicted, the combined scores of both Cons subscales outweighed those of both Pros subscales in the precontemplation stage, while the opposite was true in the action and maintenance stages.

The MANOVA revealed a significant main effect for stage [$F(16, 1519) = 4.89$, $p < 0.001$, $\eta 2 = 0.04$]. The follow-up ANOVAs indicated significant stage effects for Pros [$F(4, 500) = 9.39$, $p < 0.001$, $\eta 2 = 0.07$], Specific Pros [$F(4, 500) = 10.59$, $p < 0.001$, $\eta 2 = 0.08$], and Cons [$F(4, 500) = 3.31$, $p < 0.05$, $\eta 2 = 0.02$]. No significant difference by stage group was found for Climate Change Doubt. Compared to individuals in the precontemptation stage, the scores on Pros were significantly higher than those in the other four stages. Similarly, compared to individuals in the precontemptation stage, the Specific Pros were significantly higher in the contemplation, preparation, and maintenance stages. The Cons were significantly higher for those in the precontemplation stage than for those in the action stage.

We calculated maximal differences in the four subscales of a decisional balance measure between the precontemplation and action stages, respectively. The maximum differences of Pros and Specific Pros were 0.66 SD and 1.08 SD, respectively, while those of Cons and Climate Change Doubt were 0.28 SD and 0.22 SD, respectively.

**Self-efficacy.** Figure 3 shows the mean scores of Self-Efficacy by stages. The ANOVA revealed a significant stage effect [$F(4, 549) = 19.78$, $p < 0.001$, $\eta 2 = 0.13$]. Tukey's post-hoc tests indicated that,

compared to the individuals in the precontemplation stage, those in the other four stages showed significantly higher efficacy scores.

## Discussion: TTM Measures

These results demonstrate the internal and external validity of two key TTM constructs applied to AT and support the application of the TTM to AT, more generally. Development of these measures lays the foundation for both TTM research and intervention development in the future. In this study, only about 25% of university students were in the action or maintenance stages for AT, commuting by any other means than SOV. Of the remaining students, only about 4% were in the preparation stage, while a large percentage of students who commuted by SOV were not ready to change. These distributions differ from those of Australian students (Shannon et al., 2006), but are more consistent with those of British students (Gatersleben& Appleton, 2007). The results demonstrate that AT interventions should target the large percentage of individuals who are not yet ready to take action. The TTM recommends formulating interventions that are tailored to the full range of readiness to change for AT.

This 20-item decisional balance measure and the 8-item self-efficacy measure for AT are reasonably short, internally consistent, and psychometrically sound. The decisional balance measure consisted of four first order factors. In contrast to the general two-factor model, we found that a four factor solution fit these data better. Measuring two types of pros and cons will enable us to evaluate these constructs separately, and to tailor interventions by targeting each separately. Given the adequate but low model fit indices obtained for the self efficacy scale in the confirmatory sample, more work may be useful to further refine that scale.

Decisional balance showed predicted relationships with stage of change for AT. Briefly, the cons outweighed the pros in precontemplation, while the opposite was true in the action and maintenance stages. Around 0.6 or 1.0 SD of the increase of the Pros compared to that of half or 0.25 SD of the

decrease of the Cons between these stages suggests somevariation inthe strong and weak principles applied to this area. Further, among the four subscales, the scores of Pros, Specific Pros, and Cons were different across the stages. Since Climate Change Doubt did not differ by stage in this sample, future research will determine the utility of this scale. This study found that efficacy scores were higher among those in later stages than those in the precontemplation stage. This pattern was consistent with that predicted by the TTM.

This study has two limitations. First, cross-sectional data were collected

limiting our ability to examine causal relationships between stage of change and decisional balance and self-efficacy. Although cross-sectional studies have the potential to produce influential research findings (Sun, Prochaska, Velicer, &Laforge, 2007), cross-sectional research examines inter-individual differences, not changes over time. Therefore, it will be important to examine these construct relationships longitudinally in the future. The pattern of both these measures having their highest scores in Preparation was unusual, although it may simply reflect the very small sample size in the Preparation stage. These results should be replicated with larger and more diverse samples, from additional settings.

Finally, this study has produced two relatively brief, psychometrically sound measures to enhance research and intervention development targeting Alternative Transportation. Using the scales discussed in this paper, the authors developed a targeted expert system designed to deliver individualized messages based on subjects' Stage of Change, Decisional Balance, and Confidence. Based on many years of success with health behaviors it is designed to increase the readiness to accept and engage in Alternative Transportation among a substantial segment of our target population.

# Computer Tailored Intervention Pilot

## Method

### Program Description

*Sustainable Transportation Expert System* is a computer tailored intervention designed to promote sustainable transportation behavior, including carpool, bike/skate/scooter, walk, and use of public transportation. Participants above the age of 18 were recruited from the University of Rhode Island and included students, faculty and staff.

The study began with an overview of the research study, informed consent, and questions to determine eligibility. Among those consenting to participate, the *Sustainable Transportation Expert System*proceeded with alternating assessments and individualized feedback on transportation behavior and tailoredfeedback based on TTM constructs (including stage, decisional balance and self-efficacy). Finally, the feedback concluded with stage-matched feedback and transportation tips.

Three related behaviors were examined in this study: sustainable transportation behavior, recycling, and exercise; the intervention focused primarily on sustainable transportation. Recycling and exercise were included as behaviors related to sustainable transportation that people may be more likely to engage in. These behaviors may prime thinking about sustainable options for participants who already engaged in them. Sustainable transportation was defined: “Sustainable transportation includes any way of getting around other than driving by yourself (single occupancy vehicle use). Walking, biking, public transportation (bus/subway/train) and carpooling are all means of sustainable transportation.” Recycling was defined as: “Recycling includes regularly collecting all (or most) glass, metals, plastics and paper and depositing them in designated recycling bins.” Finally, exercise was defined as: “Regular exercise is any planned physical activity (e.g., brisk walking, jogging, bicycling, swimming, basketball, aerobics classes, etc.) performed to increase physical fitness. Such activity should be performed 5 or more times per week

for 30 or more minutes per session at a level that increases your breathing rate and causes you to break a sweat." Positive feedback for exercise and recycling was given to participants in later stages as a means of encouraging sustainable transportation behavior, but no feedback was given for participants in early stages of change.

## *Measures*

**Demographics.** Single items were used to assess participant race, gender, age, and university and enrollment status.

**Transportation Questions.** Additional items assessed participant transportation behavior including how often they most travel, what methods they most often use to get to campus, and how likely they would be to use various sustainable transportation methods. Sustainable transportation methods include: carpooling, biking, skating, or using a scooter/similar devices, walking, and using non-university public transportation (train, bus, etc.)

**Stage of Change.**Stage of change items were included for three behaviors: sustainable transportation, exercise, and recycling. Precontemplation (PC) is characterized by not currently engaging in the behavior and not intending to begin in the next 6 months. Contemplation (C) includes those thinking about starting to engage in the behavior in the next six months. Preparation (PR) is characterized as planning to engage in the behavior in the next 30 days. Action (A) includes those regularly engaged in the behavior for less than six months. Maintenance includes those regularly engaged in the behavior for six months or more.

**Decisional Balance.** The two subscales, the pros and cons of behavior change, from the decisional balance inventory were adapted for sustainable transportation behavior and weremeasured on a Likert scale ranging from 1- "not important" to 5- "extremely important". Questions were asked once at the beginning of the program and againat the end after evaluation feedback. Each subscale contained 10

questions regarding the pros (pre-test α=.87; post-test α=.91) and cons (pre-test α=.79; post-test α=.87) of sustainable transportation.

**Self Efficacy.** Self-efficacy was measured as a seven item scale regarding participant confidence to engage in sustainable transportationbehavior. Questions weremeasured on a Likert scale ranging from 1-"not at all confident" to 5-"extremely confident" (pre-test α=.89; post-test α=.93).

**Evaluation Questions.** Sixteen items asked for feedback regarding the program, including two open ended questions asking what participants liked or did not like and fourteen questions useda four-point agree/disagree Likert scale.

## *Results*

Participants (N=393) included students, faculty, and staff recruited to complete a computer tailored intervention study. Table CTI1 displays demographic characteristics of the sample and responses to transportation questions. Participants were mostly white (80.9%) and female (67.7%) and ranged from 18 to 66 years of age (M =26.84). 63.4% reported living off-campus and 75.3% reported owning a car.

81.1% of off-campus participants reported driving alone as the mode of transportation most often used in a typical week. When asked what mode of transportation off-campus participants would likely consider if they increased their use of sustainable transportation, 49.0% responded that they were very or extremely likely to carpool.

Participants were classified into one of five stages of change for three different behaviors based on their responses to staging items. "Pre-action" stages of change signify that participants werenot engaging in the target behavior and include Precontemplation (PC), Contemplation (C), and Preparation (PR). Action (A) and Maintenance (M) indicate that the participant is actively engaging in the behavior. Table 2 displays stage distributions and sample sizes for the total and off-campus participants on each of three behaviors, sustainable transpiration, recycling, and exercise. More (43.3%) participants were classified intoPC for sustainable transportation than for recycling (7.9%) or exercise (7.1%) and fewer

participants were in M for sustainable transportation (21.4%) than recycling (59.3%) or exercise (36.1%). When reduced to Pre-Action and Action/Maintenance stages, 71.5% werein Pre-Action for sustainable transportation compared to 46.3% for recycling and 29.3% for exercise.

Since the pre-test, CTI, and post-test were completed within one session, participants could not, by definition,progressto the Action stageduring the session. Instead, participants were asked to gauge their behavioral intentions as a means to examine preliminary stage movement. A significant paired sample t-test on pre- and post-test intention scores showed a moderate effect of movement towards being more likely to consider using sustainable transportation, $t(392) = -2.946$, $p = .003$, $d = .08$.

Table CTI3 contains mean responses to 14 evaluation questions and the percent of participants who “agreed” or “strongly agreed” to each question. Over 90% of participants endorsed the program as: easy to use, easy to understand, and easy to navigate. Significant differences in average evaluation score werenot found by stage or gender subgroups. This finding is essential as it indicates that even participants who werenot ready to change their behavior (precontemplators) were engaged bythe program.

## Discussion: Computer Tailored Transportation Intervention

This study demonstrates the feasibility and acceptability of the computer tailored intervention, Sustainable Transportation Expert System. Analyses indicate that 43.3% of participants were in Precontemplation for sustainable transportation, supporting the need for interventions tailored to those in early stages of change. Furthermore, a moderate effect size (Cohen, 1988) was found examining changes from pre- to post- test intention scores, indicating that participants were more likely to consider using sustainable transportation after the intervention. This intervention aimed at promoting sustainable transportation behaviorswas beneficial in changing intentions, a first step towards behavior changesthat could ultimately reduce environmental impact and climate change.

In addition, evaluation feedback revealed that the majority of participants endorsed positive aspects of the intervention, rating almost all evaluation items about 3.0 on a 4.0 scale. This is a critical accomplishment in particular because evaluations were high across stage groups. Since traditionally, Precontemplators have been the most difficult segment of the population to engage, strong evaluations here among Precontemplators are essential in that they will facilitate future dissemination in a range of samples with various stage distributions, even those with large proportions of Precontemplators.

## Conclusion

The research presented has demonstrated that the Transtheoretical Model of Change is a feasible tool for encouraging Sustainable Transportation behavior. Measurement Development produced reliable and brief measurement scales, which are the basis for the CTI and other pertinent research as well as practical applications. Developing the CTI proved complex and time consuming, which prevented follow-up measurement (due to students leaving campus for the summer). However, these TTM measures have already been applied elsewhere, in particular in a collaborative project with the University of New Hampshire (Fu, Mundorf, Redding, Paiva, &Prochaska, 2012), and further data collection is planned both at URI and at UNH. Also, the researchers are pursuing additional funding for a long-term intervention and application to other populations. The measurement scales developed and the resulting CTI have great value both for research and transportation practice. The scales along with their Alpha values are listed in Table CTI 4—and researchers are encouraged to utilize them in future projects.

This program of research supports the application of the TTM to sustainability-related behaviors and the ability of brief targeted behavioral interventions to increase people's willingness to engage in sustainable behaviors. These measures provide the empirical foundation for TTM intervention development research applied to additional sustainable behaviors (e. g. recycling, green eating, energy conservation, land/water resource management).To achieve the goal of sustainable transportation as part

of a more sustainable society, communication designed to promote individual behavior change is critical. Not only does individual change impact sustainability directly, TTM research has found that such change is often associated with policy support as well. In addition, those in Action and Maintenance for sustainable behavior can be role models for others, thus providing social support and normative support for change. Also, we expect that this approach can be applied to other kinds of sustainable behaviors in the future. TTM research has shown that even very different health and environmental behaviors can be evaluated and intervened upon using common constructs. This innovative approach has the potential to reach diverse population segments and to help provide tools for lasting change.

Attitude and behavior change regarding mobility options will gain importance in the future both for individuals and for policy makers. Individuals will face increased gasoline prices, more road congestion and pollution, and more negative consequences of a sedentary lifestyle. Policy makers also face the same congestion and pollution concerns along with limited resources for new road and highway construction. And the social costs of sedentary lifestyles in terms of healthcare and quality of life will lead to a greatersense of urgency that will likely increase attention totransportation behaviors. And finally, the pressure to mitigate the rate of Climate Change and to be prepared for its future impacts necessitates a reduced dependence on fossil fuel based transportation. Individual consumer choices along with policy decisions can facilitate the necessary changes. The TTM has provided a roadmap for change, and the research discussed here is an important starting point. Because targeted multimedia messages and Computer Tailored Interventions are easily scale-able, they have strong potential to reach large demographic and geographic segments at relatively low cost. The authors are disseminating the methodology and results of this work in order to maximize its impact in the future.

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Table MD1

Sample characteristics

| Variables | |
|---|---|
| **Age** | Mean=20.6 (yrs) (SD=3.98)<br>Range17-57 |
| **Year in school** | |
| Freshman | 15% |
| Sophmore | 32% |
| Junior | 23% |
| Senior | 27% |
| Other | 2% |
| **Gender** | |
| Men | 26.0% |
| Women | 70.1% |
| **Ethics** | |
| White (non Hispanic) | 84.4% |
| Hispanic/Latino | 5.8% |
| Black/African American | 5.8% |
| Asian | 2.2% |
| American/Alaskan Native | 0.5% |
| Other | 5.8% |

Table MD2

PCA Loadings for 4-factor Pros and Cons of Alternative Transportation

| *Item No* | *Statement* | *Loading* |
|---|---|---|
| | **General Pros** | |
| GP1 | AT is one way to improve my own health and the health of the planet | .73 |
| GP2 | Using alternative transportation is part of being green | .84 |
| GP3 | AT is worth the extra effort | .69 |
| GP4 | AT can save me money (gas/parking) | .71 |
| GP5 | By using AT, I can help to protect the planet | .76 |
| GP6 | I am proud that I can help the environment by using AT | .70 |
| | **AT-Specific Pros** | |
| SP1 | AT is more enjoyable | .64 |
| SP2 | Walking or biking to URI can help me clear my head and get some fresh air | .65 |
| SP3 | I can get work done while riding the bus or carpooling | .80 |
| SP4 | Riding the bus is safer than driving | .74 |
| | **AT-Specific Cons** | |
| AC1 | AT can be a hassle | .67 |
| AC2 | AT is not practical from where I live | .66 |
| AC3 | AT can be too much trouble | .71 |
| AC4 | Walking or biking is not practical from where I live | .63 |
| AC5 | AT would be too difficult | .74 |
| AC6 | I save time driving by myself | .63 |
| | **Climate Change Minimization** | |
| CCM1 | Worrying about climate change is not worth the time | .73 |
| CCM2 | As climate change proceeds, my transportation choices won't make a difference anyhow | .74 |
| CCM3 | Climate change is overblown by the media | .70 |
| CCM4 | Climate change is not that serious a problem | .75 |

Table MD3

PCA Loadings for Alternative Transportation Efficacy

| *No* | *Statements* | *Loadings* |
|---|---|---|
| SE1 | I am running late | .82 |
| SE2 | I have errands to run | .81 |
| SE3 | I am stressed out | .73 |
| SE4 | I am tired | .76 |
| SE5 | The weather is bad | .70 |
| SE6 | I have other people to pick up | .70 |
| SE7 | The available transportation doesnt work with my schedule | .74 |
| SE8 | It is inconvenient | .78 |

Table MD4

Means and standard deviations (in parentheses) in T-scores of General Pros, AT-Specific Pros, General Cons, Climate Change Denial, and Self-Efficacy scores by the stages of change.

| | **PC** | **C** | **PR** | **A** | **M** |
|---|---|---|---|---|---|
| ***Decisional Balance*** | | | | | |
| General Pros | 47.9 | 52.4 | 54.5 | 53.7 | 53.1 |
| | (10.20) | (7.29) | (9.75) | (8.96) | (10.09) |
| AT-Specific Pros | 47.7 | 53.5 | 58.5 | 51.0 | 52.4 |
| | (10.28) | (9.00) | (7.03) | (8.95) | (9.23) |
| General Cons | 51.0 | 49.7 | 51.1 | 47.3 | 47.6 |
| | (9.65) | (9.77) | (9.13) | (10.61) | (10.28) |
| Climate Change Denial | 49.6 | 51.5 | 51.8 | 49.6 | 50.4 |
| | (9.47) | (10.54) | (10.24) | (10.87) | (11.44) |
| | n = 287 | n = 57 | n = 18 | n = 72 | n = 71 |
| ***Self-Efficacy*** | 47.1 | 52.3 | 58.7 | 53.6 | 54.6 |
| | (9.19) | (9.23) | (7.97) | (10.24) | (9.66) |
| | n = 322 | n = 58 | n = 18 | n = 78 | n = 78 |

Note: PC = precontemplation ; C = contemplation ; PR = preparation ; A = action ; M = maintenance

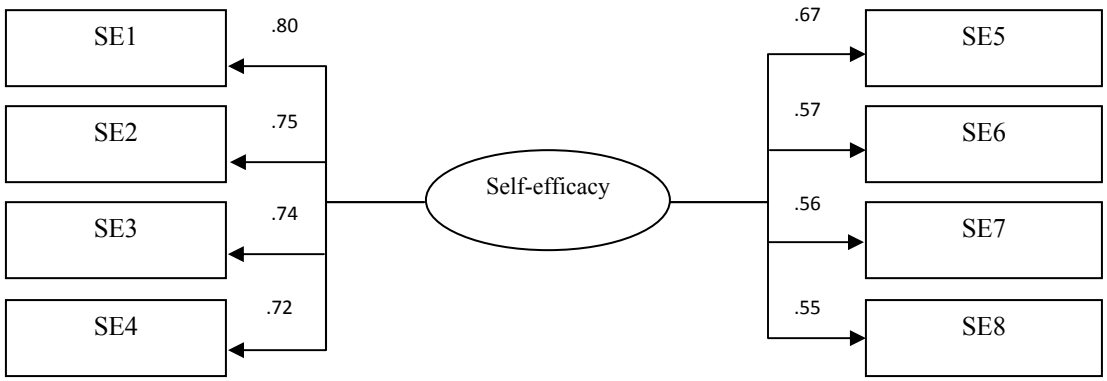
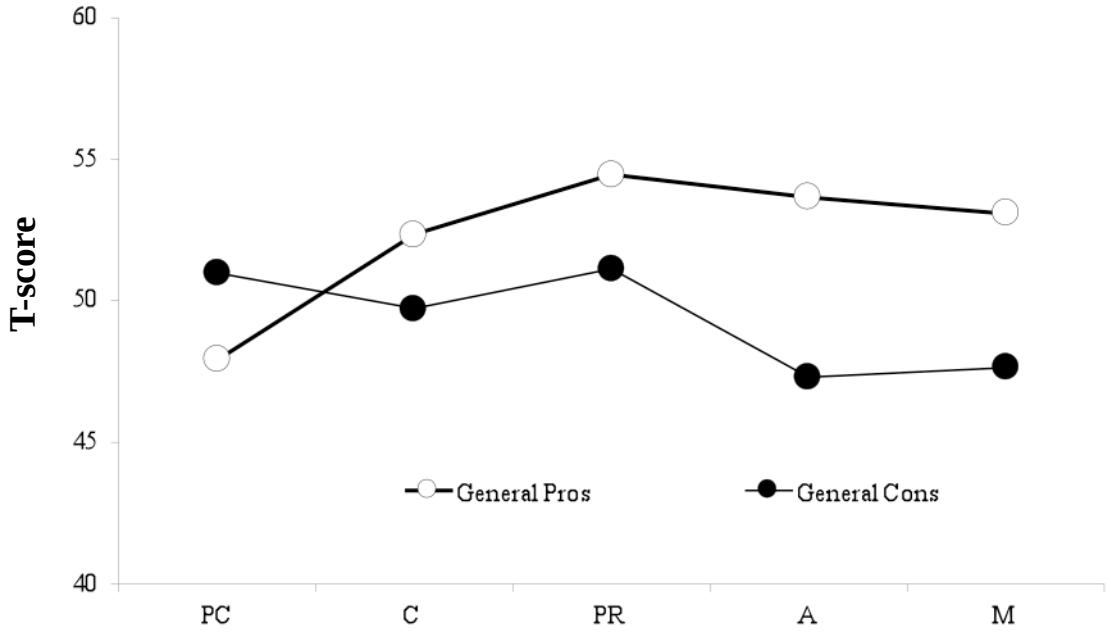


Figure MD2. Confirmatory factor analysis of self-efficacy scale

Figure MD3. T-scores of General Pros and General Cons by the stages of change

Note: PC = precontemplation ; C = contemplation ; PR = preparation ; A = action ; M = maintenance



## *Tables and Figures [CTI]*

Table CTI1

*Demographic Characteristics and Transportation Questions*

| *Demographics* | *n* | *Percent* |
|---|---|---|
| **Race/Ethnicity** | | |
| White | 318 | 80.9% |
| Black or African American | 25 | 6.4% |
| Asian | 5 | 1.3% |
| Hispanic/Latino | 22 | 5.6% |
| American Indian or Alaska Native | 2 | .5% |
| Other | 21 | 5.3% |
| **Gender** | | |
| Male | 127 | 32.3% |
| Female | 266 | 67.7% |
| **URI Status** | | |
| Yes, enrolled as a student | 287 | 73.0% |
| Yes, employed as faculty | 34 | 8.7% |
| Yes, employed as staff | 42 | 10.7% |
| Both employed at URI and taking courses | 24 | 6.1% |
| No, I am not currently faculty, staff, or student at URI Kingston | 6 | 1.5% |
| **Age** | Range: 18-66; M =26.84, SD = 13.445 | |

| *Transportation Questions* | | *n* | *Percent* |
|---|---|---|---|
| **Provide us with some detail about your where you live.** | | | |
| On campus resident | | 144 | 36.6% |
| Off campus resident | | 249 | 63.4% |
| **Do you either own or share a car?** | | | |
| I own my own vehicle | | 296 | 75.3% |
| I share a vehicle | | 38 | 9.7% |
| Neither own nor share-No access to a vehicle | | 59 | 15.0% |
| **In a typical week, how do you most often travel to URI (Off-Campus Residents)?** | | | |
| Drive Alone | No | 47 | 18.9% |
| | Yes | 202 | 81.1% |
| Carpool (at least 2 per vehicle) | No | 174 | 69.9% |
| | Yes | 75 | 30.1% |
| Bike, skate, or use a scooter/similar devices | No | 226 | 90.8% |
| | Yes | 23 | 9.2% |
| Walk | No | 204 | 81.9% |
| | Yes | 45 | 18.1% |
| Use URI on-campus shuttle services | No | 196 | 78.7% |
| | Yes | 53 | 21.3% |
| Use non-URI public transportation (train, bus, etc.) | No | 216 | 86.7% |
| | Yes | 33 | 13.3% |

Table CTI2

*Stage Distributions by Behavior for Total and Off-Campus Participants*

| | Sustainable Transportation | | Recycling | | Exercise | |
|---|---|---|---|---|---|---|
| *Stage* | *n* | *Percent* | *n* | *Percent* | *n* | *Percent* |
| **Total Sample, N=393** | | | | | | |
| PC | 170 | 43.3% | 31 | 7.9% | 28 | 7.1% |
| C | 81 | 20.6% | 36 | 9.2% | 55 | 14.0% |
| PR | 30 | 7.6% | 48 | 12.2% | 99 | 25.2% |
| A | 28 | 7.1% | 45 | 11.5% | 69 | 17.6% |
| M | 84 | 21.4% | 233 | 59.3% | 142 | 36.1% |
| Pre-Action | 281 | 71.5% | 182 | 46.3% | 115 | 29.3% |
| Action/Maintenance | 112 | 28.5% | 211 | 53.7% | 278 | 70.7% |
| **Off-campus Participants, N=249** | | | | | | |
| PC | 126 | 50.6% | 17 | 6.8% | 23 | 9.2% |
| C | 61 | 24.5% | 23 | 9.2% | 38 | 15.3% |
| PR | 15 | 6.0% | 19 | 7.6% | 53 | 21.3% |
| A | 8 | 3.2% | 24 | 9.6% | 43 | 17.3% |
| M | 39 | 15.7% | 166 | 66.7% | 92 | 36.9% |
| Pre-Action | 202 | 81.1% | 59 | 23.7% | 114 | 45.8% |
| Action/Maintenance | 47 | 18.9% | 190 | 76.3% | 135 | 54.2% |

Table CTI3

*Responses to Evaluation Questions*

| *Question* | *Mean (SD)* | *% Agree or Strongly Agree* |
|---|---|---|
| The program was easy to use | 3.37 (.71) | 91.86% |
| The questions were easy to understand | 3.08 (.78) | 80.15% |
| I would feel comfortable recommending this program to others | 3.17 (.73) | 86.51% |
| The personal feedback was easy to understand | 3.36 (.68) | 91.86% |
| The program gave me something new to think about | 3.12 (.82) | 82.44% |
| I like the way the program looked | 3.33 (.67) | 92.88% |
| The program was designed for people like me | 3.02 (.81) | 80.15% |
| I enjoyed using the program | 3.05 (.77) | 80.92% |
| The program was useful | 3.03 (.77) | 82.70% |
| The program gave sound advice | 3.19 (.70) | 89.57% |
| The program could help me be more environmentally friendly (green) | 3.07 (.79) | 80.66% |
| The program could help me make changes | 3.00 (.79) | 78.88% |
| The program was easy to navigate | 3.28 (.69) | 90.33% |
| I learned new information by using this program | 2.94 (.85) | 74.81% |

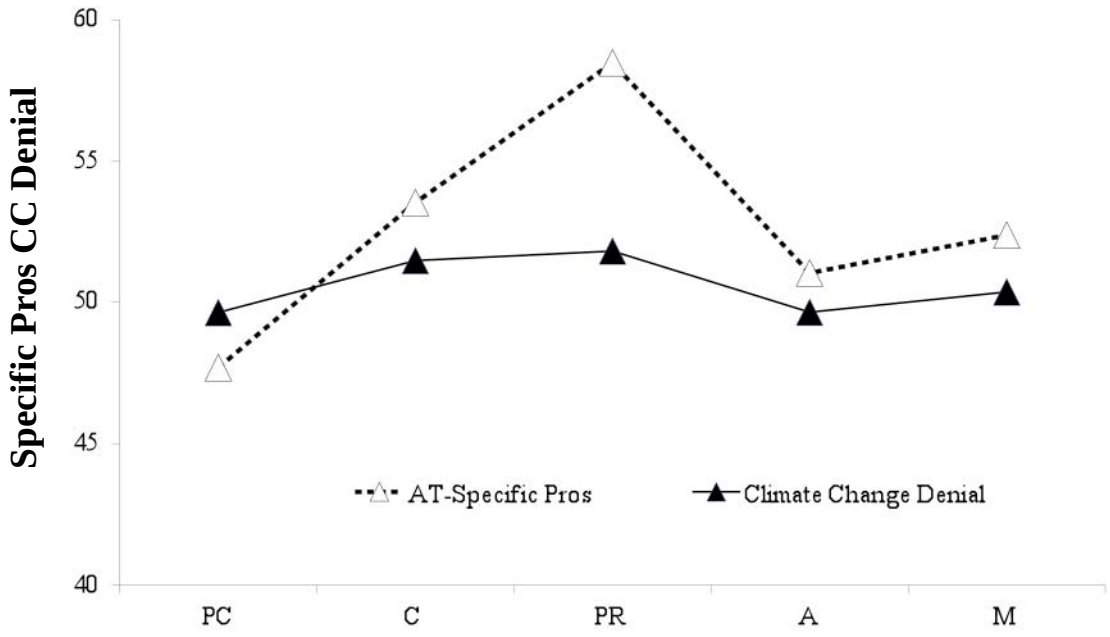



Figure CTI4. Differences of T-scores of Specific Pros and Climate Change Denial across the stages of change

Note: PC = precontemplation ; C = contemplation ; PR = preparation ; A = action ; M = maintenance

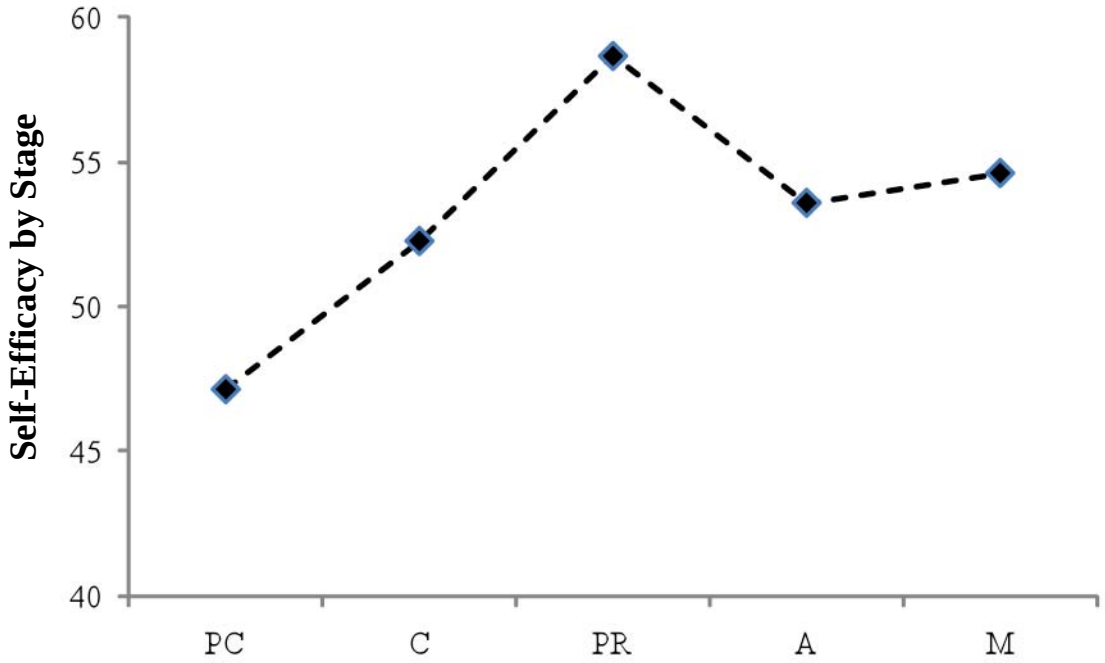



Figure CTI5. Self-efficacy by stage of change (T-score)

Note : PC = precontemplation ; C = contemplation ; PR = preparation ; A = action ; M = maintenance

Table CTI 4

Final Items and Alphas for Decisional Balance, Confidence, & Climate Change Doubt

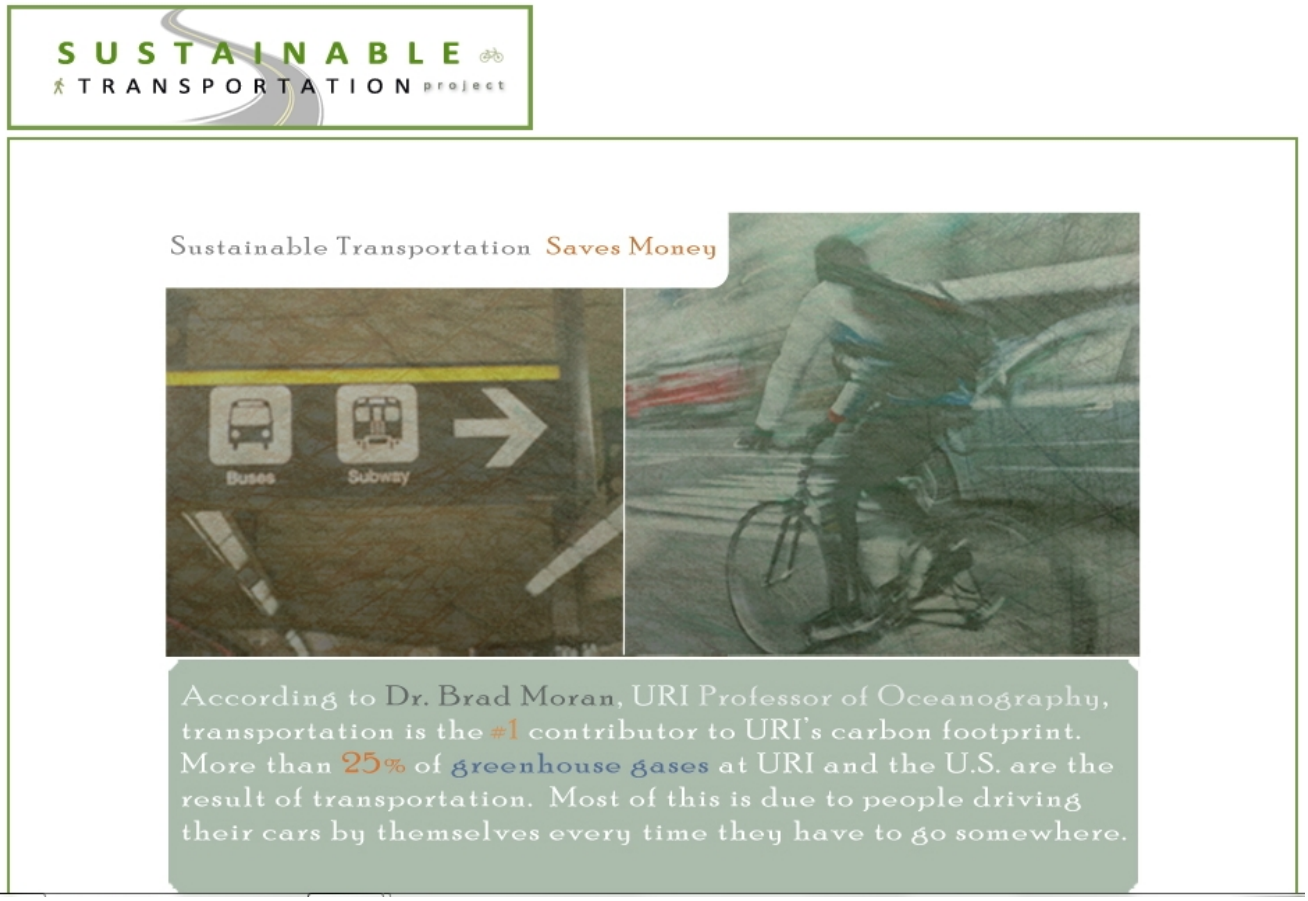
| **Scale/subscale** Item | *Alpha* |
|---|---|
| **Decisional Balance*** | |
| **Pros** | 0.84 |
| 1. Sustainable transportation is worth the extra effort. | |
| 2. I am proud that I can help the environment by using sustainable transportation. | |
| 3. Using sustainable transportation is part of being green. | |
| 4. Sustainable transportation is one way to improve my own health and the health of the planet. | |
| 5. Sustainable transportation can save me money (gas/parking). | |
| **Cons** | 0.77 |
| 1. Sustainable transportation is not practical from where I live. | |
| 2. Sustainable transportation can be a hassle. | |
| 3. I save time driving by myself. | |
| 4. Sustainable transportation would be too difficult. | |
| 5. Sustainable transportation can be too much trouble. | |
| **Confidence** | 0.82 |
| 1. I am running late. | |
| 2. I have errands to run. | |
| 3. I am tired. | |
| 4. I have other people to pick up. | |

5. It is inconvenient.

| **Climate Change Doubt** | 0.76 |
|---|---|
| 1. Worrying about climate change is not worth the time. | |
| 2. As climate change proceeds, my transportation choices won't make a difference anyhow. | |
| 3. Climate change is overblown by the media. | |
| 4. Climate change is not that serious a problem. | |

## Selected Screen Shots from the CTI Expert System

### CTI Screenshot: Introduction



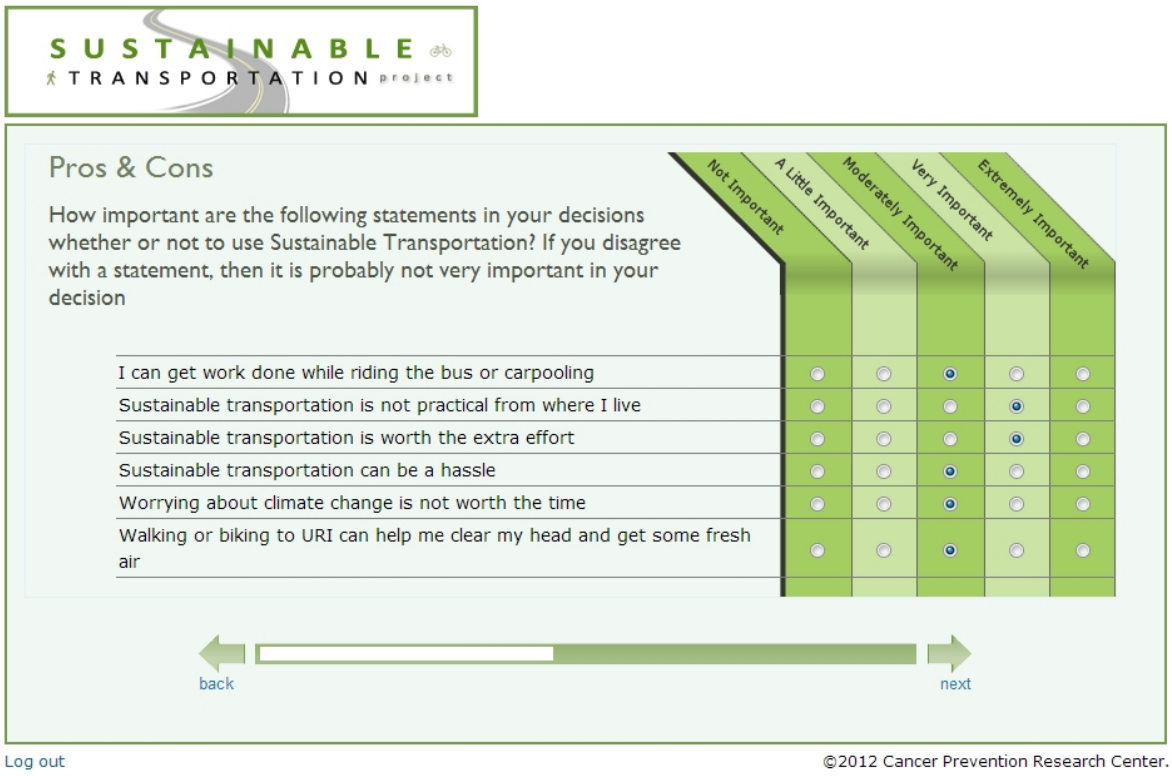
## CTI Screenshot: Introduction

SUSTAINABLE TRANSPORTATION project

By Taking the bus or train, carpooling, or biking you can enjoy some of these benefits:

- Health and Fitness
- Being Green
- Being on time and multi-tasking
- Relaxing
- Safety, avoiding accidents
- Saving Money

## CTI Screenshot: Assessment



## CTI Screenshot: Feedback