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Environmental, behavioral, and psychological predictors of transit ridership: Evidence from a community intervention

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Abstract

Understanding who takes advantage of new transit (public transportation) interventions is important for personal and environmental health. We examine transit ridership for residents living near a new light rail construction as part of “complete street,” pedestrian-friendly improvements. Adult residents (n=536) completed surveys and wore accelerometer and GPS units that tracked ridership before and after new transit service started. Transit riders were more physically active. Those from environments rated as more walkable were likely to be continuing transit riders. Place attachment, but not perceived physical incivilities on the path to transit, was associated with those who continued to ride or became new riders of transit. This effect was mediated through pro-city attitudes, which emphasize how the new service makes residents eager to explore areas around transit. Thus, place attachment, along with physical and health conditions, may be important predictors and promoters of transit use.

Keywords

Transit; place attachment; physical activity; obesity; attitudes

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1. Introduction

Environmental psychologists are aware of many reasons to promote public transit use. Public transit use is associated with more physical activity (Rissel, Curac, Greenaway, & Bauman, 2012), lower weight (Brown, Werner, Tribby, Miller, & Smith, 2015), less costly car congestion and pollution (Sallis, et al., 2015), and less sprawling development (Xia, Zhang, Crabb, & Shah, 2013), among other benefits (Litman, 2004). However, public transit is less popular than private automobile travel in the U.S., accounting for only 1.3% of trips in many urban areas (for populations 1 to 2.5 million; Santos, McGuckin, Nakamoto, Gray, & Liss, 2011). To get people to use public transit may require transit to have multiple positive features, such as convenience and perceived good quality (Brown, Werner, & Kim, 2003). One major factor prompting use is the physical convenience or accessibility of transit. The current study focuses on residents' patterns of transit ridership after a new light rail transit line extension was added to their neighborhood as part of a "complete street" improvement. We adopt a socioecological or transactional approach that identifies physical environmental, psychological, and behavioral variables related to transit ridership (Altman & Rogoff, 1987; Stokols, 1996).

Complete streets are designed or redesigned to be safe and convenient for use by those without cars, as well as for automotive users (Kingsbury, Lowry, & Dixon, 2011). Worldwide, before the invention of cars, many cities were built in ways that accommodated pedestrian, streetcar, and bicycle traffic. However, in the U.S. and other car-dominated societies, street engineering standards and zoning practices changed to make many streets especially accommodating to higher volumes and speeds of cars. Specific design features, such as wide streets, sweeping turning radii, timed traffic signals, and ample parking requirements encouraged car traffic but discouraged active use by cyclists, transit riders, or pedestrians (Southworth & Ben-Joseph, 1995). As cyclists and pedestrians sought to reverse this trend, the term "complete streets" was coined in 2003 by advocates for streets designed for multiple transportation modes (Dodson, et al., 2014). Complete street policies have proliferated quickly in the U.S. (McCann, 2013), albeit with many different operational definitions. For example, the addition of a wide shoulder along a road for pedestrians and cyclists might qualify as "complete" in a rural context whereas a more urban context might require crosswalks, separated bike paths, transit stops, or other features intended to support active transportation.

The current study addresses a complete street redesign in Salt Lake City, UT, along North Temple Street, where design formerly emphasized car access. The redesign added a light rail extension to the local system called "TRAX," narrowed the lanes available to cars from six to four, provided new wider sidewalks, and completed and widened a bike lane. Complete street improvements typically address the transportation corridor only. Yet residents who want to use light rail on the complete street are likely to walk there from home, given the absence of parking at these stations. Thus, residents must perceive the route through the neighborhood from home to the transit stop to be sufficiently attractive for them to take advantage of the complete street community improvement. This study will examine the physical and psychological features that might encourage use of transit along the complete street corridor.

1.1 Physical environmental features and transit use

The design elements that might make an area pedestrian-friendly start with the basic requirements of having enough people and pedestrian-friendly destinations to support walking. Density, whether measured in terms of housing or population, is a frequent correlate of active transportation, such as walking to get to particular places (Agrawal & Schimek, 2007; Cervero & Kockelman, 1997; Glazier, et al., 2014; Rodríguez, Evenson, Diez Roux, & Brines, 2009). Similarly, having diverse destinations within walking distance also is associated with walking (Cerin, et al., 2013; Cervero & Kockelman, 1997; Glazier, et al., 2014; Knuiman, et al., 2014; Rodríguez, et al., 2009). Although other aspects of the physical environment also support walking, density and diverse walkable destinations were identified in a systematic review to have the most consistent positive relationships with active travel (Saelens & Handy, 2008). Another environmental feature that has been associated with walks to transit stops include relatively short distances, usually less than a kilometer, between home and the transit stop (O'Sullivan & Morrall, 1996), with longer trips to light rail than buses (Daniels & Mulley, 2013). The current study will examine whether living on a walkable block with relatively high residential density and diverse destinations, and living in close proximity to the new complete street are associated with taking advantage of the new transportation options on the complete street.

1.2 Psychological processes and transit use

Past psychological research within the transportation field has often focused on the perceived service characteristics of transit, such as transit riders' responses to time and financial costs (Handy, Boarnet, Ewing, & Killingsworth, 2002). Research from environmental psychology has broadened the search for psychological predictors of transit use to include perceptions that transit use creates a more likeable city (Brown, Werner, et al., 2003), or supports a better quality of life (Steg & Gifford, 2005), or is avoided because the path to transit looks dangerous or unkempt (Loukaitou-Sideris, 2006). In this paper we also broaden the search for psychological factors that might encourage transit use by focusing on place attachments to one's home, block, and neighborhood as well as attitudes toward whether transit makes the city more likeable.

Place attachment is a central concept in environmental psychology that has traditionally been related to how individuals forge positive bonds with particular places, with many studies focusing on the home and neighborhood. Place attachment has been defined in multiple ways but one widely accepted definition is the "positive affective, cognitive, and behavioral bonding with places and people associated with a setting" (Brown & Perkins, 1992). Affective bonds may be developed when a place provides security, self-esteem, a sense of belonging and other positively charged experiences. The cognitive identification related to place attachment may include familiarity or extending one's sense of self throughout the home, neighborhood, or other attachment venue. Behavioral aspects of place attachment include use, personalization and upkeep of the place and developing routines of spending time there. Attachment can occur on different geographic levels; one may be attached to one's car, home, neighborhood, or city, for example. Attachment often involves different social units, such as individuals, families, or community groups. Place attachment

is conceptually and empirically distinct from, albeit related to, other neighborhood constructs such as social capital and perceived security (Dallago, et al., 2009).

Place attachment is increasingly found to be related to behavioral outcomes that matter beyond the individual's positive affective bonds with and attitudes toward a place. Place attachment has been associated with various pro-environmental behaviors that benefit society, such as intentions to plant native vegetation (Raymond, Brown, & Robinson, 2011); self-reported engagement in understanding climate change (Scannell & Gifford, 2013); and reports of pro-environmental activities (Scannell & Gifford, 2010; Zhang, Zhang, Zhang, & Cheng, 2014). Similarly, place attachment can be related to more involvement in the area, such as more reported place attachment among local business owners catering to tourists in natural areas (Bonaiuto, Carrus, Martorella, & Bonnes, 2002) or greater place attachments among residents with more social ties (Mesch & Manor, 1998). In a series of studies of a redeveloping neighborhood, residents of new housing in an otherwise deteriorating neighborhood reported experiencing strong attachments to and confidence in the neighborhood (Brown, Brown, & Perkins, 2004). But beyond these personal feelings, place attachment was correlated with a reduction in police reports of crime for homes near the new neighborhood (Brown, Perkins, & Brown, 2004b) and an increase in nearby housing improvements by home owners (Perkins, Larsen, & Brown, 2009). In the larger neighborhood, living on a block where neighbors had stronger place attachments also related to less vulnerability to crime incidents at those homes (Brown, Perkins, & Brown, 2004a).

However, there is also evidence of negative aspects to place attachment. For example, in the neighborhood redevelopment research above, after the new homes were built, the nearby long-term residents reported an erosion of pride in one's home (a component of place attachment). Perhaps the longer term residents reacted negatively to the contrast in the conditions between the new and older housing conditions (Perkins, et al., 2009). Other negative consequences of place attachment include increasing one's risk by remaining in a war zone in part because of attachment to home (Billig, 2006) or opposing sustainable energy developments because they threaten place attachments (Devine-Wright & Howes, 2010). Thus, past research demonstrates that individuals' place attachments often, but do not always, foster beneficial personal, community, and/or environmental outcomes as well.

When considering whether place attachment might help residents and the community benefit from new transit investments in their neighborhood, the actions of place attachment beyond the home must be considered. Attachment to the home and neighborhood might motivate one to explore and experience the neighborhood more. Lewicka identified this form of attachment as "place discovered," such as when residents take an interest in changes in their neighborhood, seek out new neighborhood destinations, and are motivated to show guests around their community (Lewicka, 2013). This forward-looking aspect of place attachment may explain how those who are attached to their homes and neighborhoods might be the ones to explore new opportunities and places. In fact, in Poland the use of transit is correlated with the "place discovered" form of place attachment (Ja kiewicz & Besta, 2014), which the authors suggested meant that positive and stimulating experiences with transit could help develop place attachment. We ask the converse: Could one's pre-existing place

attachment lead one to have positive orientations toward the place and its new transit options that encourage residents to try the new transit options in the neighborhood?

Thus, place attachment may give rise to a perception that light rail is a beneficial addition to the neighborhood that can further one's knowledge and interest concerning new travel opportunities in the neighborhood and city. If the new transit investment is interpreted in this positive way, then it may predict who initiates transit use in the complete street area. Alternatively, residents might define the new rail line as an intrusion into their neighborhood and a threat to their place attachments (Zavestoski & Agyeman, 2014). Indeed, both positive and negative orientations to new interventions in neighborhoods have been found. Residents of one town resisted the addition of alternative energy generators, fearful that it would erode the town's identity as scenic (Devine-Wright & Howes, 2010). Another community, experiencing economic decline, welcomed the energy facility intervention, being curious and excited about it and experiencing pride that their community was receiving the new investment in technology (Devine-Wright, 2011).

A second proposed psychological component to the use of transit options focuses on incivilities along the path to the new transit facilities. Incivilities are physical or social conditions that suggest that the area is not well-controlled by local officials or residents and where crime might occur without interference (Wilson & Kelling, 1982). Incivilities have been related to the avoidance of areas (Miethe, 1995). Thus if the path to the new transit has abandoned buildings, unkempt lawns, and graffiti, residents might not be willing to walk to the new transit stops. In the study neighborhood, past research (Brown, Werner, Smith, Tribby, & Miller, 2014) has shown that perceptions of neighborhood crime relate to more risk of obesity and that lower levels of objectively measured physical activity mediate this relationship. That is, results were consistent with the idea that residents who were more fearful of crime weighed more in part due to low levels of physical activity. Other reviews, however, have served to question the idea that incivilities deter people from walking. One review article found no consistent relationship between crime safety measures and utilitarian walking (Sugiyama, Neuhaus, Cole, Giles-Corti, & Owen, 2012), although an earlier review had suggested that crime safety was related to walking in some studies (Saelens & Handy, 2008). Given that levels of fear of crime were higher in this neighborhood than in other published studies that utilized the same fear of crime measures, it is worth assessing whether the perception of incivilities along the path to the new transit stop might directly relate to reluctance to try the new transit.

The following study will therefore assess whether physical environmental qualities of proximity to the new transit stops and walkability (i.e., land use density and diversity) relate to use of transit, controlling for socio-demographic factors. In addition, we test two psychological processes expected to relate to transit use. Residents who perceive incivilities along the way to the new stop may not venture out to the new transit stops. In contrast, residents who have place attachments to the broad area comprising home and the neighborhood might be ready to try the new transit option. In a mediation analysis, we test whether place attachment relates to a sense that the new community intervention fosters residents' interests in exploring their community and benefitting from new transit, which in turn predicts transit ridership.

2. Methods

2.1 Study site, participants, and procedures

The complete street redesign added an extension to Salt Lake City's TRAX light rail line, narrowed the lanes available to cars from six to four, and included new wider sidewalks and the addition of better and more complete bike lanes. The TRAX line extension connected the airport on the west to downtown on the east. The current study focuses on the area surrounding five rail stops that are within walking distance of residential neighborhoods (i.e., TRAX stations along a 3.5 km section of the “green line” from the 1940 West stop to the Bridge/Guadalupe stop at 500 W North Temple, Salt Lake City). This light rail line is on the road running on fixed rails and is powered electrically. Prior to the rail line extension, the area was served by bus transit only, and buses continued to serve the neighborhood after the rail stops were in place, allowing multi-modal transit trips. The neighborhood includes a mixture of commercial and service areas, some industrial land, the state fair park, a river, and a range of housing units, including hotels, manufactured housing (trailer) parks, apartments, private market condominiums, and single family detached housing.

Adult residents were recruited door-to-door from areas up to 2 km from the complete street corridor, as described in greater detail elsewhere (Brown, Wilson, et al., 2014). Random sampling was used to select participants for households with up to two eligible adults; when three or more eligible adults were present, a specified order of selection was used to avoid intrusive enumerating of household members (the “youngest male-oldest female” technique designed to balance gender in community recruitments (Hill, Donelan, & Frankel, 1999)). In 2012, the 910 residents who participated represented a 28.93% response rate based on the universe of all addresses that could be recruited using the American Association of Public Opinion Researchers response rate formula 3 (The American Association for Public Opinion Research, 2008). In 2013, there were 536 residents who remained in the area and participated in follow-up data collection; 34 residents refused to participate in 2013 with the rest either moving or becoming ineligible.

Adults (≥ 18) were eligible if they could speak English or Spanish, expected to live in the area for at least a year, could walk a few blocks, were not pregnant, and could give informed consent and provide survey data. Due to these eligibility requirements and to census boundaries that do not overlap precisely with the sample area, it is difficult to be definitive about representativeness. As might be expected, proportionally fewer renters were in the study sample than in the area's underlying census statistics (48% sample, 59% area), given the requirement that participants had to remain in the neighborhood one year to participate in the follow-up study. However, the sample was more representative of the area in terms of gender (51% female sample, 48% area), Hispanic ethnicity (25% sample, 26% area), and age (42 years old in sample, 44 years old in area).

Research assistants gave participants surveys as well as instructions for wearing small monitors around the waist that would assess physical activity intensity and outdoor locations. Approximately one week later researchers returned to participants' homes to retrieve the equipment and download their data onto research laptops and administer final

surveys. Participants were compensated \$50.00 for their time needed for the two surveys and a week of wearing the equipment.

2.2 Measures

2.2.1 Use of transit on the complete street—Waist-worn global positioning system (GPS) data loggers (GlobalSat 100) measured outdoor locations. The combination of accelerometer and GPS data were used to define which residents had transit trips that intersected with the complete street corridor, defined by a 40-meter buffer area surrounding the street centerline, a distance comparable to distances used to define travel corridors in other studies (Jarjour, et al., 2013; Krenn, Oja, & Titze, 2014). The data were integrated by the firm GeoStats (now Westat), so that each trip could be divided into modes, such as light rail, bus, walking, and biking, based on activity counts from the accelerometer and speed and acceleration profiles and locations indicated by the GPS data.

Data on transit use through the complete street corridor resulted in four possible ridership groups: never, continuing, former and new. Never and continuing riders never or always used transit during both the 2012 and 2013 measurement weeks, according to GPS/accelerometry measures. Former riders had transit trips through the corridor in 2012 but not 2013. And of greatest interest to researchers who want to understand community interventions are the new riders, who did not use transit through the corridor before the new transit service became available but did use it after service became available.

The following psychological and environmental measures were chosen because they were conceptually compatible with the study goals and also evidenced reliability and predictive validity in past research. For example, the place attachment measure chosen was developed for studies that focused on primary homes and neighborhoods. The items were thus focused on the appropriate geography compared to place attachment scales that were developed to assess other locales, such as lakeside vacation homes or coffee shops. Similarly, the environmental audit of neighborhood diversity and density was chosen from the Irvine Minnesota Inventory, which was developed with from an expert panel to guide its conceptualization (Day, Boarnet, Alfonzo, & Forsyth, 2006) and has also been shown to be comprehensive (Nickelson, Wang, Mitchell, Hendricks, & Paschal, 2013) and reliable (Boarnet, Day, Alfonzo, Forsyth, & Oakes, 2006).

2.2.2 Place attachment—Drawing from past research, we operationalized place attachment as a broad residential measure that included attachment to home, block, and neighborhood. The 9-item composite assessed pride in one's neighborhood, block, house or apartment, front yard, and dwelling exterior (Brown, Perkins, & Brown, 2003). The measure also assessed unhappiness at the thought of moving, whether the neighborhood is “part of me,” has a good reputation, or is a good place to live (the latter 4 items (scaled 1 through 10 from “strongly disagree” to “strongly agree”) were reverse-coded from negative wording; coefficient alphas = .83 and .85, times 1 and 2, respectively).

2.2.3 Pro-city attitudes—A 5-item composite, based on past research, assessed whether TRAX light rail increased the participant's interest in living near TRAX, reduced his/her interest in going downtown (reverse-coded), and increased his/her interest in knowing about

places close to TRAX (Brown & Werner, 2009; Brown, Werner, et al., 2003). Participants reported whether TRAX made Salt Lake City more likeable and whether they would prefer TRAX to car use, all things equal (4-point agreement scales, alphas = .71 and .74, times 1 and 2, respectively).

2.2.4 Path incivilities—A 7-item composite assessed the following problems residents perceived to exist on the way to and along the complete street: vacant homes or buildings; neighbors who do not keep up their property; house or place of suspected drug-dealing; evidence of gang activity; graffiti; poor lawn conditions; and noise (10-point, “no problem” to “big problem” response scales. Alphas for times 1 and 2 = .90). This instrument was adapted from a perceived incivilities scale that had been used in past research to address the neighborhood level, but was adapted for this application to focus on the path to the complete street corridor (Brown, Perkins, et al., 2003).

2.2.5 Density—The home's immediate environment was assessed with the Irvine Minnesota Inventory (IMI) ratings of features on the resident's block, bounded by cross streets. The density variable for this analysis is coded 1 for blocks fronted by single family detached homes only and 2 for those that have some higher density housing visible, such as duplexes, apartments or condominiums, or mobile homes. The block segment scores for density and land use diversity (below) were surrogates for local area density and diversity, based on the utility of these local area scores from past research (Werner, Brown, & Gallimore, 2010).

2.2.6 Land use diversity—The Irvine Minnesota Inventory (IMI) includes multiple land uses that are likely walking destinations, such as stores, as well as others that likely discourage walking, such as industrial uses. Each feature is scored 0 for absent and 1 for present. To create an overall score, the occurrences of 29 positive features on the resident's block were summed and the 7 negative features were subtracted from the positive features (see Appendix for all 36 items).

2.2.7 Control variables—We controlled for variables known to relate to active transportation use, including having a car available to use, being a renter, and baseline obesity and physical activity levels. Although gender and Hispanic ethnicity measures were available they did not predict outcome measures and had an indicator of lessened model fit so they were removed from the models presented below.

2.2.8 Physical activity—Following the guidelines used for the National Household and Nutrition Examination Survey (NHANES), moderate to vigorous physical activity was measured for participants who wore Actigraph GT3X+ accelerometers on the waist for about a week (Troiano, et al., 2008). Accelerometers were worn at least 3 10-hour days, with non-wear hours defined as 60 minutes of 0 accelerometer counts per minute (CPM, allowing for up to 2-minutes of spikes up to 100 CPMs), with the moderate physical activity threshold set at 2020 CPM (Troiano, et al., 2008).

2.2.9 Obesity—Height and weight were measured with portable stadiometers and calibrated scales in the participant's home and BMI was calculated as weight in kilograms

divided by height in meters squared. Obesity was defined as having a BMI ≥ 30 (Fryar, Gu, & Ogden, 2012).

2.3 Statistical analyses

Data analyses include descriptive statistics and multinomial logistic regressions to predict membership in the four transit ridership groups: never-riders, continuing riders, former riders, and new riders. The multinomial logistic regression allows a comparison of never-riders to each of the three groups of riders (SPSS procedure NomReg for unordered groups). A follow-up mediation analysis on the two groups of transit riders addresses whether the relationships between Time 1 predictors—including place attachment—and Time 2 transit ridership are accounted for or mediated by the intervening effect of Time 2 pro-city attitudes. Specifically, we used the Freedman and Schatzkin (F-S) test of differences in two sets of coefficients linking place attachment to ridership (Freedman & Schatzkin, 1992; MacKinnon, Lockwood, Hoffman, West, & Sheets, 2002). The first coefficient assesses the relationship between Time 1 place attachment and Time 2 ridership without controlling for pro-city attitudes (called the “total effect” T), but including the socio-demographic control variables. The second coefficient is estimated with the same variables plus the proposed mediator of pro-city attitudes (called the “direct effect”, or T'). The t -test determines whether the coefficient for place attachment is significantly lessened after the mediator of pro-city attitudes is added to the model, indicating that mediation through pro-city attitudes has occurred. The t -test is calculated as $(T - T')/SE_{F-S}$, where T is the unstandardized coefficient for the total effect and T' is the unstandardized coefficient for the direct effect. The F-S standard error is calculated as $\sigma_{F-S} = (\sigma^2 T + \sigma^2 T' - 2 \sigma T \sigma T' (1 - \rho_{2XI}))$, where σT is the standard error of T , $\sigma T'$ is the SE for the T' , and ρ_{2XI} is the correlation between place attachment and pro-city attitudes ($r = .13$ for new riders and $.10$ for continuing riders). This test, one of many that can be used in mediation analyses, has been found to provide power and to protect against the Type I error of claiming an indirect or mediated effect that does not exist (MacKinnon, et al., 2002). Long used in epidemiology, it can be employed if adjustments to standard errors are needed due to spatial clustering of samples (Brown, Werner, et al., 2014) or if the study involves multinomial outcomes, unlike other mediation tests (e.g., PROCESS macros, Hayes, 2013).

A preliminary unconditional general linear mixed model demonstrated no significant clustering effect for the ridership groups across Census block groups and no effects on the final model if adjusted for block group clustering by treating block group as a random effect. The simpler multinomial logistic regression model without adjustments for clustering was used. A test of multicollinearity among predictors in the initial step of the mediation models indicated no problematic levels of multicollinearity (all tolerances above $.7$ and all condition indices below 10).

3.0 Results

3.1 Description of individual differences

The four transit ridership groups are distinct in terms of their individual characteristics, as shown by descriptive statistics in Table 1. For example, having a car available to use is

highest for the never-rider group (94%), lowest among those who rode transit at both Times 1 and 2 (57%), and intermediate for the two changing ridership groups of new and former riders. Similarly, never-riders are unlikely to be renters (41%), but the majority of those who had some transit ridership were renters, varying from 58% to 82% of the three groups who had ridden transit. Those who never rode or stopped riding transit were more likely to be obese (38% and 46%, respectively) than those who continued to ride or started riding transit (24% and 31%, respectively). Never riders also accrued the least moderate-to-vigorous physical activity (17.33 minutes per 10 hours of accelerometer wear) and continuing riders accrued the most (33.62 minutes), with the changing ridership groups in between (28.78 and 23.83 minutes).

3.2 Environmental variables: Density, diversity, and distance

A multinomial logistic regression analysis controlled for the above individual difference qualities and tested what environmental and psychological features predict transit use, particularly for those who are newly attracted to transit. The three proposed environmental encouragements for transit use include proximity to the new transit stops and two walkability indicators--housing density and diverse walkable destinations on the respondent's home block.

Compared to those who never used transit through the complete street corridor, those who continued to take transit in the corridor, such as buses during 2012 and TRAX light rail during 2013, lived closer to the complete street corridor. For every additional 100 meters further from the corridor, residents were 11% less likely to use transit at both times. Compared to those who never used transit, those who discontinued transit use through the corridor lived on blocks that had denser housing forms. In the final comparison to never riders, there was no significant pattern of environmental support that predicted who would become a new rider, except for a marginal tendency ($p < .07$ and $p < .10$ in initial and proximity mediation models, respectively) for new riders to live closer to the complete street corridor.

3.3 Psychological variables: Path incivilities and place attachment

In terms of psychological variables, there was no relationship between using transit and perceived incivilities, such as poor property upkeep or graffiti along the path to the complete street corridor. However, compared to those who never used transit, those who continued or started to use transit reported stronger place attachments. As shown in the left hand columns of Table 2, continuing riders and new riders had higher place attachment levels than never riders, controlling for all other variables in the initial model.

The final multinomial logistic model resulted in a statistically superior fit compared to the null model; the -2 Log Likelihood values reduced from 913.24 to 741.28, $\chi^2(30) = 171.96$, $p < .001$. As an alternative measure of fit, Akaike Information Criteria (AIC) scores also decreased, from 919.24 to 807.28, indicating better fit. Although R^2 statistics are not available in multinomial logistic regression analyses, the Nagelkerke pseudo R^2 value of the final model was .34.

3.4 Mediation test: Place attachment, pro-city attitudes, and transit use

The relationship between place attachment and transit ridership was mediated by pro-city attitudes, net of the control variables, for the two ridership groups. For the continuing and new ridership groups, greater place attachment at Time 1 is significantly related to stronger pro-city attitudes (OLS regression B coefficients are each .06) and ridership (logistic regression Bs= .25 and .30, respectively) at Time 2. The significant relationship between place attachment and ridership weakened when the mediator of pro-city attitudes was controlled, as expected when mediation is occurring. Recall that the formal test of mediation in this analysis is whether the B coefficient for the relationships between place attachment and ridership is significantly reduced when the proposed mediator of pro-city attitudes is added to the model (Freedman & Schatzkin, 1992; MacKinnon, Lockwood, Hoffman, West, & Sheets, 2002). These tests show that pro-city attitudes mediate the relationship between place attachment and ridership for the continuing riders (the B of .25 shrinks to .21; Freedman Schatzkin $t(433) = 3.36, p < .05$) and new riders (the B of .30 shrinks to .27; Freedman-Schatzkin $t(436) = 2.70, p < .05$). Thus, the significant relationships between greater place attachment and transit ridership are explained, in part, by the fact that place attachment at Time 1 relates to pro-city attitudes at Time 2. Statistically adjusting for pro-city attitudes at Time 2, in turn, reduces the place attachment to ridership relationship, indicating mediation has taken place.

4. Discussion

Our study demonstrates that a combination of physical, social, behavioral health, and psychological variables predict which residents take advantage of the new complete streets intervention that provided new light rail transit service in their neighborhood. Walkability, individual sociodemographic variables, health indicators (i.e., objectively measured physical activity and obesity), and psychological variables of place attachment and pro-city attitudes all were significant predictors of at least one transit ridership group. To appreciate the patterns of the significant predictors, the findings for particular group comparisons are described below.

One useful comparison is between continuing riders and new riders. Continuing riders had only bus transit available in 2012 but had bus and TRAX lines available in 2013. The continuing riders had the most transit-friendly physical environments prior to the complete street renovation, given their short distance from the complete street site, where much bus service concentrated in 2012, and the diverse walkable destinations available on their home block, recalling Table 2. In contrast, no particular set of physical variables—distance, housing density, or diverse walkable destinations—characterized the environments of the new riders. In terms of psychological variables, both the new riders and continuing riders showed stronger place attachments to their homes and neighborhoods than never riders. Thus environmental variables predicted continuing ridership while psychological variables predicted new and continuing ridership. Although past research has frequently focused on the role of environmental walkability as a key to transit use (Renne, 2009), the role of psychological variables such as place attachment has been under-researched.

It is also illuminating to focus on the former riders. These individuals did not live in transit-supportive settings except for their higher density; mapping their locations (not shown) suggests they tend to live on the eastern, more urban section of the neighborhood, which clarifies why they lived in more dense areas. It is not clear why these residents did not continue riding transit. However, their place attachments were indistinguishable from never riders, with both groups expressing the lowest levels of attachment. Compared to never riders they were less likely to have access to cars, more physically active, but also more obese. Perhaps the combination of obesity and relatively low levels of place attachment dissuaded them from continuing to ride transit; past research has shown that obese individuals consider walking more effortful than other groups (Mattsson, Larsson, & Rössner, 1997). These individuals did not stop riding due to being anti-transit because their pro-city attitudes, which tapped positive feelings about TRAX and access to the city due to TRAX, were more positive than those of the never riders.

Although fear of crime in this neighborhood has been related to low levels of objectively measured physical activity and relatively high risk of obesity (Brown, Werner, et al., 2014), the perceived incivilities along the walk to transit were not deterrents to using transit along the new corridor. This may reflect participants' familiarity with their neighborhood and the perception that it is safe enough when they want to use transit, such as during rush hour when others are around. This may also be due to the fact that transit use is often an instrumental trip—one taken to get to a specific destination such as work or shopping. One past review suggests that aesthetics might be more important for leisure walking but that factors such as distance are more important for instrumental walks (Saelens & Handy, 2008), a result corroborated in a study that specifically asked people about barriers to the use of transit (Walton & Sunseri, 2010). Another study has found that places where many people walk also have litter and other incivilities, perhaps as a consequence of so much use (Suminski, Heinrich, Poston, Hyder, & Pyle, 2008). Two studies in a recent review found instrumental walking related to higher perceived incivilities (Foster & Giles-Corti, 2008); thus, despite some intuitive appeal, the connection between perceived incivilities and reduced likelihood of walking is not a robust finding in this study or elsewhere.

The role of place attachment in this study can be compared to other studies that associate place attachment with pro-social outcomes that might be related to protecting the place. Although place attachment is not always associated with engaging in pro-social behaviors or avoiding anti-social behaviors with respect to place (Hernández Bernard o, Martín, Ruiz, & Hidalgo, 2010), the review of studies in the introduction and the evidence from the current study suggest that place attachment may be an under-appreciated mechanism that may enable residents to take part in activities that benefit the physical and/or social environment.

One strength of the study is the fact that place attachment and ridership were assessed over time, so that we are confident that place attachment levels preceded any change in transit ridership after the complete street intervention was finished. Research often does not focus on how place attachment might relate to how one experiences and interacts with a future environmental event, such as a new transit line. Some research in the hospitality area suggests that place attachment can motivate visitors to return to favored vacation locales (Loureiro, 2014). Perhaps place attachment in one's neighborhood can also motivate future

activities of interest to researchers, beyond transit ridership. When investigating the realm of likely future behaviors related to prior place attachments it may be useful to remember Lewicka's concept of place attachment as "place discovered." That is, one form of place attachment is not backward looking to one's past experiences with a place, as valuable as those experiences may be in fostering place attachment. Instead, place attachment in the form of place discovered suggests that individuals are interested in deepening their positive experiences in their places of attachment, by exploring their possibilities and learning to appreciate the place through the lens of that new experience. Although we do not have systematic evidence from the study neighborhood, we noted that many families tend to take their children on TRAX rides, sharing with them the excitement of the train ride and pointing out nearby locations in a way that is not possible during a car ride. Cultivating these types of experiences may help to define a new neighborhood opportunity as a positive one, which enhances attachment and predicts future use. Researchers in allied areas might benefit by testing whether home tours might encourage neighborhood preservation efforts or renewable energy tours might encourage the willingness to use renewable power sources.

In terms of applications for transit planners, the study has several implications. First, the important role of convenience of new transit, found in prior studies, is corroborated in our panel of participants assessed at two times. The fact that continuing riders had already been living in the area holds constant the selection threat to internal validity while demonstrating the importance of convenient access to transit. For continuing riders, every 100 meters closer was associated with a 11% increase in the probability of transit use and the same relationship was marginally significant for new riders. Second, the role of health factors in transit use were confirmed. Transit planners might encourage more riders by publicizing how transit riders achieve more beneficial and objectively measured physical activity. At the same time, obese individuals were most likely to be in the former riders group, so it may be important to use very close siting and good seating in transit-served areas to enable obese individuals to perceive a transit trip as manageable. Third, the four groups of riders were sufficiently distinct that transit agencies may want to consider additional research and marketing efforts targeting these groups. Finally, transit planners might utilize highly attached residents as "transit ambassadors" during the introduction of new transit options. Currently, as part of publicity for new rail stops, there is a chaotic opening day of free rides. Perhaps providing early riders with some free passes to share with neighbors might be an effective way to cultivate more new riders beyond opening day. These early adopters, acting as transit ambassadors, might share with neighbors their pre-existing place attachments, thereby spreading enthusiasm for the neighborhood and its new transit opportunities.

The interpretation that "place discovered" is an important aspect of attachment is consistent with the findings for the mediational analyses. That is, place attachment--when it gives rise to the desire to use TRAX to venture downtown, explore areas around TRAX stations, and develop a sense that one likes one's city more--can encourage the pro-environmental behavior of using transit. The use of active transportation, in addition to aiding personal health, may allow individuals and society to benefit from reduced pollution and greenhouse gases (Xia, et al., 2013). We do not presume that people ride TRAX primarily to benefit the environment. Many environmental psychology studies have found that pro-environmental attitudes often fail to lead to pro-environmental behavior; we find it useful to identify

predictors of environmental behaviors such as transit use that do not require users to be committed to environmentalism.

The limitations to the study include the fact that there is no commonly accepted set of measures for place attachment (Hernández, Carmen Hidalgo, & Ruiz, 2013), so that each researcher develops measures that make sense in each unique research context, which hampers direct comparisons across studies. Residents were assigned to their ridership groups based on approximately one week's data collection in each of the years before and after the new transit became available; longer wear intervals might have resulted in somewhat different ridership designations among infrequent riders. The model only tested pro-city attitudes and other constructs could have been equally good mediators. Therefore future research is needed to understand more fully how place attachment can lead to the use of transit.

In sum, this study has connected transit ridership to objectively measured behaviors, including physical activity and obesity, and utilized GPS data rather than self-report to confirm ridership. In addition, density and diversity, two features of the resident's home block relevant to transit use, were confirmed by objective and reliable ratings. Although self-reports are valuable, and indeed the only known way to assess psychological variables such as place attachment, linking self-reports to objectively measured behaviors strengthens our understanding of place attachment but is seldom done. This study was able to use multiple strong measures to understand how the important health indicators of BMI and physical activity, environmental measures of proximity and walkability, and psychological qualities that might discourage or encourage transit use related to objectively assessed transit use over time after a complete street intervention.

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Appendix

Land use diversity items

Walkable destinations

- elementary schools
- high schools, colleges, or other schools
- plazas/parks/playgrounds
- other public spaces
- gyms
- movie theaters
- other recreational centers

- community centers/libraries
- museums/theaters
- post offices
- other public buildings
- religious institutions
- hospitals/clinics
- other institutional buildings
- stores/restaurants
- banks/financial services
- hotels
- car dealers
- service stations
- other commercial buildings
- offices
- dry cleaners/laundromats
- other service facilities
- undeveloped land
- farms
- other types of undeveloped land
- vertical mixed use buildings.

Less walkable destinations

- big box stores
- shopping malls
- strip malls
- drive-through services
- light industrial
- medium/heavy industrial
- other industrial.

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Highlights

- We assess who uses transit before and after a new light rail line opens
- Those who use transit at either time are more physically active
- Continuing riders live near transit on blocks with walkable destinations
- Place attachment at time 1 predicts new and continuing ridership time 2
- For the above two groups, pro-city attitudes mediate the effect

Table 1
Transit ridership groups: Proportions or means and standard deviations

Variables	Never-riders		Continuing riders		Former riders		New riders		All	
	M	SD	M	SD	M	SD	M	SD	M	SD
Car available	0.94	0.24	0.57	0.50	0.71	0.46	0.83	0.38	0.87	0.33
Renter	0.41	0.49	0.82	0.39	0.72	0.46	0.58	0.50	0.49	0.50
Obese	0.38	0.48	0.24	0.43	0.46	0.50	0.31	0.47	0.36	0.48
Moderate-to-vigorous Activity minutes per 10 hrs., accelerometer wear	17.33	14.99	33.62	23.39	28.78	25.64	23.84	16.20	20.39	17.88
Housing density, home block	1.47	0.50	1.67	0.48	1.78	0.42	1.63	0.49	1.53	0.50
Land use diversity, home block	0.58	1.17	1.29	1.42	0.95	1.05	0.67	1.13	0.68	1.20
Distance to complete street, in 100s of meters	10.10	5.22	7.03	5.38	9.75	5.19	8.99	5.09	9.68	5.29
Path incivilities	4.77	2.23	4.09	1.82	4.25	2.28	4.02	2.03	4.59	2.20
Place attachment	6.44	1.74	6.64	1.68	6.31	1.83	7.20	1.68	6.52	1.74
Pro-city attitudes (Time 2)	2.84	0.63	3.15	0.54	3.15	0.61	3.13	0.68	2.92	0.64

Table 2
Environmental and psychological associations with pro-city attitudes and transit ridership: Multinomial logistic regression initial analyses (left) and mediated analyses (right)

	Initial relation to ridership			Pro-city attitudes as mediator				
	95% CI			95% CI				
	B	SE	Odds ratio	LL,UL	B	SE	Odds ratio	LL,UL
Continuing riders (compared to never-riders)								
Car available	-1.99**	0.41	0.14	0.06, 0.30	-2.02**	0.41	0.13	0.06, 0.29
Renter	1.37**	0.44	3.92	1.64, 9.36	1.32**	0.45	3.73	1.55, 8.98
Obese	-.69	0.42	0.50	0.22, 1.16	-0.64	0.43	0.53	0.23, 1.22
Moderate-to-vigorous physical	.04**	0.01	1.04	1.02, 1.05	0.03**	0.01	1.03	1.02, 1.05
Housing density, home block	.03	0.41	1.03	0.46, 2.30	-0.02	0.42	0.98	0.43, 2.22
Land use diversity, home block	.37**	0.13	1.45	1.11, 1.88	0.36**	0.13	1.43	1.10, 1.86
Distance to complete street, in 100 meters	-.11**	0.04	0.89	0.83, 0.96	-0.11**	0.04	0.90	0.84, 0.97
Path problems	.00	0.10	1.00	0.83, 1.21	-0.01	0.10	0.99	0.82, 1.19
Place Attachment	.25*	0.11	1.28	1.03, 1.60	0.21	0.12	1.23	0.98, 1.54
Pro-City attitudes (Time 2)					0.53	0.32	1.71	0.92, 3.18
Former riders (compared to never-riders)								
Car available	-1.66**	0.45	0.19	0.08, 0.46	-1.67**	0.46	0.19	0.08, 0.46
Renter	0.60	0.42	1.81	0.80, 4.11	0.52	0.42	1.69	0.74, 3.86
Obese	0.85*	0.39	2.34	1.10, 4.99	0.93*	0.39	2.54	1.18, 5.47
MVPA	0.04**	0.01	1.04	1.02, 1.06	0.03**	0.01	1.03	1.02, 1.05
Housing density, home block	1.41**	0.48	4.10	1.61, 10.43	1.36**	0.48	3.92	1.53, 10.04
Land use diversity, home block	0.08	0.13	1.09	0.84, 1.41	0.06	0.14	1.07	0.82, 1.39
Distance to complete street, in 100 meters	0.02	0.04	1.02	0.95, 1.09	0.03	0.04	1.03	0.96, 1.10
Path problems	-0.01	0.09	0.99	0.82, 1.19	-0.02	0.09	0.98	0.82, 1.17

	Initial relation to ridership				Pro-city attitudes as mediator			
	95% CI				95% CI			
	B	SE	Odds ratio	LL,UL	B	SE	Odds ratio	LL,UL
Place Attachment	0.01	0.11	1.01	0.82, 1.25	-0.04	0.11	0.96	0.77, 1.20
Pro-City attitudes (Time 2)					0.72 *	0.33	2.06	1.07, 3.96
New riders (compared to never-riders)								
Car available	-0.94 *	0.45	0.39	0.16, 0.94	-0.96 *	0.45	0.38	0.16, 0.92
Renter	0.50	0.34	1.65	0.85, 3.20	0.43	0.34	1.53	0.78, 3.00
Obese	-0.25	0.34	0.78	0.40, 1.53	-0.17	0.35	0.85	0.43, 1.68
MVPA	0.02 *	0.01	1.02	1.01, 1.04	0.02 *	0.01	1.02	1.00, 1.04
Housing density, home block	0.38	0.34	1.47	0.75, 2.86	0.37	0.35	1.45	0.74, 2.85
Land use diversity, home block	0.01	0.14	1.01	0.76, 1.33	-0.01	0.14	0.99	0.75, 1.31
Distance to complete street, in 100 meters	-0.06	0.03	0.95	0.89, 1.01	-0.05	0.03	0.95	0.89, 1.01
Path problems	-0.04	0.08	0.96	0.83, 1.13	-0.05	0.08	0.95	0.81, 1.11
Place Attachment	0.30 **	0.10	1.35	1.11, 1.64	0.27 **	0.10	1.31	1.07, 1.59
Pro-City attitudes (Time 2)					0.54 *	0.26	1.72	1.03, 2.89

*
p < .05.**
p < .01.