Sustainable transportation stage of change, decisional balance, and self-efficacy scale development and validation in two university samples

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Single occupancy vehicle (SOV) transportation is a key contributor to climate change and air pollution. Sustainable transportation (ST), commuting by any means other than SOV, could both slow climate change and enhance public health. The transtheoretical model (TTM) provides a useful framework for examining how people progress towards adopting ST. Short valid and reliable measures for ST decisional balance, self-efficacy, and climate change doubt were developed and their relationship with stages of change was examined. Two large university-based volunteer samples participated in measurement studies. Using multiple procedures, three brief internally consistent measures were developed: decisional balance, self-efficacy, and climate change doubt. The stages of change correctly discriminated both decisional balance and self-efficacy, as well as replicated hypothesized relationships. Climate change doubt did not vary by stages; however, it may prove useful in future studies. Results support the validation of these measures and the application of the TTM to ST.

Keywords: sustainable transportation; transtheoretical model; stages of change; decisional balance; confidence; active transportation

Global climate change and the increasing prevalence of overweight/obesity and inactivity present major public health concerns facing Americans, and the world. According to the Intergovernmental Panel on Climate Change (IPCC 2007), automobile transportation is one main contributor to both greenhouse gas emissions and fossil fuel depletion. A range of transportation conservation strategies will be needed to mitigate climate change (Pacala & Sokolow 2004). Concurrently, population-based strategies to improve energy balance are needed to increase levels of physical activity, among other things (Kumanyika et al. 2008). Increased active commuting is positively related to physical activity and mental well-being (Humphreys et al. 2013; Rojas-Rueda et al. 2013). In the US, both alternative transportation (AT) and sustainable transportation (ST) have been defined as commuting by any means other than a single occupancy vehicle (SOV). Promotion of AT/ST represents one way to simultaneously reduce GHG emissions as well as to increase physical activity in individuals (e.g. Dora 1999; Woodcock et al. 2007; Kwaśniewska et al. 2010). Despite these synergistic benefits of AT/ST, census data show that 80–90% of Americans
commute by SOV (McKenzie & Rapino 2011). Although technological, economic, and regulatory approaches can address these complex issues, population-level changes in individuals’ transportation-related attitudes and behaviors are a key component of any combination of mitigation strategies. Model-based research and intervention efforts that address population drivers of AT/ST behavior change can contribute to mitigation. Although both research and intervention development to increase AT/ST are important, identification and measurement of modifiable psychological determinants of individuals’ choices to use AT/ST (Merom et al. 2008) are essential first steps.

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, effective measurement, and intervention development across a range of diverse behaviors (Prochaska et al. 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. Stages of change have been found to be systematically related to decisional balance (pros and cons) 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. 1994; Hall & Rossi 2008). Comparisons of groups in precontemplation and in action stages revealed about one standard deviation (SD) positive difference in the pros of change and about one-half SD negative difference in the cons of change across 48 health-related behaviors (Prochaska 1994; Hall & Rossi 2008). Generally, self-efficacy consistently increases across stage groups (Redding et al. 2006; Prochaska et al. 2008).

One previous intervention study to increase active commuting using the TTM was effective. Mutrie and colleagues (2002) demonstrated that a TTM-based self-help intervention did promote active commuting for those people who were either in the contemplation or preparation stages for active commuting to work (walking or cycling). Others applied some constructs from the TTM to AT/ST or active commuting (Shannon et al. 2006; Gatersleben & Appleton 2007). Gatersleben and Appleton (2007) examined stages of change for commuting to school by bicycle in British university students, and found that the majority who commuted by car had little if any intention to switch to cycling. Shannon and colleagues (2006) examined stages of change for using AT, including public transportation, walking, or cycling and evaluated associations with motivators (pros) and barriers (cons) in Australian university students and staff. They found that substantially fewer individuals were in the precontemplation stage, compared to the British study. Consistent with TTM-based predictions, they found that those in the action or maintenance stages rated the barriers (cons) lowest, while those in the precontemplation stage rated the motivators (pros) lowest. These results support the utility of the TTM framework for understanding and increasing AT/ST.

The first step toward evaluating the application of the TTM to AT/ST is measurement development for decisional balance and self-efficacy scales. Once scales are developed, theoretically predicted relationships between stage of change and these constructs can be evaluated (Velicer et al. 1998; Redding et al. 2006). This study will develop measures for decisional balance and self-efficacy for AT/ST as well as examine relationships between each construct and stage of change in two convenience samples of
university students, staff, and faculty. This study will provide an initial evaluation of the validity of the TTM applied to AT/ST (O’Hea et al. 2004).

**Method**

**Participants**

**Study 1**

Participants were $n = 588$ undergraduate student volunteers from a Northeastern university setting. This online survey was conducted in December 2010. Students were invited to participate in the anonymous online survey by their instructors for extra credit. Participants completed online informed consent forms.

**Study 2**

Participants were $n = 393$ undergraduate and graduate students, staff, and faculty volunteers from the same Northeastern university setting. This online survey was conducted in April 2012, with comparable online informed consent procedures. Students were eligible to receive extra credit in courses for study participation; however, faculty and staff volunteers did not receive any incentive.

**Procedure**

Participants completed all surveys and informed consent procedures online. This study was approved for human subjects protections by the University of Rhode Island Institutional Review Board.

**Measures**

**Stages of change**

In Study 1, the stages of change for AT were assessed using the following self-classification item. First, AT was defined: “AT includes any way of getting to school other than driving by yourself (SOV use). So walking, biking, public transportation (bus/subway/train) and carpooling are all means of AT.” Then, participants were asked to choose one statement best reflecting their situation: (1) I do not regularly use AT and I do not intend to start within the next six months (Precontemplation – PC); (2) I am thinking about regularly using AT within the next six months (Contemplation – C); (3) I am planning to regularly use AT within the next 30 days (Preparation – PR); (4) I regularly use AT and have been for less than six months (Action – A); or (5) I regularly use AT and have been for six months or more (Maintenance – M). In Study 2, the stages of change for ST were assessed using a nearly identical self-classification item, simply replacing the word, Alternative, with, Sustainable. As before, first, ST was defined: “ST includes any way of getting to school other than driving by yourself (SOV use). So walking, biking, public transportation (bus/subway/train) and carpooling are all means of ST.” Then participants chose the statement best reflecting their situation.

**Decisional balance**

In Study 1, 26 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 item to their own transportation decision-making on a five-point Likert scale (1 = not important to 5 = extremely important). For Study 2, a subset of 16 items from Study 1 were included and the word, Alternative, was replaced with, Sustainable.

**Self-efficacy**
For this scale, 17 items were included in the initial item pool assessed in Study 1. Each respondent rated their level 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). In Study 2, a subset of eight items from Study 1 was included, and again, Alternative, was replaced with, Sustainable.

**Climate change doubt**
For this scale, four items were included in both studies. Respondents rated the importance of each item in their transportation decisions using a five-point Likert scale (1 = not important to 5 = extremely important).

**Analyses**

**Measurement development**
The overarching goals of these analyses were to examine psychometric structures, including factor structures and internal consistencies, resulting in development of brief and reliable measures for decisional balance and self-efficacy for AT/ST (Noar 2003; Redding et al. 2006). EQS statistical software was used for all structural equations models (Bentler & Wu 1993) and IBM SPSS version 22 was used for components analyses and group comparisons. For all scales, Study 1 (n = 588) was used for both exploratory principal components analyses (PCA) and structural equations modeling analyses. In Study 2 (n = 393), PCA and confirmatory structural equation measurement models were also evaluated.

**Exploratory analyses**
A series of exploratory PCAs with varimax rotation on each set of items were carried out. The number of components to retain was based on the minimum average partial procedure (MAP; Velicer 1976) and parallel analysis (Horn 1965), both recommended procedures (Zwick & Velicer 1986). 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; and (3) estimate internal consistency for each component using Cronbach’s α. Item selection was an iterative process, in which items with loadings on multiple factors and items with poor loadings (< 0.40) 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

Confirmatory structural equation measurement modeling was then conducted. Since all items utilized ordinal Likert scales and the normal assumption of observed variables could not be established, this study utilized robust weighted least square (Flora & Curran 2004) estimation with polychoric correlation. This study evaluated the comparative fit index (CFI) and the root mean squared error of approximation (RMSEA). Values of CFI above 0.80 indicate acceptable fit; values above 0.90 indicate good fit (Hu & Bentler 1999). For RMSEA, values below 0.06 indicate excellent fit (Kline 1998; Tabachnik & Fidell 2001).

External validation

The TTM hypothesizes that individuals in different stages of change 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 (Hall & Rossi 2008), raw scores were converted to T-scores \( (M = 50, \text{SD} = 10). \) T-scores of pros and cons were plotted by the stages, and then patterns were examined graphically, consistent with Prochaska and colleagues (1994). Then, a multivariate analysis of variance (MANOVA) and follow-up ANOVAs with Tukey post hoc tests were conducted, using stage of change as the independent variable and all constructs as dependent variables. Based on previous work (Prochaska 1994; Hall & Rossi 2008), we also calculated maximum differences of pros and cons scores across the stages in both samples.

Results

Participants

Study 1

Table 1 shows all participant characteristics \((n = 588)\). The mean age was 20.6 years \((\text{SD} = 3.98)\). 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. Within the sample, 65.2, 15.8, 13.6, and 5.4\% were freshman, sophomores, juniors, and seniors, respectively.

Study 2

Table 1 shows all participant characteristics \((n = 393)\). The mean age was 26.8 years \((\text{SD} = 13.45)\). About 63.4\% of participants lived off-campus, while the remaining 36.6\% lived on-campus. This sample included 67.7\% women, and 80.9\% Whites, 6.4\% Blacks, 5.6\% Hispanics, and 1.3\% Asians. In this sample, 17.3, 14.2, 22.6, 16.5, 2.3, and 27.0\% were freshman, sophomores, juniors, seniors, graduates students, and university faculty or staff, respectively.

The stages of change distribution of Study 1 participants for AT is shown in Table 1: 57.9\% in PC, 10.8\% in C, 3.7\% in PR, 13.7\% in A, and 13.9\% in M. The stage of change distribution of Study 2 participants for ST is also shown in Table 1: 43.3\% in PC, 20.6\% in C, 7.6\% in PR, 7.1\% in A, and 21.4\% in M.
Principal components analyses (PCA)

Decisional balance

Using Sample 1, all items were subjected to a series of PCAs. The initial 26 items were reduced to 16 items by eliminating 10 items with low or complex loadings. Both MAP and parallel analysis initially indicated a two-factor solution (Table 2). The first five-item factor items reflected positive aspects of AT and were labeled, pros. The second five-item factor items reflected negative aspects of AT, and were labeled, cons. All items showed loadings higher than 0.5. Subscale internal consistencies were good for Pros (five-item $\alpha = 0.82$), and Cons (five-item $\alpha = 0.75$). These two factors together accounted for 55.1 % of the total item variance in Study 1.

Self-efficacy

The initial 17 items were reduced to five through a series of three PCAs, with items removed due to either poor loadings or repetitive content. Remaining items captured
good breadth of challenging situations. The final PCA showed a single factor structure (Table 2), item loadings > 0.70, and excellent internal consistency ($\alpha = 0.90$). This five-item factor accounted for 56.3% of the total item variance in Study 1.

**Climate change doubt**

This four-item factor included items reflecting doubts about the reality or importance of climate change, as well as the need to use AT/ST. All items loaded well (> 0.5) on a single factor and both Cronbach’s internal consistencies were good: Study 1 ($\alpha = 0.75$) and Study 2 ($\alpha = 0.76$).

**Confirmatory factor analyses (CFA)**

Separate CFAs using data from each sample examined the validity of a two-factor-correlated decisional balance model. Fit indices from Sample 1 for the Decisional Balance scale were good, with CFI = 0.959 and RMSEA = 0.079. The correlation between the

| Scale/subscale          | AT 2010 | ST 2012 |
|-------------------------|---------|---------|
| **Decisional balance**  |         |         |
| **Pros**                |         |         |
| Sustainable transportation is worth the extra effort | 0.789   | 0.711   |
| I am proud that I can help the environment by using sustainable transportation | 0.812   | 0.837   |
| Using sustainable transportation is part of being green | 0.779   | 0.787   |
| Sustainable transportation is one way to improve my own health and the health of the planet | 0.789   | 0.847   |
| Sustainable transportation can save me money (gas/parking) | 0.654   | 0.707   |
| **Cons**                |         |         |
| Sustainable transportation is not practical from where I live | 0.647   | 0.524   |
| Sustainable transportation can be a hassle | 0.688   | 0.755   |
| I save time driving by myself | 0.620   | 0.645   |
| Sustainable transportation would be too difficult | 0.769   | 0.836   |
| Sustainable transportation can be too much trouble | 0.792   | 0.840   |
| **Confidence**          |         |         |
| I am running late       | 0.824   | 0.831   |
| I have errands to run   | 0.840   | 0.820   |
| I am tired              | 0.687   | 0.740   |
| I have other people to pick up | 0.702   | 0.713   |
| It is inconvenient      | 0.683   | 0.711   |
| **Climate change doubt**|         |         |
| Worrying about climate change is not worth the time | 0.723   | 0.742   |
| As climate change proceeds, my transportation choices won’t make a difference anyhow | 0.768   | 0.770   |
| Climate change is overblown by the media | 0.726   | 0.769   |
| Climate change is not that serious a problem | 0.758   | 0.767   |

*Varimax rotation.*
Pros and Cons higher order factors was $r = 0.109$. Fit indices for Decisional Balance in Sample 2 were comparable, with CFI = 0.938 and RMSEA = 0.124. The correlation between the Pros and Cons higher order factors in Sample 2 was similar, $r = 0.094$. Lastly, Pros ($\alpha = 0.84$) and Cons ($\alpha = 0.77$) each showed good internal consistency in Sample 2 as well. Standardized path coefficients were very similar to PCA loadings obtained in exploratory analyses. This brief measure showed a clear factor structure with good factor loadings, as well as breadth of construct.

For the Efficacy scale, restricted structural equations models in Sample 1 revealed that fit indices were good (CFI = 0.993 and RMSEA = 0.083). Standardized item path coefficients were comparable to PCA item loadings obtained in exploratory analyses. Sample 2 analyses showed a similarly good pattern of results for this scale with CFI = 0.990, RMSEA = 0.093, and $\alpha = 0.82$.

**External validity**

MANOVAs on all four scales by Stages of change were significant in both samples. Table 3 summarizes the follow-up ANOVA results, means, and SD of standardized Pros, Cons, Self-efficacy, and Climate Change Doubt scales by AT/ST stages of change in Study 1 and Study 2.

**Decisional balance**

Figures 1 and 2 show the patterns of relationship between the Pros, Cons, and AT/ST stages. Table 3 shows the follow-up ANOVA’s stage effects (with Tukey results) for Pros ($\eta^2 = 0.068$ in Study 1 and $\eta^2 = 0.124$ in Study 2), and Cons ($\eta^2 = 0.031$ in Study 1 and $\eta^2 = 0.096$ in Study 2). Compared to those in the PC stage, Pros subscale scores were significantly higher for those in the remaining four stages in Study 1 and in all remaining stages except Action in Study 2. The Cons were significantly higher for those in the PC stage than for those in A in Study 1 and PC,C, and PR stages were all significantly higher on the Cons than those in the M stage in Study 2. Maximal differences were calculated on decisional balance subscales between the PC and A stages (Prochaska et al. 1994; Hall & Rossi 2008). On the Pros subscale, the maximum difference was 0.66 SD in Study 1 and 0.82 SD in Study 2. On the Cons subscale, the maximal difference was 0.54 SD in Study 1 and 0.78 SD in Study 2.

**Self-efficacy**

Significant medium-sized stage effects were found for self-efficacy in both Study 1 ($\eta^2 = 0.103$) and Study 2 ($\eta^2 = 0.102$). Tukey post hoc tests indicated that, compared to the individuals in the PC stage, those in the other four stages showed significantly higher efficacy scores in Study 1 and PC differed from all other stages except A stage in Study 2. Figures 1 and 2 shows mean scores on Self-Efficacy by Stage in both samples.

**Climate change doubt**

No significant differences by stage group were found for the Climate Change Doubt scale in either study.
Table 3. ANOVA results for Pros, Cons, Confidence, and Climate Change Doubt standardized scores by stage.

|                | PC     | C       | PR      | A       | M       | F     | $\eta^2$ | Tukey test       |
|----------------|--------|---------|---------|---------|---------|-------|----------|------------------|
| **2010 AT scale** |        |         |         |         |         |       |          |                  |
| Pros           | 47.76 (10.14) | 52.43 (7.37) | 54.39 (9.15) | 52.79 (9.70) | 53.30 (9.93) | 9.62** | 0.068    | PC < C, PR, A, M |
| Cons           | 51.07 (9.68)  | 50.01 (9.85)  | 51.74 (8.49)  | 46.35 (10.64) | 48.22 (10.22) | 4.21*  | 0.031    | A < PC           |
| Confidence     | 47.40 (9.14)  | 52.04 (9.69)  | 57.66 (9.51)  | 53.30 (10.28) | 54.10 (10.04) | 15.84** | 0.103    | PC < C, PR, A, M |
| Climate Change Doubt | 49.65 (9.25)  | 51.61 (10.62) | 51.85 (9.95)  | 48.93 (10.99) | 50.88 (11.42) | 1.02   | 0.007    | PC, C, PR, A, M  |
| **2012 ST scale** |        |         |         |         |         |       |          |                  |
| Pros           | 46.17 (9.88)  | 52.21 (8.12)  | 54.38 (8.48)  | 49.96 (9.24)  | 54.06 (9.92)  | 13.68** | 0.124    | PC < C, PR, M    |
| Cons           | 52.21 (10.47) | 51.55 (8.34)  | 50.54 (6.97)  | 48.44 (9.06)  | 44.36 (9.64)  | 10.35** | 0.096    | M < PC, C, PR    |
| Confidence     | 46.69 (9.56)  | 50.87 (9.62)  | 53.01 (9.75)  | 50.50 (7.90)  | 54.61 (9.76)  | 10.99** | 0.102    | PC < C, PR, M    |
| Climate Change Doubt | 50.69 (9.86)  | 50.24 (10.44) | 52.18 (8.96)  | 51.13 (9.23)  | 47.22 (10.12) | 2.32   | 0.023    | PC, C, PR, A, M  |

Note: All scores are standardized to T-scores ($M = 50, SD = 10$) to allow comparisons.

*p < 0.05; **p < 0.001.
Discussion

These results demonstrate the internal and external validity of key TTM constructs applied to AT and ST. Although the definition of these constructs was identical in every other way, results (see Table 3) were slightly stronger using the word, Sustainable, compared to Alternative, transportation. Based on this, we recommend using ST more broadly. Validation of these measures provides a solid foundation for both TTM research and intervention development. In this study, only about 25% of both university-based samples were in the action or maintenance stages for AT/ST, commuting by any other means than SOV. Of the remaining participants who did commute by SOV, the largest subgroup was not considering ST within the next six months (precontemplation). This stage distribution differs markedly from that of an Australian sample of both students and faculty/staff (Shannon et al. 2006), but is more consistent with that shown in British students (Gatersleben & Appleton 2007) for bicycling. These results are consistent with recent findings that framing the future in light of a longer past may not only explain some national differences, but enhance environmental concerns (Hershfield et al. 2014). These results also underscore the challenges faced by conservationists and
interventionists and demonstrate that ST interventions need to be able to assist the large percentage of individuals who are not yet ready to change their commuting to adopt more active and ST. TTM-tailored intervention strategies have been successful for individuals at all stages of change across a wide range of health behaviors (Noar et al. 2007; Krebs et al. 2010). Future studies will reveal whether these challenges may be even more pronounced in a more representative and diverse community-based sample.

These decisional balance and self-efficacy scales for AT/ST are reasonably short, internally consistent, and psychometrically sound. The decisional balance measure consisted of two first-order factors. This model replicates the general two-factor model found across a range of other behaviors (Prochaska et al. 1994; Hall & Rossi 2008). Measuring both pros and cons will enable us to evaluate these constructs separately and to tailor interventions accordingly (Redding et al. 1999). The reasonable confirmatory model fit indices for the self-efficacy scale suggests that more work may be useful to further develop and refine that scale.

Decisional balance demonstrated hypothesized relationships with AT and ST stages of change, generally replicating TTM stage and decisional balance relationships found across a range of health behaviors (Hall & Rossi 2008). Briefly, the cons outweighed the pros in precontemplation, while the opposite was true in the action and maintenance stages. Further, mean sum scores on Pros and Cons subscales were significantly different across the stages, accounting for between 3–10% (Cons) and 7–12% of the variance (Pros) across samples. This study found that consistent with TTM predictions, AT/ST confidence scores were higher among those in later stages than those in the precontemplation stage, and that stage differences accounted for about 10% of the variance in self-efficacy scores in both samples. These cross-sectional results underscore the salience of these constructs in this area and warrant future longitudinal examination.

Also interesting was that the brief negative attitudes scale, Climate Change Doubt, did not differ across the stages in either sample. If future studies continue to find no differences across the stages, we can conclude that doubting attitudes toward climate change may be poorly related to intentions to initiate or practice AT/ST. This subscale may still prove useful to identify specific subgroups of individuals, as has been done in other research (Leiserowitz et al. 2011). One important future challenge is to engage individuals who doubt the reality or importance of climate change in AT/ST efforts, as among those watching specific conservative media (Hmielowski et al. 2013). One potential strategy to engage these individuals may be to emphasize personal fitness and/or financial benefits, or to frame the US as a country with a long history (Hershfield et al. 2014). Alternative built environment and/or policy-based solutions (Taylor & Ampt 2003) are also warranted to better engage all segments of the population in conservation efforts.

This study has some limitations. First, both samples were cross-sectional, limiting our ability to examine causal relationships. Examining these construct relationships longitudinally is an important future direction. Second, both samples were university-based convenience samples. These results should be replicated with larger and more diverse populations, including additional community-based urban and rural settings, as well as expanded to examine additional potentially important climate conservation and/or adaptation behaviors (e.g. Green Eating; Weller et al. 2014). The specific pattern of these measures having their highest scores in preparation was unusual, although it may simply reflect the very small sample size in this preparation stage groups. Finally, this study produced four brief, psychometrically sound measures (see complete measures as supplementary materials) that can enhance research and intervention development targeting active and ST promotion.
**Supplemental data**

Supplemental data for this article can be accessed [http://dx.doi.org/10.1080/09603123.2014.938025](http://dx.doi.org/10.1080/09603123.2014.938025).

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