Habit Discontinuity and Student Travel Mode Choice

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Abstract

Overreliance on motorised travel modes aggravates existing problems of public obesity and global climate change. However, travel mode choices are often habitual, and habits are difficult to break, they ~~are~~ automatic responses to stable-contexts learnt through repetition. One approach is to destabilise the stable-contexts that cue travel habits. Such an opportunity could arise when people move-house, so we predicted that the travel mode choices and habits of university students would change, without a behaviour change intervention, when they moved-house between academic terms. University students (N = 250) completed two questionnaires, around 5.5 months apart, between new academic years; 153 students moved-house ("movers"). As predicted when movers changed their travel mode choices, their new choices became more automatic and their old choices less automatic. Mover's travel changes were planned prior to moving-house, however there was insufficient evidence that either changes in the social context or activated values were related to travel changes. We discuss these findings with respect to acquiring habits and the habit discontinuity and self-activation hypotheses (Verplanken, Walker, Davis & Jurasek, 2008) and the advantages of student house-hunting as a 'window of opportunity' for establish new travel habits amongst university students.

Keywords: Habit discontinuity hypothesis, habits, travel mode choice, university students.

Choices between walking, cycling, driving or using public transport – travel mode choices – have important consequences. Cumulative motorised travel exacerbates public obesity (McCormack & Virk, 2014) and global climate change (Sims et al., 2014). Physically-active travel (walking and cycling) alleviates these problems (Woodcock et al., 2009; de Nazelle et al., 2011). Travel mode choices are often habitual (Hoffmann, Abraham, White, Ball & Skippon, 2017; Lanzini & Kahn, 2017) and habits are difficult patterns of behaviour to change (Jager, 2003). One proposal for breaking travel mode choice habits is to take advantage of moments of change or disruption, when habits happen to be at their weakest (Verplanken & Wood, 2006). A candidate for such a moment is when someone moves-house (Verplanken et al., 2008; Verplanken & Roy, 2016). We studied the changing travel mode choices and habits of university students in the UK, predicting that students who moved-house during the study ("movers") would more often make new travel mode choices and change their travel mode choice habits compared to other students ("non-movers").

Habits and the Habit Discontinuity Hypothesis

There are various concepts of habit (Barandiaran & Di Paolo, 2014), but habits in social psychology can be conceptualised as a type of memory with three specific properties (Kurz, Gardner, Verplanken & Abraham, 2015). (1) Habits are learnt through repetition (Lally, Van Jaarsveld, Potts & Wardle, 2010). (2) Habits are cued (triggered) by *stable-contexts*: physical, temporal and social circumstances that are recurrent and unchanging (Ouellette & Wood, 1998; Verplanken & Aarts, 1999). (3) Perhaps most importantly (Gardner, 2015), cued habits lead to *automatic* behavioural responses – automatic behaviour is fast, efficiently, unconscious and

occurs with little thought (Moors, 2016) and, as such, it is difficult to control (Orbell & Verplanken, 2010) and salient information is ignored (Verplanken, Aarts & van Knippenberg, 1997. One's sense of identity or personal style is also thought to reflect one's habits (Verplanken & Orbell, 2003). Previous research has identified habits as supporting health-relevant behaviours (e.g. diet, exercise and drug use: see Gardner, 2015) including travel mode choices (Gardner, 2009; Thomas & Walker, 2015). Self-control with self-awareness can be effective in controlling habits (Quinn, Pascoe, Wood & Neal, 2010) until willpower fails and old habits reassert themselves (Neal, Wood & Drolet, 2013).

The *habit discontinuity hypothesis* is the hypothesis that if a stable-context is destabilised then the causal links between context-cues and habits are severed, temporarily, provide an opportunity to break old habits altogether (Verplanken et al., 2008) and learn new ones (Walker, Thomas & Verplanken, 2015). It is thought that stable-contexts are destabilised when certain events, "moments of change", occur (Thompson et al., 2011); these moments of change are often correlated with travel changes (Klöckner, 2004; Müggenburg, Busch-Geertsema & Lanzendorf, 2015). Some candidates include life-cycle events (Employment: Gillison, Standage & Verplanken, 2014; Parenthood: Schäfer, Jaeger-Erben & Bamberg, 2012; Thomas, Fisher, Whitmarsh, Milfont & Poortinga, 2018) and disruptive events (e.g. road-closure: Fujii, Gärling & Kitamura, 2001; workplace relocation: Walker et al., 2015). Moving-house is also a plausible candidate (e.g. Bamberg, 2006): it involves a new place, and possibly also new people, activities and schedules. Verplanken et al., (2008) hypothesised that moving-house would lead to increased awareness of pro-environmental values amongst commuters and so lead them to reduce their car-use. This was evidenced with a sample of university-commuters: those with strong pro-environmental values drove even less if they had also moved-house recently. This pattern was

replicated with a larger, representative sample of the UK population (Thomas, Poortinga & Sautkina, 2016). In a field experiment with householders, Verplanken and Roy (2016) found that an intervention promoting sustainable behaviours was somewhat more effective in increasing sustainable behaviour if participants had also recently moved-house. Importantly, a discontinuity in an old habit is hypothesised to precede behavioural change, which in turn leads to the development of a new habit through behavioural repetition; habit discontinuity precedes habit change (Walker, Thomas & Verplanken, 2015). Understanding subsequent habit changes is important because habits and behaviour are theoretically distinct (Verplanken, 2006) and because of the practical importance of establishing a habit to successfully breaking an old one (Rothman et al., 2015).

Previous research has shown that university students can possess strong travel mode choice habits (Gardner, 2009; Thomas & Walker, 2015) that are probably socially-learnt from family, friends and peers (Klöckner & Matthies, 2012). A university campus would seem to provide an ideal location within which to encourage positive behaviour changes amongst young people (Plotnikoff et al., 2015; Wilson et al., 2016) and the predictable annual university student house-hunting affords an opportunity to circumvent practical difficulties of studies of the effects of house-moving (Ampt, Stopher & Wundke, 2005). From the habit discontinuity hypothesis, we considered it plausible that students who moved-house would experience a discontinuity in their habits, facilitating changes in travel behaviour that, in turn, would lead to the formation of new travel habits (through repetition) and the loss of old travel habits through forgetting. We asked this two-part primary research question.

RQ 1a: ~~To what extent is~~ Is moving to a new house between academic years (predictor, X) associated with change in travel habits (criterion, Y) through changes in travel behaviour (mediator, M)?

RQ 1b: ~~To what extent is~~ Is travel mode change, for movers and non-movers, associated with changes in habits for current and previous travel mode use?

Motivation and Context

In addition to our primary research question, we considered several motivational and contextual factors that might be involved in habit and travel changes with habit discontinuity. Specifically, we considered the roles of travel planning, value activation and context change.

Planning to change travel mode. Several studies of moving-house and travel mode change have noted the importance of plans (intentions), before moving-house, to subsequent travel behaviour after moving-house (Bamberg, 2006; Schäfer et al., 2012; Jones & Ogilvie, 2012). The motivations for these plans are likely practical, but may also reflect value-motives, such as environmental concern (Dunlap, Van Liere, Mertig & Jones, 2000). Putting planned change into practice is consistent with the idea that habit discontinuity facilitates planned behaviour changes or, theoretically equivalent, that habit limits the effect of prior intentions upon behaviour change (Verplanken & Aarts, 1999: pp. 214-5; Gardner, 2015: pp. 9-10). However, this is less consistent with the idea that habit discontinuity (e.g. with moving-house) coincides with unanticipated motivational changes (Verplanken & Wood, 2006). Therefore, we asked this research question.

RQ 2: ~~To what extent is~~ Is moving to a new house (X) associated with changes in travel behaviour (Y) through planning to use a particular type of travel (M)?

Value activation. *Values* are "desirable, transsituational goals, varying in importance, that serve as guiding principles in people's lives" (Schwartz, et al., 2001: p. 521). The *self-activation hypothesis* (Verplanken et al., 2008) is that a moment of change (e.g. moving-house) can lead to value-led behaviour changes if (a) the value is part of an individual's self-concept (is *self-central*) and (b) the moment of change led to value activation. *Value activation* is thinking about a situation (processing information) from a value-perspective (e.g. thinking about driving as environmentally damaging, or walking as good for my health), rather than, for instance, a pragmatic-perspective (e.g. driving as convenient, walking as cheap) (Schwartz, 1977; Dahlstrand & Biel, 1997). In the context of moments of change, value-activation might occur when values are "implied by the situation or by the information a person is confronted with" or with "self-focused" cognition (Verplanken & Holland, 2002: p. 436). For students, value activation might bridge an apparent gap between value motives and travel behaviour (Shannon et al., 2006; Simons et al., 2014); indeed, UK students, as a demographic group, are generally committed to environmental sustainability (Cotton & Alcock, 2013). Most previous studies have focused upon pro-environmental values as the motivation for changes with habit discontinuity, rather than values in general (Verplanken et al., 2008; Walker et al., 2015; Thomas et al., 2016; Verplanken & Roy, 2016). Therefore, we considered whether different values might be activated at this time. Given this theory of value activation, we anticipated that when students move-house, their values could be activated and (if these values are self-central, as indexed by their strength) then movers with these values will more often change their travel behaviour than movers who do not hold these values. Therefore, we also asked this research question.

RQ 3: ~~To what extent is~~ Is moving to a new house (predictor, X) associated with changes in travel behaviour (criterion, Y) only for those with particular values (moderator, W)?

Context change. Previous research has demonstrated that habits are cued within stable contexts: for instance, smoking in public-houses (Orbell & Verplanken, 2010) and eating popcorn in cinemas (Neal, Wood, Wu & Kurlander, 2011). Wood, Tam and Witt (2005), studying the role of stable-contexts in domestic habits as students moved-house, found that exercise behaviour was influenced by similarities in the physical context (similarity of exercise locations) whereas reading newspapers was influenced by similarities in the social context (presence/absence of similar people also reading the newspapers). Aside from Wood et al. (2005), and studies in comparative psychology (e.g. Thrailkill & Bouton, 2014), we could not find any previous research addressing how changing context-cues might weaken or change habits. University life is a learning experience in independent living for young people (Rugg, Ford & Burrows, 2004) and this involves new friendships, social networks and identities (Heath, 2004; Easterbrook & Vignoles, 2012), where sharing a house with new people is an important element in this experience (Easterbrook & Vignoles, 2015). Therefore, it is plausible that changes in a student's household reflect these changes in their social context. Indeed, Young people identify the travel of their friends, family and peers as important in their own travel choices (Simons et al., 2014) and at least one study has found that the travel modes of students are associated with the travel modes of their roommates (Bopp, Behrens & Velecina, 2014). If moving-house changes the social context of the household, as indicated by a student's own perceptions of the importance of this change (Wood et al., 2005), then moving-house would be

associated with this and, in turn, these perceptions would be associated with travel behaviour change. Therefore, we asked the following research question.

RQ 4: ~~To what extent is~~ Is moving to a new house (X) associated with changes in travel behaviour (Y) through perceptions of household life change (M)?

The Present Study

In the UK, university students tend to change their term-time accommodation (move-house) in late September, before the beginning of a new academic year (NUS, 2014: pp. 27-28). Student participants in our study completed a research questionnaire in May, or early June, and a second research questionnaire between October and November. We recruited approximately equal numbers of students who did, and did not, intend to move to a new house between university terms. After September, changes in travel behaviour (university commuting) were compared between movers and non-movers.

Method

Participants

University students studying full-time in the UK were recruited through advertisements, which appeared on the notice board feature of the student intranet at a ~~particular~~ UK university and in different Facebook groups used by different university students across the UK. Students on external work-placements, distance learners, and final-year students were excluded, having no reason to commute to their university consistently. Quota sampling was used to recruit

194 approximately equal groups of people *intending* to move-house and people intending not to, as
195 well as equal proportions of post-graduates within each group.

196 Of 361 participants, 250 (69.3%) completed the study. Of these, 153 (61.2%) were
197 confirmed movers and 97 (38.8%) were confirmed non-movers. Most movers had made a
198 tenancy agreement with a landlord before they began the study but had yet to move into the
199 house (116, 75.8%). Many participants (164, 65.6%) were aged between 18 and 21 years;
200 seventy-four (29.6%) were aged between 22 and 30. The majority of participants (185, 74.0%)
201 were female. Around one-fifth (51, 20.4%) were postgraduate students. Many participants were
202 studying at one particular university, 155 (62.0%). At the beginning of the study, most
203 participants commuted as pedestrians or cyclists (182, 72.8%); others either took public
204 transport, 43 (19.3%), drove, 16 (7.1%), or used two of more modes equally, 8 (3.6%). Some
205 students were not UK licensed motorists (87, 34.8%): 5 of these students (5.7%) qualified during
206 the study. Many of the students lived close to their university: before moving, median home-
207 university distances were 1.25km (with interquartile range 2.06km). Movers tended to live with
208 different people – a student moving into a five-bedroom house might, on average, share their
209 new house with three new housemates and two of their previous housemates. Movers also
210 tended to perceive changes in their living arrangements as important, M (SD) = 4.31 (1.86),
211 compared to non-movers, M (SD) = 1.82 (1.68), t (219.86) = -10.95, $p < .001$.

212

213 **Materials**

214 **Mover/Non-mover.** This was assessed in the second questionnaire. To confirm if a
215 house-move had taken place, participants read a short definition of *term time accommodation* (as
216 distinct from a family home), before being asked: *when did you last move into new term-time*

accommodation? [*After September 1st, 2015*; *August 2015*; *June or July 2015*; *May 2015*; *Before May 1st, 2015*]. Those who indicated moving to a new house during or after May 2015 were also asked to provide a specific date for the move: none of these dates were before May 1st. Therefore, participants answering "before May 1st 2015" were coded as 'non-movers' ('0') and other participants coded as 'movers' ('1').

Travel Frequency and Travel Behaviour Change. Participants were asked how many days in a typical week they visit the university [*Never*, *1 day*, *2 days*, *3 days*, *4 days*, *5 days*, *6 or 7 days*]. The answers to this question in the second questionnaire were used as a travel frequency variable. Participants were then asked to indicate the number of days in a typical week where they use each of several different modes of transport to get to and return from the university. Figure 1 shows the answer-form presented to the participants. A short explanation of *combined transport modes* followed, before participants were asked for an open response to this question: *if you combine modes of travel in a single trip, when travelling to or from the university during a typical week, then please describe how you do so*. Where answers indicated combining two modes of travel (for walking, 5 or more minutes of walking) then *half* a journey was recorded for each mode. The proportion of walked journeys was calculated using this data. These questions were asked in both questionnaires and travel behaviour change was calculated as the proportion from the second questionnaire less the proportion from the first. This calculation is given in the equation below, where 'F' is the frequency of journeys: either by active modes (walking or cycling) or in total; either in the second questionnaire ('T=2') or in the first ('T=1').

$$\Delta\, Travel\ Behaviour = \frac{F_{Active}^{T=2}}{F_{Total}^{T=2}} - \frac{F_{Active}^{T=1}}{F_{Total}^{T=1}}$$

Thus, this variable could ~~differ~~ vary between '-1' (complete change to motorised transport) to '1' (complete change to active transport).

	To get to university from your term time accommodation							To return from university to your term-time accommodation						
	Never	1 day	2 days	3 days	4 days	5 days	6 or 7 days	Never	1 day	2 days	3 days	4 days	5 days	6 or 7 days
Walk	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍
Cycle	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍
Car or motorcycle (as driver)	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍
Car or motorcycle (as passenger including taxis)	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍
Train	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍
Bus or Tram	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍
Other	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍	❍

Figure 1. Answer form for university commuting travel behaviour. 'Never' was the default.

Travel Habit Change. Habit-strengths were assessed using the 4-item Self-Report Behavioural Automaticity Index (Gardner et al., 2012), which is a sub-scale of the 12-item Self Report Habit Index (Verplanken & Orbell, 2003). So, for each of three travel mode types participants rated these items on a 5-point scale anchored between *strongly agree* and *strongly disagree*. These items were: *when I travel during the university term, travelling* [*by car or by motorcycle* / *by walking or by bicycle* / *by bus or by train*] *is something...* (1) *...I do automatically*, (2) *...I do without having to consciously remember*, (3) *...I do without thinking*, (4) *...I start doing before I realize I'm doing it*. Travel habit scores were the average of scores across these four items, for a travel mode type. Scales were reliable, with Cronbach's Alphas exceeding .95. Travel habit (behavioural automaticity) change was the difference between scores for second and first questionnaires, potentially varying between -4 and +4 units. Participants without a driving-license were not asked motoring-habit questions.

We chose the SRBAI over the SRHI for practical reasons: to measure three different habits whilst using substantially fewer items (12 as opposed to 36). We acknowledge the cost of this approach is that behavioural automaticity is not necessarily always the same thing as habit, though the two measures are closely correlated (Gardner, 2015). For brevity, we have used 'habit' and 'behavioural automaticity' synonymously.

Planning to Walk. This was assessed in the first questionnaire and, hence, prior to moving-house. Participants answered the question *during the next 6 months I will get to and from the university by either walking or by cycling* twice, on a 7-point scale, with respect to different anchors reflecting different aspects of intention: *strongly agree* (1) and *strongly disagree* (7); *definitely will* (1) and *definitely won't* (7). The mean of the scores was taken for the planning to walk variable. The items were closely correlated (R = .870).

Distance Change. Journey distance was approximated using home-university distance: the linear distance (calculated as great-circle distances: Chamberlain, 1996) between the centre of a participant's postcode and a representative point at their university. This representative point, for each university, was a university main-building, central-square or student's union building, except when the participant's degree-subject suggested that they attended a different campus (such as a hospital or engineering campus), in which case their degree-subject school building was used. Distance change was the difference between distances from second and first questionnaire responses in kilometres.

Perceptions of Change. In the second questionnaire, participants were asked ~~to~~ *please indicate how far you have experienced important life changes in the following areas of your life over the past 3 months*. Five items described different aspects of life-change, including personal relationships and career/ education. One of the five items was used to assess perceptions of

household life change: *...in your living arrangements e.g. moving house or city, living with different people.* Ratings were made on a 7-point scale, with anchors *no change* (1) and *a profound change* (7) and a mid-point label of *an important change* (4).

Human Values. The 40-item Portrait Value Questionnaire (PVQ: Schwartz et al., 2001) was used to assess human values. In both questionnaires, participants were asked to assess whether descriptions were like (or unlike) themselves for different statements. For example: *thinking up new ideas and being creative is important to him. He likes to do things in his own original way* (items were phrased according to the participant's stated gender, 'he/his' or 'she/her'). Ratings were made on a 6-point scale, with anchors *very like me* (1) and *not like me at all* (6)*,* and *don't know* (7). Four value-dimension scores ("conservation" (CN), "self-transcendence" (ST), "self-enhancement" (SE) and "openness to change" (OTC)) were calculated; to correct individual differences in scoring, the means were centred using the participant's mean across all 40 statements (Schwartz, 2003: p. 275). Self-transcendence values are most associated with concern for the environment (Schultz & Zelezny, 1999). Scales were reliable, with Cronbach's Alphas ranging between .739 and .852. In all reported analyses, value-scores from the first questionnaire are used; values did not differ significantly (with Bonferroni adjustment for multiple comparisons): CN, $t(249) = .162$, $p > .0125$; ST, $t(249) = 2.190$, $p > .0125$; SE, $t(249) = -.254$, $p > .0125$; OTC, $t(249) = -.1377$, $p > .0125$.

Environmental Concern. Agreement/disagreement with six items from the revised New Ecological Paradigm scale (Dunlap et al, 2000; see Whitmarsh & O'Neill, 2010) was used to measure environmental concern. For instance: *humans are severely abusing the planet* and *humans were meant to rule over the rest of nature* (a reverse-score item). Ratings were made on a 5-point scale with anchors *Strongly Disagree* (1) and *Strongly Agree* (5). Environmental

concern measured in the first questionnaire was used in analyses; environmental concern did not differ significantly between questionnaires: t (247) = -.735, $p > .05$.

Procedure

The first questionnaire began with a briefing and online-consent form, before asking several screening questions. Participants then completed the questionnaire and provided contact details in confidence. All participants completed this first questionnaire between the 5th of May 2015 and the 10th of June 2015 (the majority, 92.4%, during May). Most house-moves took place in September 2015 (95, 62.1%); almost all other house-moves took places in June, July and August (52, 34.0%). All participants were re-contacted by E-mail on the 28th of October and asked to complete the second questionnaire, doing so between the 28th of October 2015 and the 21st of November 2015 (the majority, 70.4%, during October). After completing the second questionnaire, participants were thanked, shown a written debrief and were remunerated. The duration of the study for participants ranged between 141 days and 193 days (with a mean of 169 days).

Results

A prior study (Haggar, 2016: pp. 94-126) provided an effect-size estimate for the present study, with respect to the effect of moving-house on travel behaviour change: R = .159 (d = .322). Falling short of a recruitment target of 311 for a power of .80, a level of a priori power was re-estimated using the achieved sample-size ($N = 250$), less four participants as a heuristic adjustment for lost power due to unequal group sizes (Rosnow, Rosenthal & Rubin, 2000). For a sample of 246 participants, power in multiple regression was re-estimated at .70. (sensitivity to

effect-sizes of R = .189 (d = .386) in multiple regression). Compared to multiple regression, mediation and moderation analyses can require additional statistical power (Fritz & MacKinnon, 2007; Dawson, 2014) to detect comparable effects.

Several additional variables were included as alternative explanations and controls. For travel and habit changes, *initial levels of travel and habit* (respectively) allow for regression to the mean (Alison, 1990; e.g. Lanzini & Thøgersen, 2014). *Distance change* has been accounted for in both planned travel and travel changes to control for the influence of distance changes that occur when students move-house; distance is an important factor in travel choices (Ewing & Cervero, 2010) including those of students (Bopp et al., 2014; Shannon et al., 2006; Simons et al., 2014). *Environmental concern* has been allowed for in estimating planned travel to represent a prior motive for walking/cycling. *Travel frequency* (the number of days the student travelled to the university each week) helps to separate the influence of behaviour change on habit change from that of the extent of repetition (Lally et al. 2010; see also Friedrichsmeier, Matthies & Klöckner, 2013).

A bootstrapping approach was used to address potentially problematic non-normality of residuals (a symmetric leptokurtic distribution) and to optimise statistical power (Howell, 2013). We report a conditional process model (path model) alongside~~, for comparison,~~ a simpler mediated multiple regression model for comparison; both were bootstrapped with 5000 bootstrap samples and Bias-Corrected and accelerated (BCa) 95% confidence intervals; they were calculated using the PROCESS macro for SPSS (Hayes, 2018); variables were *not* centred or standardized. Key statistics for this model are presented in Figure 2; descriptive statistics and correlations (Table A1), as well as tabulated results for each model (Tables A2 and A3), are reported in the Appendix.

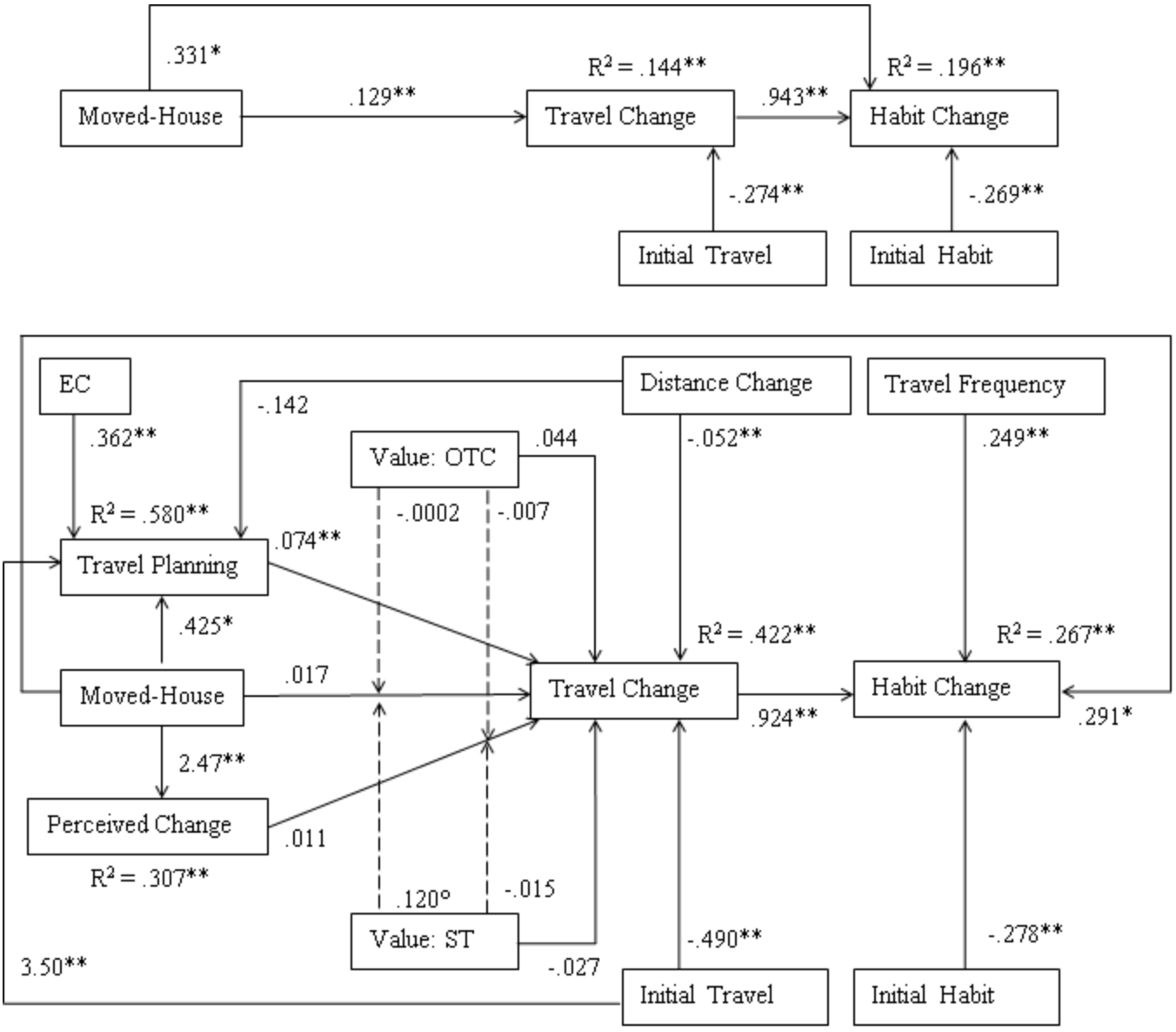

Figure 2. Mediated multiple regression (top) and conditional process models of the associations between moving-house, changing walking/cycling behaviour and changing walking/cycling habits. Variables are measured in their original units and are not centred. "OTC" is 'Openness to Change'; "ST" is 'Self-Transcendence; "EC" is 'Environmental concern'. Dashed lines represent moderation (interaction) effects. °$p < .1$; *$p < .05$; **$p < .01$.

Habits and Habit Discontinuity

The first part of our primary research question was: ~~*to what extent*~~ *is moving to a new house between academic years (X) associated with change in travel habits (Y) through changes*

in travel behaviour (M). Figure 2 (top) shows that changes in walking/cycling to the university statistically mediate ~~some of the~~ association between moving-house and changes in walking/cycling habits. ~~However, much of the association is not mediated through behaviour-change.~~ This pattern of association was also found once allowing for other ~~paths and~~ variables (Figure 2, bottom). Therefore, moving to a new house is associated with change in travel habits through changes in travel behaviour. The second part of our primary research question was: ~~*To what extent*~~ *is travel mode change, for movers and non-movers, associated with changes in habits for current and previous travel mode use.* We addressed this question by considering patterns of correlation. Changes between motorised and active travel modes were closely negatively correlated for movers (active-public, R = -.67, active-driving, R = -.42) but motorised mode changes were not statistically significantly correlated, indicating that, for the most part, movers switched to or from active travel modes. Table 1 shows how travel modes changes were associated with habit changes for movers.

Table 1 Correlations [with 95% confidence intervals] between Changes in Habit and Travel Behaviour

		Travel Behaviour Change		
		Active	Driving[a]	Public
Habit Strength Change	Active	**.456**** **[.303, .583]**	-.244 [-.407, -.086]	**-.343**** **[-.474, -.184]**
	Driving[a]	-.266 [-.384, -.052]	**.358*** **[.172, .590]**	.124 [-.063, .248]
	Public	**-.389**** **[-.523, -.234]**	.043 [-.082, .253]	**.478**** **[.322, .594]**

Note. $N = 152$. Statistical significance was Bonferroni adjusted to correct for multiple comparisons.
[a] Sub-sample of legal motorists ($n = 91$).
**p<.001. *p< .0056.

~~Left-diagonal~~ Same-mode correlations were moderately positive, indicating that adopting new modes was associated with strengthening habits for these new modes. ~~Some off-diagonal~~ Other correlations indicate that switching between active and public transport modes was associated with weakening habits for the previous mode. That ~~other~~ off-diagonal correlations did

not reach significance can be partly attributed to smaller sample sizes (few motorists in the sample) and partly to the lack of switching between public transport and driving. By comparison to movers, non-movers showed evidence of switching between all modes (active-public, R = -.44, active-driving, R = -.60, public-driving, R = -.453). However, associations between travel and habit changes for non-movers tended not to reach statistical significance, beyond public transport habits for new users strengthened, R = .458, and public transport habits amongst new users of active transport weakened, R = -.281). Therefore, travel mode change, for movers and non-movers, is associated with changes in habits for current and previous travel mode use. ~~travel mode change was sometimes associated with strengthening habits for current travel modes and/or weakening habits for previous travel modes, but~~ Patterns of association, however, do also differ descriptively between movers and non-movers. ~~and, for non-movers, cannot be easily attributed to modal changes alone.~~

Altogether, contrary to the idea that habits are mostly formed through repetition, travel-mode change explains some of the association between moving-house and travel habit changes ~~but does not explain it completely~~. This may be related to the way in which changes in travel habits with travel modes are manifest for both movers and non-movers but differ descriptively between the two groups.

Motivation and Context

Our second research question was: ~~*to what extent*~~ *is moving to a new house (X) associated with changes in travel behaviour (Y) through planning to use a particular type of travel (M)*. Figure 2 (bottom) shows that the association between moving-house and changes in walking/cycling was *entirely* accounted for by planning to walk/cycle. Therefore, moving to a new house is associated with changes in travel behaviour through planning to use a particular

type of travel. This indicates that if moving-house lead to this behaviour change through habit discontinuity, then this facilitated behaviour changes that were already being contemplated. While marginal, the full mediated path from moving-house to habit change through planned travel changes is statistically significant, B = .029, 95% CI [.0005, .0723], which raises the possibility that moving-house leads to implementing plans to walk/cycle that lead to stronger habits of walking and cycling.

Our third research question was: ~~*to what extent*~~ *is moving to a new house (predictor, X) associated with changes in travel behaviour (criterion, Y) only for those with particular values (moderator, W).* ~~and~~ Our fourth research question was: ~~*to what extent*~~ *is moving to a new house (X) associated with changes in travel behaviour (Y) through perceptions of household life change (M)*. Our model (Figure 2, bottom) shows that both these questions may be answered ~~in the negative~~ negatively. Once other factors were accounted for, there was no evidence that perceptions of change mediated an association between moving-house and changes in walking/cycling. No such associations were evident, either, when a moderating effect of values was considered. So, when planned travel is accounted for, there is no evidence to suggest that value-activation or context-change, occurring *after* moving-house, influences travel behaviour.

Discussion

We studied how the travel mode choices of a sample of university students in the UK changed between university terms, focusing upon the effect of moving-house as a moment of change (Thompson et al., 2011). From the habit discontinuity hypothesis (Verplanken et al., 2008), we predicted that movers (students who moved-house) would more often make new travel mode choices and, in turn, develop new travel mode habits when compared to non-movers. Our

predictions were correct~~, but only to a limited extent~~. Moreover, summarising our findings as a whole, we found that students who made plans to walk or cycle to university were more likely to do so if they moved to a new house, despite little scope for change, initially, given 73% of participants already walking or cycling to the university when the study began.

We found that much of the association between moving-house and travel *habit* change was not explained by the changes in travel *behaviour* that we measured. This raises the possibility that this direct association could be explained through the travel behaviour changes we did *not* measure (e.g. for shopping trips), as is implied by the concept of a generalised habit (Verplanken & Aarts, 1999) and previous approaches to measuring habitual travel mode choices (Verplanken, Aarts, van Knippenberg & van Knippenberg, 1994). It is also plausible that moving-house changed the context of travel in a way that facilitated habit development independently of practice, such as by altering the structure of habitual routines (scripts) within which travel choice habits may be nested (see Judah, Gardner and Aunger, 2012). This latter account is suggested (but by no means evidentially supported) by the patterns of correlation we report, whereby movers show a more general pattern of habit change with travel mode change, whereas non-movers showed habit changes limited to particular modal changes (to and from public transport upon public transport habits). Our findings further support the idea that habit learning is not merely a function of repetition (Lally et al., 2010).

From ideas of planned behaviour, value activation and contextual change, we considered the mediating or moderating roles of planned walking/cycling, human values and perceptions of important household changes in the association between moving-house and travel choices. We found that planning to walk/cycle entirely explained this association and so perceptions of change did not, regardless of the values of the participants. This is consistent with a habit

discontinuity leading only to students enacting previously contemplated travel changes or starting to contemplate travel changes but without putting these into action (Dahlstrand & Biel, 1997; Prochaska, Redding & Evers, 2008; Bamberg, 2013). We might also speculate that value-activatation operates through the activation only of quite specific values (see Maio, 2010) rather than universal human values (Schwartz et al., 2001), in which case future work might concentrate on the activation of specific value judgements (see also Schwartz, 1977). However, given that students as a group are thought to be concerned about the environment (Cotton & Alcock, 2013), it is not surprising that we found (irrespective of moving-house) that concern for the environment influenced students' plans to walk or cycle in the future.

With respect to the role of context change (as indicated by perceptions of change), we found no evidence that this accounted for changes in walking/cycling with moving-house. Accurate measurement of context changes through self-report, as well as identifying the salient context changes for a certain behaviour, is difficult (Wood et al., 2005) and a subjective measure may not accurately detect changes in contextual cues that operate without consciousness (Bargh & Chartrand, 1999). More-controlled studies will be necessary to better isolate the potential effects of contextual cues upon travel behaviour (e.g. Wansink, Ittersum & Painter, 2006; Orbell & Verplanken, 2010); contextual cuing is, indeed, important in separating habits from other forms of automaticity (Wood & Rünger, 2016).

Our findings contribute to the existing evidence that moving-house marks a window of opportunity for changing behaviour (Bamberg, 2006; Schäfer et al., 2012; see also Thompson et al., 2011) and habits (Rothman et al., 2015). They are also consistent, broadly, with the habit discontinuity hypothesis (Verplanken et al., 2008)~~, albeit inconsistent with some of the specific ideas about how it functions~~. So, while our findings tend to favour moving-house as a moment

461 of change during which university students may be more inclined to change their travel
462 behaviour and cultivate new habits of travel, they provide only a partial account of the
463 underlying factors involved. One clear finding is the importance of prior planning, which has
464 been emphasised in the results of previous work (Bamberg, 2006; Schäfer et al., 2012; Jones &
465 Ogilvie, 2012). It follows that attempts to change student travel behaviour through interventions
466 (e.g. Kormos, Gifford & Brown, 2015; Wilson et al., 2016; see also Michie, van Stralen & West,
467 2011) might consider intervening both during house-hunting and after students move to their new
468 accommodation, in order to maximise the impacts of planned and unplanned changes in travel
469 choices and unstable travel habits. As our findings are also inconclusive with respect to the
470 activation of values, an educational or persuasive intervention (Michie, van Stralen & West,
471 2011) to target morally concerned students (Eriksson, Garvill & Nordlund, 2008) may be
472 effective in bringing value-motives into focus (c.f. Verplanken & Roy, 2016).

473 Our study was limited in several respects. It lacked statistical power, with the
474 consequence that small effects may not have been detected and the coefficients of effects we did
475 detect are not estimated with much certainty. We have used contrasts to show patterns of
476 association: we collected data both before and after the house-move, to establish a sequence of
477 events, and compared movers and non-movers, to establish group differences over time.
478 However, these contrasts cannot evidence causes and effects, but only statistical associations
479 consistent or inconsistent with different causal accounts. Similarly, we cannot exclude the
480 possibility that the links we show between variables do not arise spuriously, due to confounding
481 factors, though we have taken account of some commonplace explanations. For instance,
482 distance remains an important alternative explanation: while, in our sample, students tended to
483 live relatively close to the university, this is not always the case (Davison, Ahern & Hine, 2015).

Similarly, our study does not take account of situational factors that might be particular to students (Klöckner & Blöbaum, 2010) and so it is plausible that our findings would differ when students are compared to non-students, particularly with respect to the actual control students have over their own travel choices under financial and other constraints. We also note that our measurements, being derived from self-report, lacked precision; and that habit (as behavioural automaticity), journey distance (as home-university distance) and contextual-change (as perceived life-event importance) were measured by proxy and not directly. However, it is encouraging, with respect to future application of our findings, that active transport use increases were made even in a sample where active transport use was prevalent and so opportunities for increasing behavioural frequency were limited (see Friedrichsmeier, Matthies & Klöckner, 2013).

The findings of our study add to the evidence concerning travel changes with residential relocation, habit discontinuity and habit change. Our findings support the general conclusion that moving-house is a moment at which some students choose to change their travel behaviour and that this can lead to increases in the use of physically active travel modes for commuting. Our more specific findings are less clear with respect to the habit discontinuity hypothesis and self-activation hypotheses, showing a comparative importance of prior planning rather than reconsideration after moving-house. This study is also one of the few to address the question of how the absence of context-cues could link a moment of change (such as moving-house) to a weakening of habits and subsequent changes in behaviour, though we found no evidence for this process. Less theoretically, our study demonstrates some potential for intervening to change university student travel behaviour during predictable annual changes in accommodation that may mark a moment during which university students are better able to take control of their

travel behaviour to walk and cycle to the university more often, benefitting the environment and their own health.

Appendix A: Statistical Tables

Table A1: Descriptive Statistics and Bivariate Correlations

	1	2	3	4	5	6	7	8	9	10	11	12
1	1	.378**	.562**	.004	.009	-.134*	.057	.389**	-.031	.129*	.028	.413**
2	.378**	1	.342**	.213**	.017	.017	.055	.740**	.013	.170**	-.049	.716**
3	.562**	.342**	1	.046	.062	-.033	.101	.273**	-.064	.218**	.046	.298**
4	.004	.213**	.046	1	.107	.344**	.010	.116	-.073	-.022	.098	.048
5	.009	.017	.062	.107	1	.041	-.005	.032	.059	.053	.002	.031
6	-.134*	.017	-.033	.344**	.041	1	.003	-.049	.040	-.033	.158*	-.131*
7	.057	.055	.101	.010	-.005	.003	1	-.317**	-.456**	.060	.287**	-.024
8	.389**	.740**	.273**	.116	.032	-.049	-.317**	1	.205**	.112	-.156*	.740**
9	-.031	.013	-.064	-.073	.059	.040	-.456**	.205**	1	-.054	-.322**	.107
10	.129*	.170**	.218**	-.022	.053	-.033	.060	.112	-.054	1	.229**	.136*
11	.028	-.049	.046	.098	.002	.158*	.287**	-.156*	-.322**	.229**	1	-.308**
12	.413**	.716**	.298**	.048	.031	-.131*	-.024	.740**	.107	.136*	-.308**	1
M	.61	5.84	3.35	3.79	.31	.39	-.01	.73	-.01	5.46	-.05	4.08
SD	.488	2.080	2.163	.690	.619	.551	.291	.418	1.756	1.101	.993	1.360
N	250	250	250	250	250	250	250	250	246	250	248	250

Note: 1 = Moved-House; 2 = Planned Travel; 3 = Perceptions of change; 4 = Environmental Concern; 5 = Openness-To-Change; 6 = Self-Transcendence; 7 = Travel change; 8 = Initial Travel; 9 = Distance Change; 10 = Travel Frequency; 11 = Habit Change; 12 = Initial Habit.

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

Table A2: Travel Change (M) Mediated Multiple Regession Model of Association Between Moving-House (X) and Habit Change (Y)

Criterion	Predictor	B (SE)	95% CI
Travel change	Constant	.110 (.033)**	[.049, .179]
	Moved-House	.129 (.043)**	[.047, .214]
	Initial Travel	-.274 (.055)**	[-.383, -.171]
R^2		.144	
F		20.587**	
Habit Change	Constant	.852 (.207)**	[.463, 1.279]
	Moved-House	.332 (.158)*	[.029, .652]

	Travel Change	.943 (.311)**	[.340, 1.572]
	Initial Habit	-.269 (.056)**	[-.382, -.167]
R^2		.196	
F		19.876**	
N		248	

Note: SE = standard error. CI = confidence interval.
p < .05. ** p < .01

513

Table A3: Conditional Process Model of Moving-House (X) and Habit Change (Y) Association, Mediated by Travel Planning (M1), Perceived Change (M2) and Travel Change (M3)

Criterion	Predictor	B (SE)	95% CI
Travel Planning	Constant	1.68 (.560)**	[.594, 2.800]
	Moved-House	.425 (.208)*	[.016, .842]
	Distance Change	-.142 (.077)	[-.298, .009]
	Env. Concern	.362 (.137)**	[.101, .637]
	Initial Travel	3.50 (.307)**	[2.893, 4.091]
R^2		.580	
F		82.791**	
Perceived Change	Constant	1.851 (.172)**	[1.539, 2.207]
	Moved-House	2.474 (.229)**	[2.003, 2.911]
R^2		.307	
F		107.805**	
Travel Change	Constant	-.131 (.051)**	[-.234, -.035]
	Moved-House	.017 (.051)	[-.083, .117]
	Travel Planning	.074 (.018)**	[.039, .109]
	Perceived Change	.011 (.012)	[-.012,.035]
	Value: ST	-.027 (.045)	[-.116, .064]
	ST*Moved	.120 (.064)	[-.005, .245]
	ST*P.Change	-.016 (.016)	[-.048, .016]
	Value: OTC	.044 (.045)	[-.044,.129]
	OTC*Moved	.002 (.056)	[-.102, .120]
	OTC*P.Change	-.007 (.012)	[-.030, .015]
	Distance Change	-.052 (.020)**	[-.090, -.013]
	Initial Travel	-.490 (.090)**	[-.660, -.306]
R^2		.422	
F		15.491**	
Habit Change	Constant	-.464 (.383)	[-1.220, .302]
	Moved-House	.291 (.144)*	[.010, .576]
	Travel Change	.924 (.289)**	[.350, 1.487]

	Travel Frequency	.249 (.072)**	[.108, .388]
	Initial Habit	-.278 (.056)**	[-.390, -.171]
R^2		.267	
F		21.886	
N		245	

Note: SE = standard error; CI = confidence interval; "Env. Concern" is 'Environmental Concern'; "OTC" is 'Openness-to-change; "ST" is 'Self-Transcendence'. "Moved" is 'Moved-House'; "P.Change" is 'Perceived Change'.

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

514

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