Project Report

The Stability of Transport-Related Attitudes over Time: A Case Study During COVID-19

Prepared for **Teaching Old Models New Tricks (TOMNET) Transportation Center**

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16. Abstract
The usefulness of attitudes in travel demand forecasting requires predictability. Since travel demand models aim to simulate future populations, research would be impracticable if the characteristics of the populations were subject to substantial unpredictable variation over time. We investigate the stability of individuals' attitudes using waves of the COVID Future survey answered 3.5–9.5 months apart. Both individual attitudinal statements and factor-analyzed attitudes demonstrate moderate stability. This stability is mostly consistent across different sub-populations, although certain groups such as young people displayed lower levels of stability than the general population. Attitudes about home environment and lifestyle were particularly stable, while those about pandemic-specific topics such as remote work or disease risk were more unstable. We conclude that attitudes generally display stability, although the presence of significant life disruptions likely produces temporary instability. We also demonstrate that the stability of attitudes can have an effect on the stability of intended future actions.

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EXECUTIVE SUMMARY

Attitudes and preferences are important for modeling travel behavior (Conway et al., 2020). While the importance of attitudinal variables in predicting transport choices is mostly well-established in the literature (de Abreu e Silva, 2014; Belgiawan et al., 2016; Kitamura et al., 1997), some dissent comes from those who dispute the long-term stability (and therefore *utility*) of at least certain attitudes (Jensen et al., 2013; Borriello & Rose, 2021). While some have found stability in transport-related attitudes (van de Coevering et al., 2021; Willis & Lee, 1980), others have reported instability over time frames ranging from one week to two years (Sunkanapalli et al., 2000; Adams et al., 2013; Thøgersen, 2006).

We investigate the stability of individuals' attitudes using waves of the COVID Future survey answered 3.5–9.5 months apart. The survey included Likert-scaled indicators of travel-related attitudes ranging from environmentalism to opinion on remote work. We compared both individual attitudinal statement stability over time as well as factor-analyzed attitudinal stability over time.

Both comparisons indicate moderate stability in attitudes. This stability is mostly consistent across different sub-populations, although certain groups such as young people displayed lower levels of stability than the general population. Attitudes about home environment and lifestyle were particularly stable, while those about pandemic-specific topics such as remote work or disease risk were more unstable. We conclude that attitudes generally display stability, although the presence of significant life disruptions likely produces temporary instability. We also demonstrate that the stability of attitudes can have an effect on the stability of intended future actions.

The data collected in this project is publicly and permanently available on the ASU Dataverse (https://dataverse.asu.edu/dataverse/covidfuture).

Abstract

The usefulness of attitudes in travel demand forecasting requires predictability. Since travel demand models aim to simulate future populations, research would be impracticable if the characteristics of the populations were subject to substantial unpredictable variation over time. We investigate the stability of individuals' attitudes using waves of the COVID Future survey answered 3.5–9.5 months apart. Both individual attitudinal statements and factor-analyzed attitudes demonstrate moderate stability. This stability is mostly consistent across different sub-populations, although certain groups such as young people displayed lower levels of stability than the general population. Attitudes about home environment and lifestyle were particularly stable, while those about pandemic-specific topics such as remote work or disease risk were more unstable. We conclude that attitudes generally display stability, although the presence of significant life disruptions likely produces temporary instability. We also demonstrate that the stability of attitudes can have an effect on the stability of intended future actions.

1 Introduction

Attitudes and preferences are important for modeling travel behavior (Conway et al., 2020). While the importance of attitudinal variables in predicting transport choices is mostly well-established in the literature (de Abreu e Silva, 2014; Belgiawan et al., 2016; Kitamura et al., 1997), some dissent comes from those who dispute the long-term stability (and therefore *utility*) of at least certain attitudes (Jensen et al., 2013; Borriello & Rose, 2021). While some have found stability in transport-related attitudes (van de Coevering et al., 2021; Willis & Lee, 1980), others have reported instability over time frames ranging from one week to two years (Sunkanapalli et al., 2000; Adams et al., 2013; Thøgersen, 2006). Because of their correlation with relatively stable behaviors (e.g., mode choice), we hypothesize that transport-related attitudes are themselves stable over time. We also expect the stability of attitudes to be reflected in the outcomes they are hypothesized to influence; that is, more stable attitudes should be held by people with more stable behavior. We also hypothesize that stability will be lower for individual statements than for factors which represent underlying attitudes indicated by multiple questions, since factors are less likely to reflect idiosyncratic responses to individual questions.

The remainder of this article is organized as follows. Section 2 describes the data used in this study, which was collected during the COVID-19 pandemic. Section 3 presents an analysis of responses to single attitudinal statements across multiple survey waves. Section 4 describes our methodology for factor analysis and summarizes the stability of attitudinal factors derived from the statements appearing in section 3. In section 5, sub-samples of respondents based on demographics, personal characteristics, survey experience, and pandemic experience are separately analyzed to explore heterogeneity in attitudinal stability across the sample. Section 6 addresses the connection between attitudinal stability and stability of expected behavior and Section 7 concludes with key findings and suggestions for future research.

2 Data

Our data come from the first two waves of the COVID Future survey, which were administered in June 2020–October 2020 and November 2020–May 2021 (Chauhan et al., 2021). COVID-19's impact on travel, shopping and dining habits, remote working, and learning were major topics covered in the survey. Also included was a battery of attitudinal statements covering respondents' perceptions and opinions related to these topics. Individual responses were recorded three and a half to nine and a half months apart. About 50% of responses were recorded between four and seven and a half months apart, with an average gap between responses of five and a half months. To achieve a large, representative sample, we contacted respondents through survey organizations (Data Axle and Qualtrics) using a quota-sampling method. The 2,673 respondents analyzed here are fairly representative, though older, more educated, more likely to be female, and slightly higher income than the population (Table A1). One potential source of sample bias is that our Wave 1 respondents were quota-sampled to be representative, but respondents had to return for the second wave of the survey for this analysis. A higher likelihood of certain individuals to complete the Wave 2 survey could contribute to a non-representative sample. All respondents were from the United States, with 45 of 50 states and Washington, D.C. represented[1].

3 Stability of attitudinal statements

The survey included Likert-scaled indicators of travel-related attitudes ranging from environmentalism to opinion on remote work. For each of the 26 attitudinal statements analyzed here, we recorded the mean score for each of the two waves of the survey and the mean absolute difference in score, with a one-point difference indicating a one-point shift on a five-point scale[2]. We also reported the percentage of respondents who answered a question identically in both waves of the survey as well as the percentage of respondents whose change in answer between waves was zero or one points. An intraclass correlation coefficient (ICC) is provided for each question. ICC is a correlation coefficient used to measure the similarity of observations between paired waves of data (Liljequist et al., 2019). As is recommended by Koo and Li (2016), a two-way mixed effect, absolute agreement, single rater ICC is calculated. This form of ICC is appropriate since the data involves a repeated sample of the same raters ("two-way"), cannot be perfectly generalized ("mixed effects"), is not concerned with relative consistency ("absolute"), and deals with individual rather than group consistency ("single rater").

Travel-related attitudinal statements demonstrate moderate stability (Table 1). The mean absolute difference in score was less than one for all statements. For most statements, only 50-60% of respondents provided exactly the same answers in both waves, which could suggest that responses are not stable. However, close 90% of respondents on average selected an answer that was the same or adjacent on the Likert scale—for instance, transitioning from strongly disagree to somewhat disagree. These small changes are unlikely to substantially affect modeling outcomes, particularly once factor-analyzed.

Koo and Li (2016) suggest ICC cutoffs of 0.5, 0.75, and 0.9 to signify moderate, high, and excellent stability, respectively. All statements have moderate stability, except one with high

[1]The sample did not include any respondents from Alaska, Delaware, Hawaii, North Dakota, or Wyoming

[2]Scores are coded from -2 to 2, with positive numbers indicating agreement

stability and one with low stability. The average ICC is 0.63 for an attitudinal question.

Figure 1 illustrates the stability of attitudinal statements by displaying heatmaps for the questions with varying ICC values. Darker values indicate higher numbers of respondents associated with a particular cell. All questions show a clustering of respondents along the bottom left-top right diagonal, which contains the 5 cells associated with the same answer in both waves of the survey.

	Mean					
	Wave 1	Wave 2	Mean absolute difference	Percent exactly matching	Percent within 1 point	Intraclass correlation coefficient
Shutting down businesses to prevent the spread of coronavirus is not worth the economic damage that will result	-0.57	-0.37	0.65	55%	86%	0.71
I am concerned that friends or family members will have a severe reaction to the coronavirus if they catch it	0.99	0.89	0.57	57%	90%	0.64
Society is overreacting to the coronavirus	-0.98	-0.96	0.47	68%	90%	0.76
If I catch the coronavirus, I am concerned that I will have a severe reaction	0.69	0.53	0.61	56%	87%	0.69
Everyone should just stay home as much as possible until the coronavirus has subsided	1.05	0.93	0.56	58%	90%	0.69
My friends and family expect me to stay at home until the coronavirus subsides	0.32	0.24	0.81	44%	81%	0.54
I am committed to using a less polluting means of transportation (e.g., walking, biking, and public transit) as much as possible	0.21	0.18	0.62	51%	89%	0.66
I am committed to an environmentally-friendly lifestyle	0.72	0.71	0.45	61%	95%	0.70
Sometimes I worry about the effects of airplane trips on the environment	-0.01	0.00	0.65	52%	87%	0.69
I dislike change	0.12	0.11	0.55	57%	90%	0.67
I enjoy spending time with the people I live with	1.22	1.22	0.39	68%	94%	0.65
The time I spend traveling to places provides a useful transition between activities	0.66	0.66	0.67	49%	87%	0.42
Apartment living doesn't provide enough privacy	0.56	0.58	0.70	50%	85%	0.56
Having shops and services within walking distance of my home is important to me	0.39	0.38	0.66	49%	88%	0.67
I like to have a yard at home	1.25	1.25	0.39	68%	94%	0.72
Even if I do not end up buying anything, I still enjoy going to stores and browsing	0.33	0.31	0.68	52%	86%	0.66
In-person shopping is usually a chore for me	-0.14	-0.13	0.64	53%	88%	0.69
I enjoy shopping online	0.94	0.97	0.45	63%	94%	0.71
Online learning is a good alternative to high school- and college-level classroom instruction	0.16	0.07	0.84	43%	79%	0.53
Video calling is a good alternative to in-person business meetings	0.78	0.78	0.67	50%	87%	0.50
Video calling is a good alternative to visiting friends and family	0.25	0.17	0.81	46%	80%	0.55
I am generally satisfied with my life	0.80	0.80	0.58	59%	89%	0.58
It is hard to get motivated to work away from the main office	-0.34	-0.34	0.72	51%	82%	0.51
I like working from home	0.52	0.47	0.58	59%	86%	0.64
I enjoy the social interaction found at a conventional workplace	0.64	0.62	0.55	56%	91%	0.64
Learning how to use new technologies is often frustrating	-0.09	-0.04	0.63	54%	87%	0.69

Table 1: Test-retest reliability of individual attitudinal statements

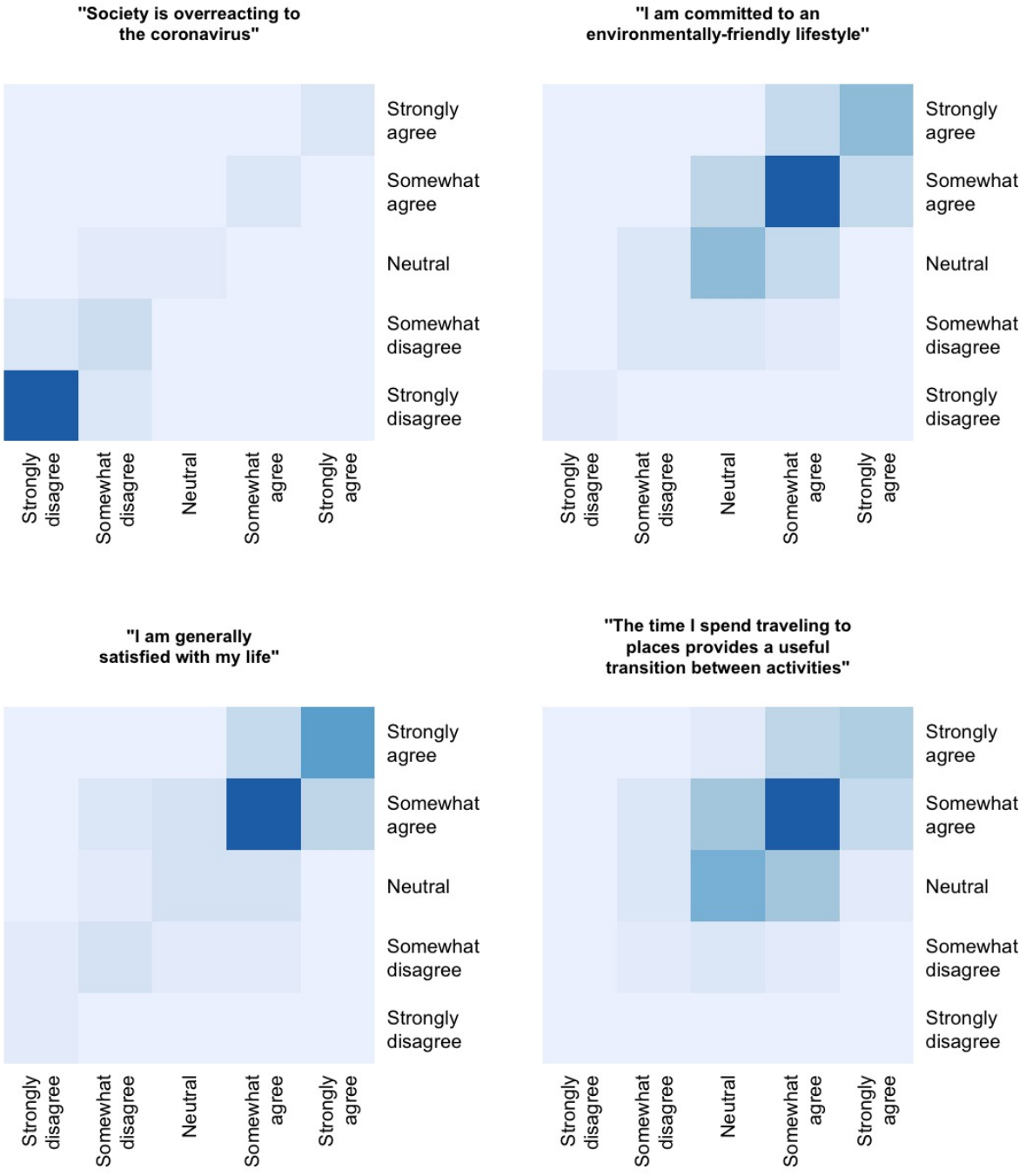

Figure 1: Heatmaps of Wave 1 and Wave 2 responses to four attitudinal statements; Wave 1 responses are recorded along the x-axis and Wave 2 responses are recorded along the y-axis

4 Stability of attitudinal factors

Factor analysis is a strategy commonly used to identify attitudinal constructs by reducing a large number of indicator statements to a smaller set of underlying factors (Conway et al., 2020). We performed an exploratory factor analysis of the attitudinal statements to identify eight factors from Wave 1 responses (Table B1). An eight-factor solution was chosen because it produces interpretable factors with eigenvalues greater than 1.

Using the regression method, we estimated factor scores for both Wave 1 and Wave 2 responses. Factor analysis is generally applied to standardized data (Grice, 2001). In order to make factor scores directly comparable, we "standardized" the Wave 2 responses *using the mean and standard deviation of the Wave 1 data*. We then scored both waves of responses using identical weights generated from Wave 1 data. Once factor scores had been computed, we standardized them to have mean 0 and standard deviation 1. Since the Wave 1 data was used for standardization, the mean and standard deviation of Wave 2 factor scores were slightly different from 0 and 1, although close. Because of these standardization and scoring techniques, Wave 1 and Wave 2 scores are directly comparable and a 1-point change in a factor score can be interpreted as a one-standard deviation change.

In line with the methodology of Adams et al. (2013), we calculated an ICC for the Wave 1 and Wave 2 scores for each attitude. As with our analysis of individual questions, we calculated the mean score difference and mean absolute score difference between waves, as well as the percentage whose Wave 1 and Wave 2 scores were within one standard deviation of each other.

Our analysis shows that factor-analyzed attitudes are also moderately stable (Table 2). Changes in factor scores are symmetrical around 0, showing no definite trend over time (Figure 2)[3]. The mean absolute changes in score are all fractions of a standard deviation. The changes in attitude that did occur were fairly small in magnitude; 89–93% of respondents recorded a change in factor score of less than one standard deviation. Using the guidelines recommended by Koo and Li (2016), all attitudes display moderate stability.

An unexpected result is the lack of improved stability once attitudinal statements are factor analyzed. Although the average ICC among factors (0.66) is slightly higher than that of questions (0.63), the difference is not great. This contradicts previous research (Adams et al., 2013). The higher stability of factors is generally found because idiosyncratic responses to certain questions reduce question-level stability more dramatically than they reduce factor-level stability. Such idiosyncratic responses may have been uncommon in this data set.

As a visual presentation of factor-level stability, respondents' Wave 1 and Wave 2 scores for a given factor were plotted (Figure 3). These scatter plots show clustering around the identity line, indicating that most respondents have Wave 2 scores very close to their Wave 1 scores[4].

[3]The unusual distribution of the "Pro-In-Person-Shopping" histogram is a result of this factor score being determined almost entirely by a single question (see Table B1)

[4]The unusual cloud of points on the "Pro-In-Person-Shopping" scatter plot is a result of this factor score being determined almost entirely by a single question (see Table B1)

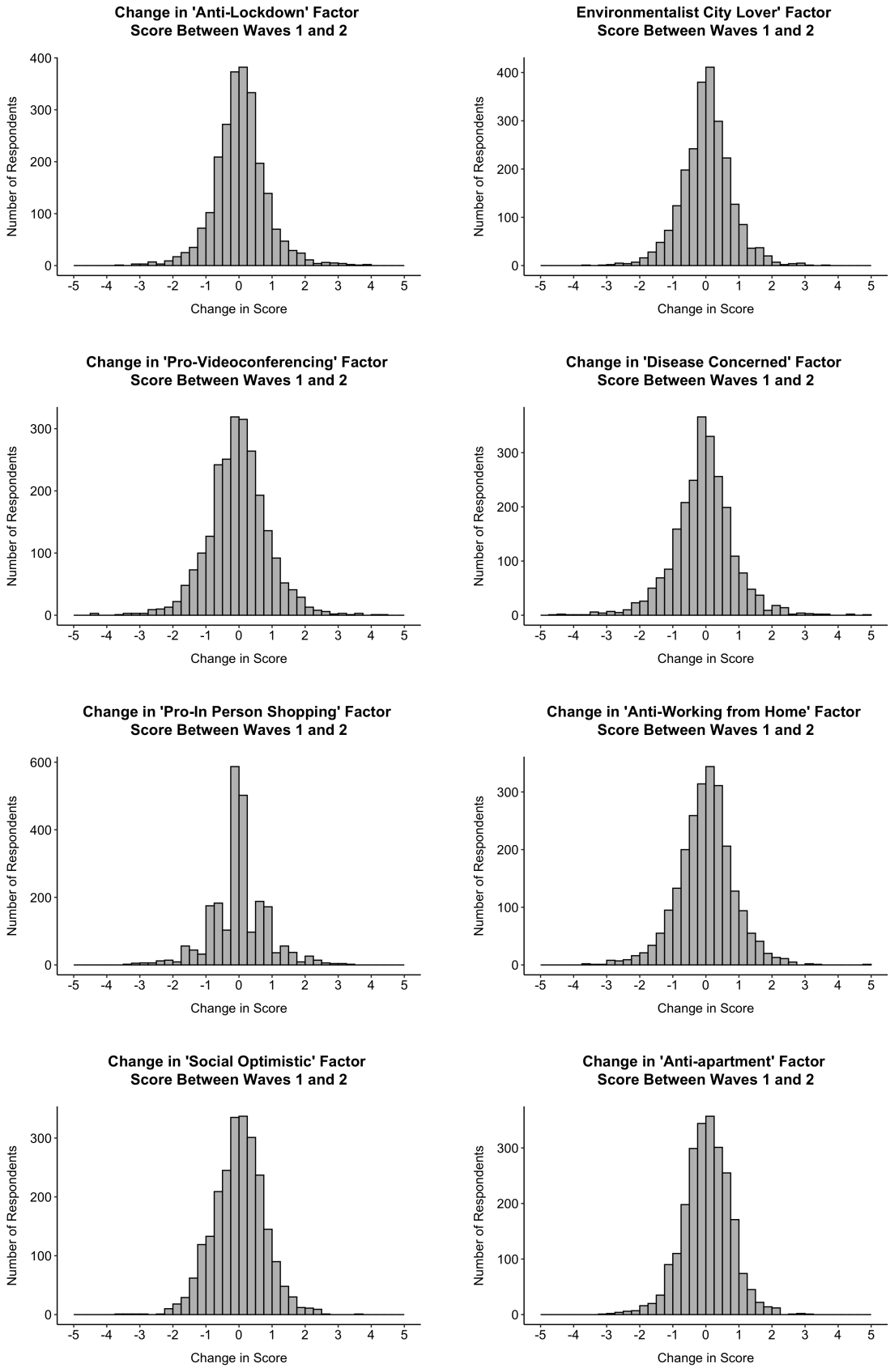

Figure 2: Histogram of changes in score between Wave 1 and Wave 2 for each factor from the Wave 1 factor analysis

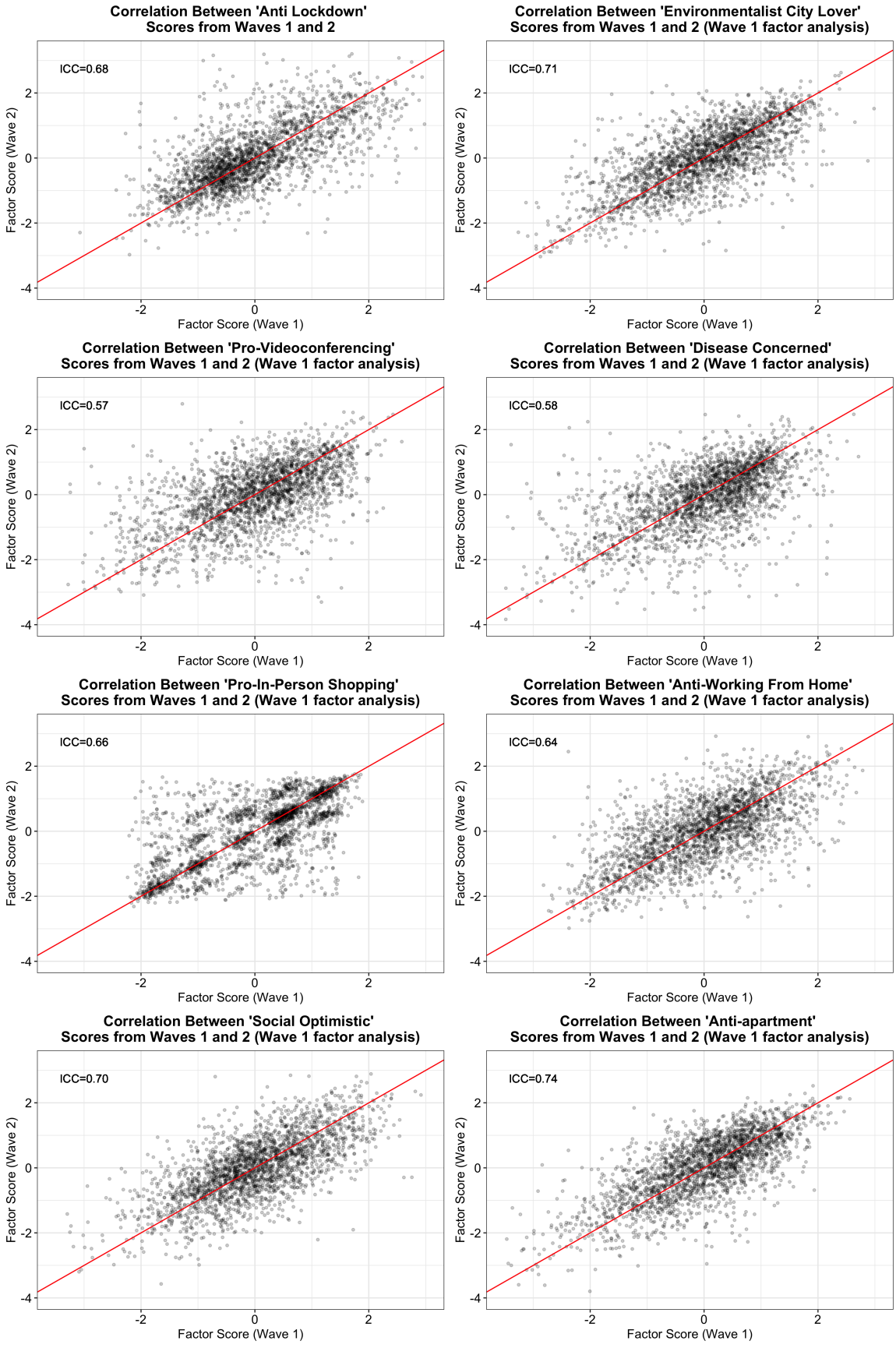

Figure 3: Correlations between Wave 1 and Wave 2 scores for each factor from the Wave 1 factor analysis

	Mean change in score	Mean absolute change in score	Percent within 1 SD	ICC
Anti-lockdown	0.04	0.57	91%	0.68
Environmentalist city lover	0.03	0.56	92%	0.71
Pro-videoconferencing	-0.03	0.67	89%	0.57
Disease concerned	-0.08	0.67	91%	0.58
Pro-in-person-shopping	-0.00	0.57	92%	0.66
Anti-working from home	0.00	0.63	90%	0.64
Social optimistic	-0.00	0.60	92%	0.70
Anti-apartment	0.03	0.56	93%	0.74

Table 2: Summary of Waves 1 and 2 factor scores based on Wave 1 factor analysis

5 Robustness check across sub-samples

We also analyzed the attitudinal stability of specific sub-populations of respondents. First, we grouped respondents by demographics and personal characteristics such as age, gender, education status, industry of employment, and household size. For this analysis, we considered high income respondents to be those making over $100,000 annually and low income respondents to be those making under $50,000 annually. Large households were those containing more than three people. Finally, the cutoff for living an an urban environment was a zip code-level housing density of at 854.4 housing units per square kilometer and the cutoff for a rural environment was less than 39.4 housing units per square kilometer Kolko, 2015.

Next, we created groups based on when respondents took the survey, the gap between Wave 1 and Wave 2 responses, and the manner through which the respondent was recruited. A long gap between survey waves was at least 135 days and an early respondent took the Wave 1 survey by the end of July 2020.

Finally, we categorized respondents by whether they had experienced certain events such as transitioning to remote work, contracting COVID-19, and living under various lockdown measures. For each group, we replicated the factor-level analysis outlined above and provided an ICC for each factor based on only members of that particular group. This served the dual purpose of acting as a robustness check and allowing for more detailed conclusions to be drawn about attitude stability across the population.

Two of the most important demographic characteristics that appear to impact stability are age and education level. Respondents younger than 35 have lower stability, a result consistent with other findings from the literature (Alwin & Krosnick, 1991; Visser & Krosnick, 1998). Likely because most are under age 35, students in the sample have less stable attitudes than non-students. In addition to age, higher levels of educational attainment are associated with higher attitudinal stability. Workers who describe themselves as being employed in a professional field report their own attitudes more consistently than non-workers or those employed in other fields. Similar to the

case of students and young people, the attitudinal stability of professionals likely results from most members of this group holding at least an undergraduate degree.

Factor	Men (n=925)	Women (n=1732)	Age<35 (n=340)	Age 35-64 (n=1365)	Age≥65 (n=926)	Bach. degree (n=1465)	No bach. degree (n=1207)	High income (n=777)
Anti-lockdown	0.69	0.68	0.62	0.68	0.70	0.70	0.66	0.67
Environmentalist city lover	0.71	0.71	0.63	0.73	0.72	0.73	0.69	0.70
Pro-videoconferencing	0.58	0.57	0.58	0.59	0.55	0.61	0.52	0.60
Disease concerned	0.53	0.61	0.57	0.60	0.58	0.54	0.63	0.56
Pro-in person shopping	0.67	0.64	0.53	0.65	0.68	0.68	0.62	0.70
Anti-working from home	0.63	0.65	0.65	0.64	0.61	0.69	0.58	0.69
Social optimistic	0.69	0.70	0.66	0.72	0.70	0.71	0.68	0.67
Anti-apartment	0.74	0.74	0.68	0.73	0.77	0.73	0.75	0.68

Factor	Mid income (n=883)	Low income (n=937)	Small household (n=1719)	Large household (n=946)	Urban (n=847)	Sub-urban (n=1618)	Rural (n=193)	Essential worker (n=573)
Anti-lockdown	0.71	0.67	0.70	0.65	0.68	0.69	0.69	0.64
Environmentalist city lover	0.70	0.73	0.73	0.68	0.70	0.70	0.71	0.66
Pro-videoconferencing	0.60	0.53	0.56	0.60	0.61	0.55	0.58	0.49
Disease concerned	0.62	0.56	0.58	0.59	0.62	0.56	0.60	0.53
Pro-in person shopping	0.69	0.61	0.68	0.61	0.63	0.67	0.68	0.59
Anti-working from home	0.62	0.62	0.64	0.64	0.64	0.66	0.54	0.57
Social optimistic	0.66	0.71	0.72	0.66	0.72	0.70	0.68	0.67
Anti-apartment	0.76	0.75	0.76	0.68	0.76	0.70	0.69	0.67

Factor	Profes-sional (n=558)	Admin-istrator (n=112)	Other worker (n=136)	Non-worker (n=1293)	Student (n=178)	Non-student (n=2495)	All (n=2673)
Anti-lockdown	0.71	0.60	0.68	0.70	0.57	0.69	0.68
Environmentalist city lover	0.73	0.59	0.73	0.73	0.62	0.72	0.71
Pro-videoconferencing	0.71	0.66	0.53	0.54	0.55	0.58	0.57
Disease concerned	0.59	0.64	0.63	0.59	0.56	0.58	0.58
Pro-in person shopping	0.75	0.67	0.71	0.64	0.51	0.67	0.66
Anti-working from home	0.73	0.74	0.68	0.57	0.60	0.65	0.64
Social optimistic	0.73	0.67	0.69	0.70	0.62	0.71	0.70
Anti-apartment	0.75	0.61	0.75	0.77	0.58	0.75	0.75

Table 3: Attitudinal factor stability (ICC values) for different demographic groups

In addition to personal characteristics, respondents were also grouped by how and when they took the COVID Future survey (Table 4). Both waves of data collection took place over fairly broad time periods. As a result, respondents varied widely in how long they waited between

taking the first and second waves. Unsurprisingly, respondents with a short gap reported their attitudes more consistently than those who were surveyed over a longer time period. However, the difference between these two groups for many questions is not large, which is an encouraging sign that attitudinal stability does not deteriorate rapidly as the time scale for repeated measurements moves from the short-term to the medium-term.

Attitude stability also varied by when respondents were surveyed. Those who took Wave 1 early in the pandemic provided more stable responses than those who were initially surveyed later. Major life events or disruptions have been found by some to cause attitudinal change (Hatemi, 2013; Janke & Handy, 2019), and the COVID-19 pandemic will undoubtedly cause permanent attitudinal changes for many. The timing and mechanisms by which pandemic experience alters attitude are likely dependent on an individual's preexisting opinions, the severity of the pandemic in their region (and the timing of this severity), governmental response, and other context-specific characteristics. While regional variation existed, the severity of the COVID-19 pandemic in the United States generally worsened toward the end of 2020 and peaked in early 2021. It is possible that people surveyed during this period of severe outbreak were experiencing a greater magnitude of disruption in their lives and therefore had less stable attitudes.

Respondents were contacted by a variety of means for the COVID Future survey. A Qualtrics opinion panel was used in addition to direct emails via Data Axle from both the University of Illinois at Chicago (UIC) and Arizona State University (ASU). Respondents contacted by UIC via email had the lowest average attitudinal stability, but this is largely due to their extremely low stability on the Disease concerned factor; the three groups showed similar stability for all other attitudes

Factor	Long gap (n=1447)	Short gap (n=1198)	Early (n=1924)	Late (n=749)	Qualtrics (n=1776)	ASU group (n=710)	UIC group (n=187)	All (n=2673)
Anti-lockdown	0.67	0.71	0.69	0.67	0.69	0.66	0.66	0.68
Environmentalist city lover	0.68	0.74	0.73	0.67	0.72	0.69	0.70	0.71
Pro-videoconferencing	0.58	0.57	0.56	0.61	0.56	0.59	0.52	0.57
Disease concerned	0.55	0.62	0.60	0.53	0.63	0.52	0.35	0.58
Pro-in person shopping	0.65	0.66	0.66	0.66	0.65	0.67	0.63	0.66
Anti-working from home	0.63	0.66	0.66	0.60	0.62	0.71	0.59	0.64
Social optimistic	0.68	0.73	0.73	0.64	0.69	0.69	0.70	0.70
Anti-apartment	0.71	0.76	0.74	0.73	0.75	0.70	0.73	0.74

Table 4: Attitudinal factor stability (ICC values) for different non-demographic groups

A final robustness check examined whether pandemic experience affected attitudinal stability (Table 5). The health risk posed by COVID-19 and a transition to remote work have been two of the pandemic's most wide-reaching impacts. However, personal experience with either did not have an impact on attitude stability. Those who believed themselves or a household member had COVID-19 did not exhibit markedly different stability from those who did not believe anyone in their household had the disease. Similarly, attitude stability did not differ noticeably across those who had experience working from home before pandemic, those who began working from home for the first time during the pandemic, and those who were in-person workers both before and

during the pandemic. On the other hand, our survey indicates that experiences such as lockdowns that affected groups of people more evenly did have an impact on attitudinal stability. People who experienced closures of schools or businesses reported more consistent attitudes than those who did not experience these, perhaps because the severity of COVID-19 was mitigated by such policies. No similar effects were found for those who experienced mask mandates and social distancing or stay-at-home orders.

Moving has been a unique experience during the pandemic, especially among those who have chosen to move as a direct result of a transition to online work. Movers reported greater attitudinal change between waves than non-movers. This is unsurprising, given that movers would have experienced a life disruption of greater magnitude than non-movers.

Factor	Had COVID-19 (n=390)	No COVID-19 (n=2283)	Previous WFH (n=395)	New WFH (n=344)	No WFH (n=474)	Masks (n=2500)	No masks (n=173)	Distance (n=2484)
Anti-lockdown	0.65	0.69	0.65	0.69	0.68	0.68	0.68	0.68
Environmentalist city lover	0.67	0.72	0.67	0.69	0.69	0.71	0.76	0.71
Pro-videoconferencing	0.55	0.58	0.63	0.62	0.58	0.58	0.48	0.58
Disease concerned	0.57	0.59	0.57	0.58	0.56	0.58	0.56	0.58
Pro-in person shopping	0.68	0.65	0.68	0.70	0.65	0.66	0.58	0.66
Anti-working from home	0.67	0.64	0.64	0.69	0.59	0.65	0.53	0.64
Social optimistic	0.68	0.71	0.71	0.67	0.71	0.70	0.75	0.70
Anti-apartment	0.74	0.74	0.70	0.73	0.72	0.73	0.80	0.74

Factor	No distance (n=189)	Closures (n=2493)	No closures (n=180)	Movers (n=150)	Non movers (n=2523)	All (n=2673)
Anti-lockdown	0.78	0.69	0.56	0.63	0.69	0.68
Environmentalist city lover	0.73	0.71	0.70	0.66	0.71	0.71
Pro-videoconferencing	0.46	0.58	0.48	0.63	0.57	0.57
Disease concerned	0.67	0.58	0.60	0.46	0.59	0.58
Pro-in person shopping	0.63	0.67	0.48	0.62	0.66	0.66
Anti-working from home	0.62	0.65	0.54	0.57	0.65	0.64
Social optimistic	0.77	0.71	0.64	0.59	0.71	0.70
Anti-apartment	0.71	0.74	0.74	0.57	0.75	0.74

Table 5: Attitudinal factor stability (ICC values) for groups with different pandemic experiences

An in-depth robustness check reveals that some key groups of respondents experienced unusually stable or unstable attitudes during the COVID-19 pandemic. Despite this heterogeneity, all 42 sub-samples of respondents show fairly consistent levels of stability. Attitudinal factors with stability outside the "moderate" range (ICC greater than 0.75 or less than 0.5) were rare.

6 Impact of attitudinal stability on behavioral expectations

Finally, we explored the relationship between attitude stability and behavioral stability. Our hypothesis is that attitudes should be fairly stable since they are often found to be important predictors of stable behaviors such as mode choice. Evidence for this relationship would be found in the form of a correlation between attitudinal stability and behavioral stability. The COVID Future survey gathered information from respondents on their expectations of future behaviors such as working from home, using various daily travel modes, flying, dining in a restaurant, taking online classes, and more. We selected attitudes and behaviors with a plausible relationship to each other (for example, the Environmentalist city lover attitude and flying for personal trips) and performed an analysis of variance (ANOVA) to determine the relationship between attitude stability and stability of expected behavior. Respondents were grouped based on how different their Wave 1 and Wave 2 expectations of behavior were (an ordinal scale was used to report expected future behavior; for personal airplane trips, respondents could report ”much less [than before COVID-19]”, ”somewhat less”, ”about the same”, ”somewhat more”, or ”much more” – other behavioral outcomes used this scale or a similar one). For example, a respondent might be classified as reporting identical expectations in both waves of the survey, shifting one rank along the ordinal scale, shifting two ranks along the ordinal scale, and so on. Then, an ANOVA was used to determine if absolute changes in factor score between waves differed among groups.

The stability of the Environmentalist city lover, Pro-videoconferencing, Disease concerned, and Pro-in-person shopping factors were all found to be related to the stability of one or more expected future behaviors. Variable scores for the Environmentalist city lover factor were found to be more common among those whose expectations for future pedestrian travel and future personal airplane travel changed between waves. Stability in expectations of personal airplane travel were also related to stability of the Disease concerned attitude. The stability of the Pro-videoconferencing attitude was correlated with the stability of students’ desire to take online classes in the future. Finally, a stable Pro-in-person shopping attitude was associated with stable expectations about ordering groceries online for delivery. To the extent that the stated preference data of the COVID Future survey will be reflective of actual future behavior, attitude stability and behavioral stability exhibit a relationship in many cases.

Notably, some expected associations between stable attitudes and stable behavioral expectations were not found in our data. One notable example is that the variability of the Anti-working-from-home attitude has no impact on how constant respondents’ expectations about actually working from home were. Similarly, an unstable level of Disease concern had no association with unstable expectations about future use of public transit. Along with other insignificant tested relationships, these examples show that the association between attitudinal stability and expected behavioral stability is not universal.

7 Conclusion

We conclude that attitudes are moderately stable over a period of three and a half to nine and a half months. Despite our hypothesis to the contrary, we find that the stability of individual attitudinal statements is comparable to that of factor-analyzed attitudes. We also find multiple instances of attitudinal stability being predictive of expected behavioral stability. This supports the hypothesis

that attitudinal stability can, to an extent, be inferred from the stability of the outcomes which it predicts.

Our analyses also suggest that there is varied stability between different attitudes. 'Pro-videoconferencing, Disease concerned, and Anti-working from home are the least stable attitudes across the general sample as well as many demographic subgroups, possibly because the pandemic has caused many people to experience remote work, virtual communication technologies, and public health concerns in a way that was new to them. Consistent with findings from the field of psychology, the increased familiarity with these ways of life may induce positive or negative attitudinal changes (Moreland & Zajonc, 1982; Norton & Frost, 2007). On the other hand, the most stable attitudes in the survey were those which likely were affected least by the COVID-19 pandemic. The Anti-apartment, Environmentalist city lover, and Social-optimistic attitudes tended to change less between survey waves than explicitly pandemic-related attitudes.

Nevertheless, the pervasive effects of COVID-19 likely influenced the stability of even these tangentially related attitudes – urban life and socialization have certainly undergone changes during COVID-19. Psychological research suggests that such major life disruptions are associated with attitude change (Hatemi, 2013), and this relationship has been found for travel-related attitudes in particular (Janke & Handy, 2019). COVID-19 constitutes a major life event for many, so the stability observed here could be unusually low. In fact, some other reviews of the stability of transport-related attitudes find higher question-level ICCs of 0.66 to 0.77 (Molina-Garcia et al., 2010), which suggests greater reliability of attitudinal indicators under more typical circumstances. Even in this atypical time, however, attitudes are moderately stable.

There remain major gaps in the literature that require future research. This paper presented an exploratory analysis of the relationship between stable attitudes and stable behavioral expectations. This topic, particularly in the context of travel-related attitudes and transport choices, requires further research. Additionally, a detailed discussion of how geography affected attitudes during COVID-19 would be a valuable addition to the literature. People's attitudes – and also their attitudinal stability – is likely dependent in part on the severity of COVID-19 in their area, as well as the responses of their government and peers. Further investigation into this link will be important to understanding the long-term societal changes that COVID-19 is certain to cause.

References

Adams, E., Goodman, A., Sahlqvist, S., Bull, F., & Ogilvie, D. (2013). Correlates of walking and cycling for transport and recreation: Factor structure, reliability and behavioural associations of the perceptions of the environment in the neighbourhood scale (PENS). *International Journal of Behavioral Nutrition and Physical Activity*, *10*. https://doi.org/10.1186/1479-5868-10-87

Alwin, D., & Krosnick, J. (1991). Aging, Cohorts, and the Stability of Sociopolitical Orientations Over the Life Span. *American Journal of Sociology*, *97*(1), 169–195. https://doi.org/10.1086/229744

Belgiawan, P., Schmöcker, J., & Fujii, S. (2016). Understanding car ownership motivations among Indonesian students. *International Journal of Sustainable Transportation*, *10*, 295–307. https://doi.org/10.1080/15568318.2014.921846

Borriello, A., & Rose, J. (2021). Global versus localised attitudinal responses in discrete choice. *Transportation*, *48*, 131–165. https://doi.org/10.1007/s11116-019-10045-3

Chauhan, R., Conway, M. W., Capasso da Silva, D., Salon, D., Shamshiripour, A., Rahimi, E., Khoeni, S., Mohammadian, A., Derrible, S., & Pendyala, R. (2021). A database of travel-related behaviors and attitudes before, during, and after COVID-19 in the United States [revision submitted, preprint available at https://arxiv.org/abs/2103.16012]. *Scientific Data*.

Conway, M. W., Mirtich, L., Salon, D., Harness, N., Ross, A., & Hong, S. (2020). How important are attitudes in travel behavior models? [Presented at Bridging Transportation Researchers, presentation available at https://bridgingtransport.org/blog/archive-of-jan-2020-meeting/].

de Abreu e Silva, J. (2014). Spatial self-selection in land-use travel behavior interactions: Accounting simultaneously for attitudes and socioeconomic characteristics. *Journal of Transport and Land Use*, *7*, 63–84. https://doi.org/10.5198/jtlu.v7i2.696

Grice, J. W. (2001). Computing and evaluating factor scores. *Psychological methods*, *6*(4), 430–450. Retrieved January 8, 2021, from http://search.proquest.com/docview/72384053?pq-origsite=summon

Hatemi, P. (2013). The Influence of Major Life Events on Economic Attitudes in a World of Gene-Environment Interplay. *American Journal of Political Science*, *57*(4), 987–1007. https://doi.org/10.1111/ajps.12037

Janke, J., & Handy, S. (2019). How life course events trigger changes in bicycling attitudes and behavior: Insights into causality. *Travel Behaviour and Society*, *16*, 31–41. https://doi.org/10.1016/j.tbs.2019.03.004

Jensen, A., Cherchi, E., & Mabit, S. (2013). On the stability of preferences and attitudes before and after experiencing an electric vehicle. *Transportation Research Part D: Transport and Environment*, *25*, 24–32. https://doi.org/10.1016/j.trd.2013.07.006

Kitamura, R., Mokhtarian, P., & Laidet, L. (1997). A micro-analysis of land use and travel in five neighborhoods in the San Francisco Bay Area. *Transportation*, *24*, 125–158. https://doi.org/10.1023/A:1017959825565

Kolko, J. (2015). *Urban Headwinds, Suburban Tailwinds*. Trulia Research.

Koo, T., & Li, M. (2016). A guideline of selecting and reporting intraclass correlation coefficients for reliability research. *Journal of Chiropractic Medicine*, *15*(2), 155–163. https://doi.org/10.1016/j.jcm.2016.02.012

Liljequist, D., Elfving, B., & Roaldsen, K. (2019). Intraclass correlation – A discussion and demonstration of basic features. *PLOS One*, *14*, 131–165. https://doi.org/10.1371/journal.pone.0219854

Molina-Garcia, J., Castillo, I., & Sallis, J. (2010). Psychosocial and environmental correlates of active commuting for university students. *Preventive Medicine*, *51*, 136–138. https://doi.org/10.1016/j.ypmed.2010.05.009

Moreland, R., & Zajonc, R. (1982). Exposure effects in person perception: Familiarity, similarity, and attraction. *Journal of Experimental Social Psychology*, *18*(5), 395–415. https://doi.org/10.1016/0022-1031(82)90062-2

Norton, M., & Frost, J. (2007). Less is more: The lure of ambiguity, or why familiarity breeds contempt. *Journal of Personality and Social Psychology*, *92*(1), 97–105. https://doi.org/10.1037/0022-3514.92.1.97

Sunkanapalli, S., Pendyala, R., & Kuppam, A. (2000). Dynamic Analysis of Traveler Attitudes and Perceptions Using Panel Data. *Transportation Research Record*, *1718*, 52–60. https://doi.org/10.3141/1718-07

Thøgersen, J. (2006). Understanding repetitive travel mode choices in a stable context: A panel study approach. *Transportation Research Part A: Policy and Practice*, *40*(8), 621–638. https://doi.org/10.1016/j.tra.2005.11.004

van de Coevering, P., Maat, K., & van Wee, B. (2021). Causes and effects between attitudes, the built environment and car kilometres: A longitudinal analysis. *Journal of Transport Geography*, *91*, 102982. https://doi.org/10.1016/j.jtrangeo.2021.102982

Visser, P. S., & Krosnick, J. A. (1998). Development of attitude strength over the life cycle: Surge and decline. *Journal of Personality and Social Psychology*, *75*(6), 1389–1410. https://doi.org/10.1037/0022-3514.75.6.1389

Willis, C., & Lee, J. W. (1980). Time Stability of Attitudes Toward Transit Use in the Orlando, Florida, Urbanized Area [Presented at the 59th Annual Meeting of the Transportation Research Board, available in Transportation Research Record, issue 761, pages 56-58.].

A Demographics of Sample

Table A1 shows the demographics of the respondents in our sample, who were older, more educated, and slightly higher income than the overall population. The sample also heavily over-represented women.

		Survey	Census
Education	No school completed	–	1.5%
respondents 25 years	Some grade/high school	0.7%	10.2%
old or older	Completed high school or GED	12.7%	26.9%
(n=2672)	Some college or technical school	31.7%	28.9%
	Bachelor's degree(s) or some graduate school	33.0%	20.0%
	Completed graduate degree(s)	21.8%	12.6%
Income	Less than $10,000	3.2%	6.3%
(n=2597)	$10,000 to $14,999	3.7%	4.3%
	$15,000 to $24,999	7.6%	9.0%
	$25,000 to $34,999	9.4%	8.9%
	$35,000 to $49,999	12.1%	12.4%
	$50,000 to $74,999	18.9%	17.4%
	$75,000 to $99,999	15.1%	12.6%
	$100,000 to $124,999	11.4%	9.2%
	$125,000 to $149,999	5.8%	5.8%
	$150,000 to $199,999	6.2%	6.6%
	$200,000 or more	6.5%	7.6%
Age	18–24	3.2%	12.1%
(n=2631)	25–34	9.8%	17.9%
	35–49	20.6%	24.5%
	50–64	31.3%	24.9%
	65 and over	35.2%	20.7%
Gender	Female	64.9%	50.8%
(n=2668)	Male	34.7%	49.2%
	Other	0.4%	–
Sample size		2673	

Table A1: Demographics of respondents alongside Census data from 2018 1-year American Community Survey

B Wave 1 factor analysis

Presented here is the factor analysis that reduces 26 attitudinal statements into 8 underlying factors. Statements from Table 1 that do not appear here did not have a loading greater than ± 0.3 for any factor.

	Anti-Lockdown	Environ-mentalist City Lover	Pro-Video-Conferencing	Disease Concerned	Pro-In-Person Shopping	Anti-Working From Home	Social Optimistic	Anti-Apartment
Shutting down businesses to prevent the spread of coronavirus is not worth the economic damage that will result	0.781	–	–	–	–	–	–	–
I am concerned that friends or family members will have a severe reaction to the coronavirus if they catch it	–	–	–	0.805	–	–	–	–
Society is overreacting to the coronavirus	0.803	–	–	–	–	–	–	–
If I catch the coronavirus, I am concerned that I will have a severe reaction	–	–	–	0.684	–	–	–	–
Everyone should just stay home as much as possible until the coronavirus has subsided	-0.556	–	–	–	–	–	–	–
I am committed to using a less polluting means of transportation (e.g., walking, biking, and public transit) as much as possible	–	0.863	–	–	–	–	–	–
I am committed to an environmentally-friendly lifestyle	–	0.687	–	–	–	–	–	–
Sometimes I worry about the effects of airplane trips on the environment	–	0.580	–	–	–	–	–	–
I dislike change	–	–	–	–	–	–	-0.348	–
I enjoy spending time with the people I live with	–	–	–	–	–	–	0.345	0.317
Apartment living doesn't provide enough privacy	–	–	–	–	–	–	–	0.467
Having shops and services within walking distance of my home is important to me	–	0.393	–	–	–	–	–	–
I like to have a yard at home	–	–	–	–	–	–	–	0.541
Even if I do not end up buying anything, I still enjoy going to stores and browsing	–	–	–	–	0.959	–	–	–
In-person shopping is usually a chore for me	–	–	–	–	-0.520	–	–	–
Online learning is a good alternative to high school- and college-level classroom instruction	–	–	0.600	–	–	–	–	–
Video calling is a good alternative to in-person business meetings	–	–	0.728	–	–	–	–	–
Video calling is a good alternative to visiting friends and family	–	–	0.692	–	–	–	–	–
I am generally satisfied with my life	–	–	–	–	–	–	0.326	–
It is hard to get motivated to work away from the main office	–	–	–	–	–	0.666	–	–
I like working from home	–	–	–	–	–	-0.415	–	–
I enjoy the social interaction found at a conventional workplace	–	–	–	–	–	–	0.431	–
Learning how to use new technologies is often frustrating	–	–	–	–	–	0.419	–	–

Table B1: Exploratory factor analysis (minimum residual method, varimax rotation) based on Wave 1 data. Only loadings greater than ±0.3 are shown.