The gendered complexity of daily life: effects of life-course events on changes in activity entropy and tour complexity over time

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Abstract: This paper studies changes in the complexity of activity patterns (measured by Shannon entropy) and trip chaining patterns following life course (and accessibility) related key events from a gender specific perspective. It is theoretically informed by the mobility biographies approach and by gender/travel studies. The data used is the German Mobility Panel (GMP) 1994 to 2012 in which households and their members are asked three times in three subsequent years to report the trips they made over a week. Changes made from one year to the next are regressed to key events over the life course, cohort effects and period effects, while sociodemographics, residential and workplace spatial context attributes are controlled. A cluster-robust regression approach is used to account for the non-independent character of panel observations. Significant effects were found for some key events, including the birth of a child, entry into the labour market, and changes in spatial context, accessibility and mobility. Some effects differed distinctly between men and women, suggesting that men and women are differently affected by life course events. However, taken overall the associations found, as well as their gender specifics, are rather limited. Hence, key events over the life course seem to be only loosely associated with the complexity of activity and trip patterns.

Keywords: activity pattern, mobility biography, gender, key event, trip chain complexity, travel behaviour change

1 Introduction

It has long been argued that women's daily lives are far more complex than men's. The reasoning behind this claim is that women tend to be committed to multiple duties to a greater extent than men; such duties include employment, housework, and caregiving for children, the elderly or other persons in need (MacDonald, 1999). Hence women juggle a multitude of activities over the course of a day, many of which take place out of the home and are thus linked to trip-making. This has substantial consequences for their travel patterns. Firstly, women travel shorter distances than men on average (Crane, 2007; Scheiner, 2010), which may be due to the spatial ties imposed on them by household work and caregiving duties. Secondly, women tend to organise their trips into more complex trip chains than men to gain efficiency in travel patterns

(Cao et al. 2008; Islam and Habib 2012; Paleti et al. 2011; Strathman and Dueker 1995). Thirdly, more varied activities suggest that women have more complex activity spaces than men, involving more 'anchor points' such as the home, the workplace, or children's school(s) or nursery. Fourthly, complex activity and associated travel patterns may encourage women to use flexible modes of transport such as the car to juggle all their duties (Dobbs, 2005).

On the other hand, this picture is not equally true for all women and men. Couples with children, particularly those with infants, tend to exhibit a strongly traditional division of labour (Grunow et al., 2012), with the husband being the primary wage-earner, while the wife is responsible for the multitude of social and maintenance tasks outlined above. For couples without children the picture is different. They typically show more modern, sometimes close-to-equal patterns of activities (Grunow et al., 2012; Scheiner, 2013). Single households do not exhibit any division of labour at all, but they are nonetheless known to have different activity and trip patterns depending on gender (Taylor and Mauch, 1997).

These considerations suggest that the complexity of activity and travel patterns changes over the life course as an outcome of life course related key events. The most researched example in this respect is the birth of a child which typically goes along with a 're-traditionalisation' of gender roles among couples, even among those who pursued relatively equal work-sharing before (Grunow et al., 2012). The changing travel patterns induced by such key events have been studied in the past decade under the label 'mobility biographies' (Axhausen, 2007; Lanzendorf, 2003; Scheiner, 2007) or 'life course' / 'life events' approach (Chatterjee et al., 2013; Oakil et al., forthcoming; Sharmeen et al., 2014).

This paper employs this mobility biography approach from a gender perspective using regression modelling. The focus of interest is changes in complexity of activity and travel patterns as an outcome of key events. Gender is accounted for by using interaction terms. At the same time, cohort and period effects, state variables and inertia in behaviour are accounted for. Complexity is measured by two variables: an entropy measure of activity patterns and the number of trips per tour as a measure of trip chaining. Both variables are constructed from trip diaries completed for a whole week by a nationwide sample of respondents from Germany. The data span the period from 1994 to 2012. A companion paper (Scheiner, forthcoming(b)) focuses on mode choice changes.

The next section introduces the state of the research. This is followed by a description of the data, the modelling approach and the variables used. Subsequently the results are presented, starting with an overview of cross-sectional figures of complexity, moving on to descriptive analysis of change in complexity, and ending with two regression models of activity pattern entropy and tour complexity. The paper closes with some conclusions for further research.

2 State of the research – gendered complexity of daily life

2.1 Activity patterns

Empirical studies of gender differences in activity patterns are so numerous that they cannot be reviewed here in detail. Most of these studies compare mean values and proportions of time allocation to different activities between men and women (McGinnity and Russell, 2008; Anxo et al., 2007 in a lifecycle perspective). Many also use regression modelling or other more complex techniques to isolate the impact of gender from other factors. Most often they focus on housework (Bianchi et al., 2000; Treas and Drobnic, 2010; Grunow et al., 2012; Farrell et al., 2012 in a review; Mencarini and Sironi, 2012). Employed work is often considered simultaneously

(Gershuny and Kan, 2012; McGinnity and Russell, 2008; van der Lippe et al., 2011), while leisure is considered in relatively few studies (Anxo et al., 2007; Hilbrecht, 2009; Milkie et al., 2009).

The general finding is that there is little gender inequality in terms of total workload including paid (employed, marketed) and unpaid (non-marketed, household/family) work (Gille and Marbach, 2004, for Germany). On the other hand, a somewhat higher workload among full-time employed mothers as compared to full-time employed fathers has been found in the US (Milkie et al., 2009). Distinct differences emerge when paid and unpaid work are considered separately, with men taking on disproportionate shares of paid work and women disproportionate shares of unpaid work.

The number and age of children are consistently identified as key impact factors of worksharing, with mothers' family obligations increasing with the number of children, and decreasing with the age of the youngest child (McGinnity and Russell, 2008; Scheiner, 2013).

Gender differences in activity patterns have been observed to converge over time in various countries (Fisher et al., 2007, for the USA, 1965-2003; Gershuny and Kan, 2012, for 12 countries; ca. 1961-2004; Bianchi et al., 2000, for housework in the USA, 1965-1995; Sayer, 2010, for nine countries, ca. 1965-2003). In Germany, time use for unpaid work among men increased over the period 1991/92 to 2001/02, and so did time use for paid work among women (Gille and Marbach, 2004). Women's relative overload in terms of unpaid work (odds ratios women/men) consequently declined considerably from factor 1.7 in 1991 to 1.4 in 2001. Nonetheless, gender specifics in the division of work still exist around the world (Baxter, 1997; Sayer, 2010). Virtually no changes could be detected among parents in Germany (Gille and Marbach, 2004). Mothers make a constantly above-average contribution to unpaid work. There may be some self-selection in this finding in that those women and men who maintain more traditional norms may be more likely than others to found a family.

Gender convergence has also been observed in the distributions of activities over the day and the week. This means that women's temporal distribution of activities over the course of a day is becoming more similar to that of men (Fisher et al., 2007).

Measuring complexity in activity or trip patterns is far from straightforward and involves more than considering just the degree of participation in activities or trips. One possibility is to study multitasking, which is mostly defined as performing more than one activity at a given time (see Circella et al., 2012 for discussion). Bianchi et al. (2007) found that married mothers report more frequent multitasking than married fathers, using multitasking as a strategy of time-management to juggle multiple duties. This result was based on self-report and, hence, may be biased by subjective considerations of multitasking. However, there is similar evidence of this gender gap in time use diaries. Gille and Marbach (2004) construct an indicator of turbulence from the variety of activities undertaken during a day, the number of transitions between different activities, and multitasking (activities undertaken simultaneously). They find that women's daily lives are considerably more turbulent than men's. Additionally, Offer and Schneider (2011) find that fathers multitask about 35% of their time (sleeping time excluded), compared to 43% for mothers, and the types of multitasking mothers typically perform appear to be more strongly associated with negative affects and stress than those of fathers.

Another way to study complexity would be to focus on fragmentation of activity patterns. Fragmentation means "the disintegration of activities into smaller sets of acts that can then be performed at different times, differents locations, or both" (Alexander et al., 2011, 678), which may make activity patterns more burdensome and/or more difficult to schedule. Lenz and Nobis (2007) cluster a sample of German respondents according to their travel, work schedule and use of mobile devices to find out about the level of fragmentation of activities. They find the highest proportion of women in a cluster of 'conventional part-time workers' with little fragmentation. Hubers et al. (2008) study temporal fragmentation in terms of the number of activity episodes in a day. They find more non-daily shopping episodes and fewer leisure episodes for women. Alexander et al. (2011) study a number of different spatial and temporal measures of fragmentation in the Netherlands. The few significant gender differences they find suggest somewhat more fragmentation among men than women.

Spatial and temporal fixity of activities may also contribute to complexity in scheduling. Based on a time-geographic approach in the tradition of Cullen and Godson (1975), Schwanen et al. (2008) find that women coordinate and negotiate more space-time fixity constraints than men. This is not because women consider childcare or maintenance work to be more binding than men, but because they engage in such activities more than men. From trip chain analysis, one may derive similar conclusions (see below).

There are a number of theoretical explanations for such gender differences in complexity. Probably the most important single factor is the increasing female labour force participation that can be observed in various countries (Dustmann, 2005). This shift from the male-breadwinner-and-female-housewife-model to more modern arrangements (Farrell et al., 2012) does not necessarily result in more equal gender relations. As long as men continue to pursue their careers without contributing to filling the gap in caregiving and housework, it rather leads to women's 'double burden' or 'second shift' (Hochschild and Machung, 1989; Milkie et al., 2009).

Gender norms and preferences are also likely to play a substantial role. Taylor and Mauch (1997) show that even in single households women shop more often than men, and trace this finding back to socialisation effects. Alternatively, it may be subject to preferences for certain goods (such as healthy food which has to be purchased freshly). The somewhat leisure-like character of shopping may also play a role, although not for grocery shopping (which was the focus of this study). Fortin (2005) finds evidence in a cross-national study of 25 OECD countries that women's participation in the labour market and their earnings depend strongly on gender norms which in turn are shaped by socialisation. These norms include perceptions of women's homemaker role, attitudes towards gender equity, and inner conflicts between family values and egalitarian views ('mother's guilt').

Another explanation is more biological in nature. Mäntylä (2013) studies gender differences in the capability to multitask in an experimental study. He traces these differences back to biologically determined cognitive spatial abilities.

2.2 Trip chaining

Individuals organise their daily trips in tours, i.e. sequences of trips starting and ending at home. Tours involving an outbound plus an inbound trip are typically conceived as simple tours, while tours involving more than two trips (or more than one stop) are considered complex (see Section 3.3 for a discussion of definitions).

Trip chaining has been a topic of inquiry for decades in transport studies (see Hanson, 1979; Thill and Thomas, 1987, for early reviews). Organising trips in complex chains is typically considered to serve efficiency in travel or, to put it another way, to minimise the disutility of travel (Chen, 1996; Spissu et al., 2007). For instance, people who have more than one job tend to link non-employment activities in their work-to-home tour (Castro et al., 2011). By reducing total travel time, trip chaining contributes to increased accessibility (Chen, 1996). Over time, trip chaining has increased considerably (McGuckin et al., 2005; review in Currie and Delbosc, 2011).

Several variables have been found to impact people's propensity to chain trips, including social circumstances, the spatial environment, and the transport system. Trip chaining is linked to mode choice, but the direction of causality is not clear (see discussion in Ellison and Greaves, 2010). It is typically assumed that the complexity of trip chains impacts mode choice (Hensher and Reyes, 2000; Krygsman et al., 2007). Complex chains are considered less suitable for public transport use due to its limited flexibility (Bhat and Sardesai, 2006; Currie and Delbosc, 2011; Hensher and Reyes, 2000; Krygsman et al., 2007; Mousavi et al., 2012; Strathman and Dueker, 1995). However, Mohammadian et al. (2011, 59-60) find that public transport is more prevalent in complex than in simple trip chains (likewise: Primerano et al., 2008).

There is consistent evidence that women are more likely to make complex trip chains than men (Chu, 2003; Noland and Thomas, 2007; Paleti et al., 2011; Portoghese et al., 2011) both with respect to job tours and non-job tours[1] (Islam and Habib, 2012; Strathman and Dueker, 1995; in data from Switzerland Ye et al., 2007, find no gender effect on complexity in non-job tours). As people typically link different types of activities in a chain, a large part of research attention is devoted specifically to the links between employment and non-job trips. Studies show that female employees are more likely than their male counterparts to use a complex job trip pattern, i.e. they are more likely to stop on the commute (Cao et al., 2008).

Men and women also differ in terms of the types of trip chains undertaken. Men undertake more simple employment or education trip chains and more complex chains involving employment, while women undertake more simple shopping and escort trip chains, and more complex chains involving shopping and/or leisure purposes, but not employment (Primerano et al., 2008). Krygsman et al. (2007) point out that women are much more likely than men to take responsibility for social functions such as serving passengers on their commute. As such purposes are highly constrained (e.g. by school or daycare start and end times), one may suspect that women are less flexible than men in their travel patterns (McGuckin and Nakamoto, 2005). Mohammadian et al (2011) add that working-age women make more complex chains than their male counterparts, but within complex chains men make more stops than women.

Distinguishing age categories, Mohammadian et al. (2011) find that elderly women are just as likely as elderly men to perform complex trip chains. Conversely, Schmöcker et al. (2010) find the expected gender gap in complexity among the elderly in London.

In a SEM study Golob and McNally (1997) show gender-specific interactions between two partners in a household in terms of participating in certain activities, thus affecting the gendered complexity of patterns. They also corroborate the finding that women make more complex trip chains than men (likewise: Kuppam and Pendyala, 2001, with a focus on in-home v. out-of-home activities).

Perhaps their more complex patterns are the reason why women "tend to be more structured in terms of how the week is planned" (Lee and McNally 2006, 553). However, comparing activity scheduling with realised activity behaviour reveals that many trip chains are formed 'as opportunity knocks' while being out of the home (Lee and McNally, 2006).

The general explanation for women's more complex trip chaining is their stronger responsibility for various activities. "Gender differences in side trip making [complex chain] arise mainly from gender differences in household division of labor" (Sarmiento, 1996, 44). Consequently, trip chain complexity refers to mothers more than to women in general (McGuckin et al., 2005). Mothers also encounter higher levels of fixity constraints (Kwan et al., 2009) and, hence, may be more

[1] These two types are mostly named work and non-work trip chains in the literature. However, the term 'non-work' masks that this type of trip chains includes much unpaid work, such as shopping, errands, and escort trips.

likely to seek efficiency. This may not be true for women in general, as Schwanen et al. (2008) did not find a significant gender effect in fixity constraints, other variables held constant. The need for efficiency in travelling is further fuelled by mothers' above-average complexity in activity patterns.

2.3 Gendered changes in complexity over the life course

As both the complexity of activity patterns and trip patterns is linked to specific life situations (most notably employment, caregiving duties and household structures), changes in life situation may be expected to result in changes in pattern complexity. For instance, retiring may result in reduced complexity due to the loss of job trips. The birth of a child is likely to result in enhanced complexity for parents due to their more varied obligations.

The birth of a first child versus that of a further child in a family may exhibit different effects on household organisation and travel patterns (Lanzendorf, 2010, and Schulze, 2009 for Germany), particularly on activity pattern and tour complexity. The birth of a first child normally induces marked changes in household organisation and the gender division of labour. The birth of a further child involves a similar need for care for the youngest. However, this need meets ongoing needs for care, escort and activity among the elder sibling(s). Thus, parents may opt to split their obligations, inducing even more complex patterns on the household level, or else they may opt to further shift their division of employed and household/family work towards a more traditional pattern, which could result in extremely complex patterns for one partner (typically the wife) while the other (male) partner would be responsible for breadwinning. In any case, making a distinction between the birth of a first child versus that of a further child in a family is clearly of interest.

As outlined, such changes in complexity may be gender specific as the changes in life situation are linked to gender. Due to the lack of life course-oriented studies in a gender context there is little direct evidence for gendered effects of key events (but see Rönka et al., 2003 for various key events; Wall et al., 2013 for residential moves). However, from cross-sectional data there is much evidence that "the presence of children continues to affect women's travel patterns more than men's", as McGuckin and Nakamoto (2005, 54) put it in a study on trip chaining.

Perhaps women generally tend to react more distinctly to context changes. For instance, Mokhtarian et al. (2010) study gendered reactions to the temporary closure of a US highway. They find that women more than men change their behaviour in terms of temporal shifts in travelling, route choice, public transport use or carpooling. A German study supports this notion by finding that women use their cars in a less habitualised manner than men (Matthies et al., 2002).

2.4 Conclusions from the literature

There is overwhelming research on gender differences in time-use and activity patterns, on trip chaining, and on the life course in general. Most research on gendered activity and travel patterns is static in character. It is typically based on complex modelling rather than simple comparisons between the sexes. On the other hand, researchers have just begun to develop the potential of life course approaches for activity/travel studies over the past decade. The label 'mobility biographies', among others, has been used in this respect. However, these studies have little relationship to gender issues to date.

The novelty of this paper is, firstly, that it links these strands of research. Secondly, it is relatively unusual to explicitly study complexity in activity pattern/time-use research. Thirdly, it is based on German data, while the majority of studies in all relevant fields discussed above are from North America.

Germany is commonly considered a conservative (or social capitalist/corporatist) regime in terms of gender relations, similar to France, Belgium, and The Netherlands (Kan et al., 2011; van der Lippe et al., 2011). Germany has some notable incentives for couples to conduct a male-breadwinner-and-female-housewife type of work sharing, including a joint income tax system for couples and a relatively poor provision of public childcare (Cooke, 2006; Kan et al., 2011). Parental leave regulations are generous (36 months since 1992), but included little financial benefit until 2006 (Geisler and Kreyenfeld, 2012). Female labour force participation rates have increased steadily over time, but with high proportions of part-time work (Dustmann, 2005). In the past few years, Germany has undertaken considerable efforts to expand child care facilities, and to encourage women into employment and fathers to take paternal leave (Geisler and Kreyenfeld, 2012). Hence Germany has recently experienced a process of rapid change in gender relations.

3 Methods

3.1 Data

In the following, changes in complexity are studied empirically from a gender perspective. The data used is the German Mobility Panel (GMP) 1994 to 2012[2]. The GMP is a household survey with the sample organised in overlapping waves. Every household is surveyed three times over a period of three consecutive years (Chlond and Kuhnimhof, 2005), e.g. from 1994-1996, before being excluded from the survey. A trip diary is used to collect information on trips over a whole week from all household members aged ten years or over. Sociodemographic attributes for the household and its members are collected as well as spatial context attributes at the residence and at the household members' places of work or education.

An important limitation is that household income has only been recorded since 2002. Income is thus excluded from the analysis, rendering it impossible to directly investigate the effects of income changes. Education level and employment status are used as rough proxies for income. Coding multiple life course events results in missing values in many cases (see Scheiner, 2011, for details). As life course events are relatively rare events in an individual's life, no event in cases of uncertainty is assumed. The coefficients estimated are thus based on changes among those for whom an event occurred, while some of those for whom no event is assumed may in fact have experienced one.

A second limitation is that, as in most other German data, there are no small-scale geocodes available. Even municipality and postal codes have been included since 2003 only on a generalised level (postal codes include the first two of five digits). Hence, the calculation of straight-line or network distances is not possible. Any distance or accessibility measures are based on respondents' self-reports.

The data include a total of 30,631 individual weeks of report. Among these, 14,554 weeks are 'last-time-reports' for which no change to the next year can be detected. For 15,699 weeks complete information (other than that discussed above) is available, and these are used in regression modelling. This sample is composed of 9,533 individuals, for 6,166 of whom two observations of change are available (from the first to the second and from the second to the third year of report).

[2] The GMP is conducted by the University of Karlsruhe on behalf of the Federal Ministry of Transport, Building and Urban Development (BMVBS). The data are provided for research use by the Clearingstelle Verkehr (www.clearingstelle-verkehr.de).

3.2 Analysis approach

This paper uses regression modelling to detect the effects of a comprehensive set of life course events, access and mobility changes, cohort and period effects on activity pattern and tour complexity. Descriptive analysis of selected life course events that turned out significant is presented as well. Descriptive analysis is undertaken using weighted data. Unweighted data are used for regression modelling and any tests of significance.

To take the gender specifics of life courses into account, interaction terms between any variable and gender are used. This procedure resulted in exorbitant multicollinearity in some cases, with variance inflation factors (VIF) exceeding VIF=100. In an extended, stepwise modelling process VIF values could be reduced dramatically (see Section 3.3 on variables).

The panel nature of the data results in non-independent (clustered) observations, thus violating a most basic assumption of statistical analysis. The use of OLS regression with such data may result in the underestimation of standard errors because the amount of independent information available is inflated. The significance of parameters may therefore be overestimated (Hedeker et al., 1994).

There are two basic ways of treating panel data in regression. Either one employs a random effects model or a cluster-robust estimation based on pooled data. The former has the disadvantage that it assumes constant correlation between successive observations of the same unit. In contrast, clustered regression with pooled data allows for arbitrary correlation. The estimates are less efficient and, similar to OLS, the standard errors may be too small when the number of clusters is finite (Nichols and Schaffer, 2007; Wooldridge, 2003). However, the cluster-robust standard error estimator converges to the true standard error as the number of clusters (not the number of observations) approaches infinity (Kézdi, 2004; Nichols and Schaffer, 2007). Given the relatively large sample and cluster number, neither of these issues should raise serious concern.

Hence, a pooled data approach is used that accounts for clustering by using a robust estimation method controlling for autocorrelation within subjects emerging from the temporal order (sequence) of records. This means that the correlation matrix of within-subject dependencies is estimated as part of the model. The SPSS procedure GEE (generalised estimating equations) is used for the analysis. The coefficients reported may simply be interpreted as population average estimates, as in ordinary regression. The exponentiated coefficients (Exp(B)) are to be interpreted as percentage changes in the dependent variable for a one-unit change in explanatory variable, i.e. negative regression coefficients result in values smaller than 1.

Concerning model specification (see Garson, 2010, for details), the autoregressive correlation type is used due to the temporal order of within-subject measurements. This means that values at a given point in time are a function of prior values plus error term. The dependent variables used are continuous in nature, and normal distribution is assumed. A graphical inspection reveals that this assumption holds true, which is not surprising as behavioural change from one year to the next is scattered around zero.

Unlike OLS regression, there is no determination coefficient available for cluster-robust regression. SPSS reports a quasi likelihood under independence criterion (QIC) which is an extension of the Akaike Information Criterion (AIC) for repeated measures (Garson, 2010). It is available in a corrected form (QICC) that penalises model complexity and small sample size. QICC works in a 'the smaller the better' form. It is reported for the final models as well as for the intercept models. However, there is no formal test of significance in model improvement available.

For comparison, OLS regressions with a random subsample of one observation per individual are estimated. The results are available upon request from the author. OLS regressions are known to be relatively robust against mild violations of assumptions. A comparison of the cluster-robust regressions with the OLS regressions shows different levels of significance and effect magnitudes in some cases. However, generally the two modelling approaches yield similar results for the magnitudes and, more importantly, the signs of the coefficient estimations, supporting the robustness of the findings. There are no instances of significant effects changing signs. The R^2 values from the OLS regressions are reported in the results table for readers' convenience.

3.3 Variable definitions

Target variables

People organise their trips in trip chains that form tours. There are various definitions of trip chains in the literature. Firstly, some authors use the terms tour and trip chain interchangeably (Frank et al. 2008, 39). However, a tour is typically defined as a sequence of trips that starts and ends at a person's home (Paleti et al., 2011) or workplace (see Schmöcker et al. 2010 for discussion), while some authors consider trip chains to be parts of tours that link two 'anchors' (typically home and workplace). Seen this way, the morning commute between home and work may be considered a complex chain in itself, if it involves an in-between stop, and tours may be composed of more than one trip chain (McGuckin and Nakamoto, 2005, 50; Sarmiento 1996, 42; Vande Walle and Steenberghen, 2006).

Secondly, the criterion by which trip chains are separated from each other does not need to be a specific start and end point as defined by activity. A trip chain may well be defined as a sequence of trips that are interrupted by dwell times of not more than 30 minutes (Schmöcker et al., 2010; McGuckin and Nakamoto, 2005). It could, e.g., start at the workplace and end at a shopping centre.

The complexity of a tour refers to the number of trips (Timmermans et al., 2003) or stops (Paleti et al., 2011) involved, with the number of trips being one more than the number of intermediate stops. Typically, multiple stop tours involving at least three trips are considered complex tours, while tours including two trips (outbound plus inbound trip) are considered simple tours. For trip chains, the same definition of complex versus simple is typically used (Frank et al., 2008; Paleti et al. 2011, 5; Schmöcker et al., 2010; Strathman and Dueker, 1995).

For the purpose of this paper, tour complexity is defined as the mean number of trips per tour from home to home a person makes over a whole week. Hence, the analysis is at the level of the individual, and the target variable is the change in a person's mean tour complexity, calculated as the difference from one year to the next.

Likewise, the analysis of activity pattern complexity is on the individual level as well, and change is calculated again as the difference between complexity in a year of observation and the preceding year. Activity is a nominal-scaled variable and measuring complexity in its patterns requires a qualitative measure of variance. There are various such measures (Coulter, 1989). From a detailed discussion of three key measures (variation ratio, index of diversity, Shannon's entropy) in Wagner and Franzmann (2000), it is concluded that Shannon entropy fits the purpose of this paper particularly well. The variation ratio measures the share of cases (here: duration of activity) that do not fall into the modal category of the distribution. Hence, it is not a true measure of diversity as it does not address the distribution of cases over other categories. The index of diversity differs from Shannon's entropy in that it emphasises strong categories (as it is based on squared values), whereas the entropy emphasises weakly represented categories as it is based on logarithm. One may assume that side activities 'in-between' considerably affect the overall complexity of daily patterns and, hence, such side activities should rather be over- than underrepresented in a measure of complexity.

Hence, activity pattern complexity is measured using Shannon's entropy. Entropy is a measure of qualitative variance used in physics and information science, but in social sciences as well. It describes the amount of heterogeneity in the distribution of certain categories (here: activities). Heterogeneity is minimal when only one activity is performed, and reaches its maximum when the total amount of activity time is distributed equally over all categories. Hence, entropy simultaneously considers the number of different activities and the relative amount of time devoted to each activity, which resembles the merging of two measures of activity fragmentation used by Alexander et al. (2011): the number of fragments and the distribution of fragment sizes. The reasoning behind the latter measure is that "a plate broken into 10 pieces of equal size is more fragmented than a plate broken into 10 pieces, one of which is 90% of the original plate" (Rutledge, 2003, quoted from Alexander et al. 2011, 682). After all, this is the basic reasoning in feminist claims that women's activity patterns are more complex than men's. Men tend to devote most of their work time to employed work and only little time to household and family work, while women typically spread their limited time budgets more evenly over different types of work. In other words: the difference does not primarily lie in the number of different activities, but in women's more equal distribution of time to various activities.

Mathematically, entropy is defined as $-\sum (p_i * \ln(p_i))$ (Coulter, 1989). In this study the p_i are the shares of time spent for an activity plus associated trips in the week of report. Six out-of-home activity classes are available for analysis, including employment, business, education, shopping/private errands, escort, and leisure. Trip times are added to the activity at the destination. Activities not performed result in zero values of time use. These activities enter the calculation of entropy as zero values. The procedure makes sure that, e.g., an individual who spreads her time evenly over business and leisure faces less entropy than somebody who spreads her time evenly over business, leisure and education, but more entropy than someone who devotes 70% of her time to business and only 30% to leisure. Ultimately, zero entropy means that a person conducts only one type of activity over the week of report, while the maximum value (here: 1.79) means that the time spent out of home is equally distributed over all activity types.

The use of tour complexity and activity pattern entropy is not meant to indicate that these two measures reflect the same dimension of daily life. In fact, there is hardly any correlation between the two (r=0.03) even if the correlation is significant (p=0.01). Rather, tour complexity reflects the attempt of an individual to efficiently organise his or her trips. On the other hand, activity pattern entropy reflects a complex daily life in terms of the requirement to juggle multiple activities with a similar level of importance (in terms of time spent for any activity), while a low level of entropy means that an individual's daily life tends to be devoted to only one activity.

Explanatory variables

Various state and change variables including sociodemographics and spatial context at the residence and at the place of work or education (for the sake of brevity: workplace) are considered as explanatory variables. Change variables reflect life course events or changes in spatial/access context or mobility. State variables reflect the baseline value observed in the year prior to change. Some of the variables used are explained in the following, as required (see Table 1 and Table 2 for the full set along with descriptive statistics).

With respect to cohort effects, cohort plus cohort squared divided by 100 are considered simultaneously in order to capture non-linear effects. Those born in 1900 are coded as cohort zero while those born in 1901 are coded as cohort one and so forth[3]. To capture period effects, the year of survey (1994 equals zero) is considered. An interaction term between year of survey and a dummy taking the value one for years from 2000 and zero for years to 1999 was included because recent trends observed in travel behaviour suggest a peak in travel around the year 2000 (BMVBS, 2013). This interaction term is still continuous in nature, but zero until 1999.

To account for the interaction between travel/activity pattern complexity and mode choice, a variable capturing the change in driving (the share of trips made as a car driver in the report week) is included. It is acknowledged that the change in mode use is not necessarily a cause of change in complexity; it may well be the other way round.

Finally, the respective baseline value of the dependent variable under study in the year prior to change is included, as those with a high level of complexity may be expected to reduce complexity more than those who exhibit very simple patterns (Krizek, 2003).

The analysis started with a set of 116 variables, including 58 baseline and 58 change variables. 59 of 116 variables were retained in the final analysis (22 baseline and 37 change variables). The following baseline variables did not pass a very moderate significance level of p=0.10 in any model and were excluded in a stepwise process, except for categories logically related to other categories:

- Living with partner versus not living with partner
- Possession of driving license
- Various spatial / access variables: city size category, central versus remote location of residence (subjective report), urbanity (calculated from self-reported walking access in the neighbourhood to various facilities), parking situation at the workplace (subjective report), walking distance from public transport (PT) stop to workplace, PT connection to work (from various categories, as reported by respondents), PT quality in neighbourhood (calculated from the number of different systems accessible on foot)
- Interaction terms between gender and (a) employment, (b) education level, (c) cohort, (d) period.

Following the same reasoning, some change variables were excluded as well.

- Change in PT quality in neighbourhood
- Change in workplace
- Change in residential location (upward versus downward in the central place hierarchy).

Other studies report significant effects of workplace or residential relocation on travel behaviour (Chatterjee et al, 2013; Oakil, forthcoming; Scheiner, 2006) and social interaction (Sharmeen et

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[3] Models including age plus age squared, but excluding cohort, were run for comparison. These models turned out as virtually identical to those including cohort. However, one may assume age effects to be captured to a large extent by using life course changes (such as founding a family, starting a job, retiring etc.). Thus, cohort is used for further analysis. It should be noted that cohort does not perfectly correlate with age here, as cohort depends exclusively on year of birth, while age also depends on year of observation.

al, 2014). A reason for the lack of significance here may be the inaccurateness of measurement implied by the non-availability of geocodes.

Furthermore, some variable categories were lumped together for the sake of parsimony due to lack of significance and effect signs pointing in the same direction, respectively:

- The distinction between the birth of a first child versus that of a further child in a family is limited to descriptive analysis; it was abandoned in the regression modelling due to lack of significance. All effects had the same signs for the first and for further children.
- Parking situation at the workplace and PT connection to work: the categories 'gets worse / much worse' are merged into one category, as are those 'gets better / much better', respectively. These variables are based on the self-reporting of respondents; the quality of the PT connection is calculated from various categories (see Scheiner, 2011, for details).

Other variables, although not significant in any case, were retained in the analysis. These variables may be expected to strongly affect activity and travel patterns from a theoretical perspective:

- Household formation with a partner
- Separation from partner
- Finishing school or apprenticeship
- Start of apprenticeship.

The reason for expecting strong effects on complexity is that starting an apprenticeship – to use this example – by definition implies taking up a new activity, and it typically involves a new node in the daily activity space. Hence, it may be expected to affect complexity more than, say, a change in workplace, which by definition does not mean that somebody enters or leaves the workforce. Forming a household with a partner, as another example, implies some kind of intra-household worksharing which a single household cannot realise.

Last, but not least, period effects were tested in two alternative, yet finally abandoned, model specifications. Firstly, a quadratic function and, secondly, a linear function was used. Both these variants performed slightly worse than the version presented here in terms of improvement in QICC. The quadratic function was not significant; the linear function was significant and positive in the entropy model.

As noted above, the modelling process started with excessive multicollinearity problems. Due to the exclusion of a large number of variables, this problem was reduced substantially. In the resulting models, all VIF are < 4 except for gender (5.2), which is well below the usual threshold of acceptance (VIF<10, Schendera, 2008, 105). Exceptions are cohort (VIF=64.5) and cohort squared (VIF=72.9) which are naturally correlated but retained in the model due to the recent debate on gender specific trends in travel behaviour among young adults (Kuhnimhof et al., 2012). Because of the observed peak in travel around the year 2000 (BMVBS, 2013), year of survey and an interaction term between year of survey and 'year of survey = 2000 or later' are both used in the models despite high VIF levels (VIF=15.9 and VIF=15.7, respectively).

	Type*	Min	Max	Mean	SD
Change in no. of trips per tour	C	-27.3	40.4	0.01	1.45
Change in entropy	C	-1.39	1.46	-0.02	0.32
No. of children in household (< 10 yrs)	B	0	4	0.25	0.60
No. of children in household (10-13 yrs)	B	0	3	0.16	0.43
No. of children in household (14-17 yrs)	B	0	3	0.16	0.42
No. of children in household (< 10 yrs) * female	B	0	4	0.13	0.45
No. of children in household (10-13 yrs) * female	B	0	3	0.08	0.32
No. of children in household (14-17 yrs) * female	B	0	3	0.09	0.32
Change in urbanity	C	-5	5	-0.02	1.11
Change in urbanity * female	C	-5	5	-0.01	0.81
Cohort (born in 1900 = 0)	B	5	100	55.62	18.44
Cohort, squared, div. by 100	B	0.25	100	34.34	21.74
Year of survey (1994 = 0)	B	0	17	9.11	4.84
Year of survey (1994 = 0) * 2000 or later	B	0	17	8.29	5.89
Change in driving (share of driving in all trips)	C	-1	1	0.002	0.215
No. of trips per tour in baseline year	B	1	41	2.56	1.10
Entropy in baseline year	B	0	1.67	0.72	0.30

Table 1: Continuous variables used in regression: descriptive statistics

* B = baseline variable; C = change variable.

	Type*	N	Per cent 'yes'
Gender female	B	8,239	52.5%
Birth of child	C	294	1.9%
Birth of child * female	C	147	0.9%
Child leaving home	C	293	1.9%
Child leaving home * female	C	154	1.0%
Household formation with a partner	C	297	1.9%
Separation from partner	C	213	1.4%
Household formation with a partner * female	C	142	0.9%
Separation from partner * female	C	120	0.8%
Full-time employed (reference)	B	5,271	33.6%
Part-time employed	B	2,214	14.1%
Apprenticeship, trainee, education	B	2,144	13.7%
Not employed	B	6,070	38.7%
University entrance qualification or higher (reference)	B	5,400	34.4%
Elementary school qualification without apprenticeship or no qualification	B	2,144	13.7%
Elementary school qualification plus apprenticeship	B	3,739	23.8%
Secondary school qualification level I	B	4,416	28.1%
Finished school or apprenticeship	C	933	5.9%
Finished school or apprenticeship * female	C	474	3.0%
Start of apprenticeship	C	108	0.7%
Start of apprenticeship * female	C	49	0.3%
Entry into labour market	C	562	3.6%
Entry into labour market * female	C	337	2.1%
Leaving labour market (no retirement)	C	324	2.1%
Leaving labour market (no retirement) * female	C	212	1.4%
Retirement	C	445	2.8%
Retirement * female	C	274	1.7%
PT connection to place of work or education gets...			
... worse / much worse	C	1,447	9.2%
... better / much better	C	1,493	9.5%

... worse / much worse * female	C	739	4.7%
... better / much better * female	C	724	4.6%
Parking situation at place of work or education gets...			
... worse / much worse	C	1,252	8.0%
... better / much better	C	1,232	7.8%
... worse / much worse * female	C	608	3.9%
... better / much better * female	C	616	3.9%
Gaining driving license	C	313	2.0%
Loss of driving license	C	170	1.1%
Gaining driving license * female	C	171	1.1%
Loss of driving license * female	C	92	0.6%
Car not available (reference)	B	4,599	29.3%
Car occasionally available / after agreement	B	1,789	11.4%
Car regularly available	B	9.311	59.3%
Car occasionally available / after agreement * female	B	1,043	6.6%
Car regularly available * female	B	4,395	28.0%
Decrease in car availability	C	880	5.6%
Increase in car availability	C	949	6.0%
Decrease in car availability * female	C	466	3.0%
Increase in car availability * female	C	528	3.4%
n		15,699	100.0%

Table 2: Dummy variables used in regression: descriptive statistics

All variables are coded as yes=1, no=0.
* B = baseline variable; C = change variable.

4 Results

4.1 Mean state value comparisons

We begin by looking at state values of entropy and tour complexity in typical life situations, categorised by gender. The life situations are constructed in a straightforward manner from household type and employment. For households without children (couples and singles), young households are distinguished from mid-aged adults and the elderly.

Table 3 shows that in some life situations women exhibit higher entropy levels in activity patterns than men. This refers particularly to employed singles, employed individuals living in a couple with smaller or adolescent children, employees in 'other' (non-family) households with three or more adults, and lone parents no matter whether they are employed or not. The differences in magnitude are particularly striking among employed couples with children and among lone parents whether employed or not. This finding supports the familiar notion that mothers rather than women overall are particularly affected by above-average complexity in daily life due to their multiple duties. Conversely, men exhibit a slightly, but significantly, higher level of entropy than women among elderly couples without children.

These gender differences are only partially reflected in tour complexity. In only one of the life situations studied does a significant gender difference appear both in entropy and tour complexity: employed lone mothers make more complex tours and experience more entropy than employed lone fathers.

Otherwise, there is little significance in gender differences in tour complexity. Firstly, non-employed women living in a couple with adult children make considerably more complex tours than their male counterparts. However, this finding is based on small numbers, and it is not supported by differences pointing in the same direction among couples with younger children. Among those with small children, non-employed women make more complex tours than their male counterparts, but among those with older children it is the other way round (differences are not significant).

Secondly, women make more complex tours among non-employed individuals living in a couple without children, where at least one partner is younger than 60 years of age. This probably reflects gender-specific circumstances in that such situations include more housewives than househusbands, but more unemployed men than women. Such men may consider themselves jobless rather than housekeepers and hence may be less inclined to seek efficiency in trip-making.

Compared to gender differences, the differences between life situations, as defined by employment status and household type, are far more striking. Employed individuals exhibit considerably higher levels of entropy than those who are not employed. This is true for all life situations identified, least so for households with children where even those not employed experience relatively high levels of entropy. Again, this pattern is different for tour complexity. One may assume that employed individuals with children have more reason to pursue efficiency in trip-making than those without a job and/or without children because they have to cope with multiple duties. Indeed, those employed make more complex tours than those who are not employed, and this is true for all sub-groups. However, there is no systematically higher level of tour complexity in households with children compared to those without.

Age also seems to play a certain role, even if it has been very roughly categorised here. Comparing young-to-mid-aged with elderly singles reveals that the elderly exhibit both lower levels of activity entropy and tour complexity. This pattern is repeated among couples without children.

4.2 Mean value comparisons of change

Activity and trip patterns may change according to life course events. We now present descriptive analysis of changes in entropy and tour complexity (Table 4).

It meets expectations that no significant change can be detected for respondents who did not experience any life event in the year prior to the survey. Concerning the effects of life events, the birth of a child leads to a reduction in entropy, possibly because of reduced employment hours. The difference between the birth of the first versus a further child is only minor. However, only the birth of the first child markedly reduces mothers', but not fathers', entropy. Even if the gender difference is not significant, it supports the idea of reduced employment affecting mothers much more than fathers. There is also a marked, albeit not significant difference in changes in tour complexity, depending on the position of the child born. After the birth of the first child trip patterns tend to become more complex, which favours the idea of young parents aiming for more efficiency. However, following the birth of a further child, tour complexity tends to decrease, particularly among fathers. This may reflect men's increased tendency to take on the breadwinning role no later than after the birth of the second child.

A child moving out of the parental household results in decreasing entropy in parents' activity patterns. This may perhaps be due to the lapsing of shared family activities.

Entering or leaving the labour market is also associated with changes in activity and travel behaviour. While entry into the labour market leads to more complex activity patterns and trip-making, leaving the labour market reduces entropy, particularly for the transition into unemployment, less so for the transition into retirement.

There are some significant gender differences in the effects of labour market-related events on behaviour. Entering the labour market increases entropy among women, but not men, which may

Employed	Sex	Entropy	Trips per tour	N	Employed	Sex	Entropy	Trips per tour	N
	Single, 18-59 years					Couple with children, youngest child 10-17 yrs			
Yes	M	**0.78**	2.75	1,035	Yes	M	**0.73**	2.44	1,765
	F	**0.81**	2.77	985		F	**0.79**	2.45	1,629
	All	0.79	2.76	2,020		All	0.76	2.44	3,394
No	M	0.61	2.52	221	No	M	0.71	2.43	109
	F	0.62	2.55	211		F	0.70	2.36	220
	All	0.61	2.53	432		All	0.70	2.39	329
All	M	**0.75**	2.71	1,256	All	M	**0.73**	2.44	1,874
	F	**0.78**	2.73	1,196		F	**0.78**	2.44	1,849
	All	0.76	2.72	2,452		All	0.75	2.44	3,723
	Single, 60+ years					Couple with children, youngest child 18+ yrs			
Yes	M	0.75	2.65	96	Yes	M	0.76	2.68	937
	F	0.79	2.45	190		F	0.76	2.60	724
	All	0.78	2.51	286		All	0.76	2.65	1,661
No	M	0.55	2.43	770	No	M	0.65	**2.33**	141
	F	0.55	2.37	1,473		F	0.60	**2.88**	169
	All	0.55	2.38	2,243		All	0.63	2.62	310
All	M	0.57	2.45	866	All	M	0.74	2.64	1,078
	F	0.57	2.37	1,663		F	0.74	2.65	893
	All	0.57	2.39	2,529		All	0.74	2.64	1,971
Couple, no children, younger partner < 60 yrs						Other household with 3+ adults			
Yes	M	0.79	2.75	1,367	Yes	M	**0.73**	2.58	820
	F	0.79	2.70	1,350		F	**0.80**	2.61	844
	All	0.79	2.73	2,717		All	0.76	2.59	1,664
No	M	0.58	**2.44**	576	No	M	0.62	2.40	271
	F	0.57	**2.74**	573		F	0.57	2.38	358
	All	0.57	2.59	1,149		All	0.59	2.39	629
All	M	0.74	2.67	1,943	All	M	0.71	2.55	1,091
	F	0.72	2.71	1,923		F	0.73	2.54	1,202
	All	0.73	2.69	3,866		All	0.72	2.54	2,293
Couple, no children, both partners 60+ yrs						Lone parent			
Yes	M	0.77	2.60	162	Yes	M	**0.73**	**2.42**	830
	F	0.74	2.60	135		F	**0.84**	**2.52**	1,314
	All	0.76	2.60	297		All	0.80	2.48	2,144
No	M	**0.54**	2.43	1,813	No	M	**0.63**	2.38	35
	F	**0.51**	2.42	1,654		F	**0.75**	2.45	232
	All	0.52	2.42	3,467		All	0.74	2.44	267
All	M	**0.55**	2.45	1,975	All	M	**0.72**	**2.42**	865
	F	**0.52**	2.43	1,789		F	**0.83**	**2.51**	1,546
	All	0.54	2.44	3,764		All	0.79	2.48	2,411
Couple with children, youngest child < 10 yrs						All household types			
Yes	M	**0.76**	2.61	2,161	Yes	M	**0.75**	2.61	9,173
	F	**0.90**	2.60	1,532		F	**0.82**	2.60	8,703
	All	0.81	2.60	3,693		All	0.78	2.60	17,876
No	M	0.72	2.37	86	No	M	0.57	2.43	4,022
	F	0.74	2.47	755		F	0.58	2.44	5,645
	All	0.73	2.46	841		All	0.58	2.44	9,667
All	M	**0.75**	2.60	2,247	All	M	**0.70**	2.56	13,195
	F	**0.85**	2.55	2,287		F	**0.72**	2.53	14,348
	All	0.80	2.58	4,534		All	0.71	2.55	27,543

Table 3: Mean entropy and tour complexity in various life situations, categorised by gender

M: Male, F: Female. Employed respondents include students and those in apprenticeship
Bold: gender difference significant (p=0.05, two-tailed t-test)

reflect the familiar idea of a female 'second shift'. On the other hand, men, but not women, show a marked increase in tour complexity when they enter the labour market, thus coupling various activities in their tours.

Leaving the labour market shows opposed gender differences: while men tend to increase entropy and decrease tour complexity, it is the other way round for women. The changes in entropy may reflect that employed men have relatively simple activity patterns focusing on their jobs, while employed women combine multiple duties and, hence, their daily lives become less

		Change in...		
		entropy	trips per tour	n
Birth of first child	M	-0.03	0.21	49
	F	-0.16	0.14	52
	All	**-0.09**	0.18	101
Birth of further child	M	-0.07	-0.15	92
	F	-0.04	0.00	96
	All	**-0.06**	-0.07	188
Child leaving home	M	-0.05	0.05	141
	F	-0.06	0.13	161
	All	**-0.06**	0.10	302
Entry into labour market	M	**-0.03**	**0.39**	228
	F	**0.10**	**-0.02**	341
	All	**0.04**	**0.15**	569
Leaving labour market (no retirement)	M	**0.07**	-0.17	113
	F	**-0.11**	0.15	216
	All	**-0.04**	0.03	329
Entry into retirement	M	-0.06	**-0.18**	172
	F	0.03	**0.01**	277
	All	**-0.01**	-0.06	449
PT connection to place of work or education...				
... gets worse / much worse	M	-0.02	-0.04	719
	F	-0.02	0.03	752
	All	**-0.02**	0.00	1,471
... gets better / much better	M	-0.04	-0.09	781
	F	-0.02	-0.05	740
	All	**-0.03**	-0.07	1,521
Parking situation at place of work or education...				
... gets much worse / worse	M	-0.04	-0.04	651
	F	-0.02	0.06	614
	All	**-0.03**	0.00	1,265
... gets much better / better	M	-0.04	-0.06	628
	F	-0.03	-0.04	624
	All	**-0.04**	-0.05	1,252
No life event experienced	M	0.01	0.03	1,403
	F	-0.01	0.01	1,566
	All	0.00	0.02	2,969
Total sample	M	-0.02	0.00	7,599
	F	-0.01	0.02	8,413
	All	-0.01	0.01	16,012

Table 4: Changes in mean entropy and tour complexity after experiencing various life course events, categorised by gender

M: Male, F: Female
Rows M+F bold: gender difference significant (5%, two-tailed t-test)
Row 'all' bold: effect of life course event significantly different from zero (5%, two-tailed t-test)

complex when they leave the labour market. Similarly to transition into unemployment, retirement produces less complex tours for men. It seems that men tend to organise their tours into chains only if time is seriously constrained.

Finally, there are two significant accessibility variables: the PT connection to and the parking situation at the workplace are significantly associated with entropy. As both the improvement and worsening of the PT connection or parking situation seem to affect entropy in the same (negative) direction, these effects are difficult to interpret. As these findings were not reproduced in the regression model presented below, one may suspect that unobserved background variables are at play here. Hence, this result should not be overstated.

Taken overall, the descriptive findings suggest that a number of life course events affect the complexity of activity and travel patterns. These events are related to the family cycle and to labour market changes or, to put it in 'mobility biography terms', in household biography and employment biography. However, given that a substantial number of other events have been tested without any significant effects being found, it seems that such changes in complexity are limited to only few key events in the life course.

4.3 Multiple regression analysis

Before getting into the details of the regression results, a key result confirming the descriptive analysis above is that only relatively few life course events are significant, and even fewer have distinct gender specific effects (note the elaborations above about events that have been excluded from analysis in the course of the modelling process).

Effects of baseline variables

We start by briefly looking at the significant effects of state variables that capture the respondents' life situations in the year prior to change in entropy or tour complexity, respectively (Table 5).

Part-time employees increase their entropy more than full-time employees (reference category), while for unemployed individuals and those in education the opposite is true. Part-time employees decrease their tour complexity from one year to the next more than full-time employees. Individuals with different education levels also exhibit different trends in entropy and tour complexity. Both entropy and tour complexity by and large seem to increase with education level. Those with a university degree (reference category) increase both their entropy and tour complexity most strongly from one year to the next. Respondents with permanent car availability increase entropy as well as tour complexity more than those without access to a car. These results taken together seem to suggest that increases in complexity may be related to having a relatively high social status and strong resources, with part-time v. full-time employment being an exception.

The effects of cohort and cohort squared taken together suggest that changes in entropy as well as in tour complexity become stronger from one cohort to the next, but in a curvilinear function that reaches its maximum among those born in 1983 (for entropy) and in 1977 (for tour complexity). These cohorts include adolescents to mid-aged adults over the study period. One may suspect that the period of observation is relatively short for a cohort study. Hence the cohort variables may mask age effects to some extent. Thus, the maxima found appear to be reasonable.

Period effects are significant as well. They suggest that entropy decreases relatively quickly over time until the turn of the millennium, and, after a small jump, continues to decrease more slowly afterwards. Tour complexity tends to increase strongly initially, but only slowly after the turn of the millennium.

The gender effect suggests that women increase tour complexity from one year to the next more than men, other variables held constant. The only significant gender interaction in baseline effects is that the number of small children in the household increases mothers' but not fathers' entropy over time. This may reflect children's increasingly diversified needs as they grow older, and it suggests that mothers bear the prime responsibility of meeting these needs.

Finally, baseline behaviour in the year prior to change yields by far the strongest effects in both models, suggesting considerable path dependency in behaviour. Those experiencing the highest levels in entropy or tour complexity are most likely to reduce their levels.

Effects of change variables – life course events and access changes

Few life course events and changes in the transport system significantly affect entropy or tour complexity.

Entry into the labour market results in increased entropy, for women even more than for men, which suggests that the simple cliché of male activity patterns, 'just work, nothing else' is not true, at least not for the time after someone has entered the labour force. At the same time, tour complexity increases for men but not for women.

Conversely, leaving the labour market reduces entropy, but only for women, suggesting that men who leave the labour force fill the 'void' with other out-of-home activities. Entry into retirement induces somewhat different changes than leaving the labour force for other reasons. Retiring means that entropy decreases for both genders, but less for women than for men..

A number of other associations related to access and mobility are found. Gaining a driving license is associated with increased entropy. Increased car use (measured in terms of the share of driving in all trips) is also associated with increased entropy, but reduced tour complexity. The latter result may be a direct impact of car use, as the car is a flexible and fast mode of transport that may reduce the need for efficiency in the way trips are organised. The positive association between driving and entropy is not as straightforward. The need to drive may be induced by increased entropy and the associated requirement to juggle more varied commitments. Conversely, the time saved by using the car may allow people to juggle more activities. The association between mode choice and entropy is also reflected in a significant effect of the PT connection to the workplace. A decrease in the quality of the PT connection is associated with increased entropy.

Similarly, the connection between mode choice and tour complexity may help explain the significant effect of the parking situation at the workplace. More parking space results in reduced tour complexity (but only for men, interaction term with gender just fails to reach significance). This association may be mediated by an increased propensity to use the car for the commute.

5 Conclusions

This paper has studied changes in complexity in activity and trip patterns over time from a gendered life course perspective. Activity pattern complexity was captured by Shannon's entropy, i.e. the 'qualitative mix' of out-of-home activities an individual performs. Trip pattern complexity was captured by the mean number of trips per tour over a week. An attempt was made to trace back the changes in complexity to life course-related key events and changes in accessibility, transport and spatial context. The paper thus contributes to research by linking the strands of activity/travel pattern and life course research ('mobility biographies') together from a gender perspective. Within the gender-activity/travel nexus the paper also employed a relatively unusual perspective by explicitly studying activity pattern complexity.

		Change in entropy			Change in no. of trips per tour		
		B	Exp(B)	Sig.	B	Exp(B)	Sig.
Intercept		0.330	1.391	0.000	1.488	4.430	0.000
Gender, household, family biography							
Gender female	B	-0.001	0.999	0.926	0.086	1.090	0.017
No. of children in household (< 10 yrs)	B	0.009	1.009	0.095	0.016	1.016	0.525
No. of children in household (10-13 yrs)	B	-0.002	0.998	0.773	-0.057	0.945	0.163
No. of children in household (14-17 yrs)	B	0.008	1.008	0.297	0.054	1.056	0.243
No. of children in household (< 10 yrs) * female	B	0.033	1.033	0.000	-0.033	0.968	0.297
No. of children in household (10-13 yrs) * female	B	0.010	1.010	0.319	0.006	1.006	0.899
No. of children in household (14-17 yrs) * female	B	0.010	1.010	0.345	-0.070	0.932	0.194
Birth of child	C	-0.033	0.967	0.158	0.091	1.096	0.420
Birth of child * female	C	-0.019	0.981	0.575	-0.038	0.963	0.768
Move out of child	C	-0.001	0.999	0.973	-0.076	0.927	0.410
Move out of child * female	C	-0.014	0.986	0.667	0.172	1.188	0.198
Household formation with a partner	C	-0.007	0.993	0.733	-0.062	0.940	0.322
Separation from partner	C	-0.019	0.982	0.519	-0.091	0.913	0.223
Household formation with a partner * female	C	0.008	1.008	0.799	0.055	1.056	0.562
Separation from partner * female	C	0.066	1.068	0.079	0.011	1.011	0.903
Social status, employment and educational biography							
Employment (reference: full-time)							
Part-time employed	B	0.064	1.067	0.000	-0.103	0.903	0.001
Apprenticeship, trainee, education	B	-0.040	0.961	0.001	0.066	1.069	0.216
Not employed	B	-0.061	0.941	0.000	-0.051	0.950	0.103
Education level (reference: university entrance qualification or higher)							
Elementary school qualification without apprenticeship or no qualification	B	-0.035	0.965	0.000	-0.209	0.811	0.000
Elementary school qualification plus apprenticeship	B	-0.044	0.957	0.000	-0.181	0.834	0.000
Secondary school qualification level I	B	-0.026	0.974	0.000	-0.103	0.902	0.000
Finished school or apprenticeship	C	0.009	1.010	0.487	0.048	1.049	0.429
Finished school or apprenticeship * female	C	0.004	1.004	0.833	-0.062	0.940	0.370
Start of apprenticeship	C	-0.054	0.947	0.081	-0.114	0.892	0.177
Start of apprenticeship * female	C	0.085	1.088	0.140	0.134	1.143	0.358
Entry into labour market	C	0.069	1.072	0.001	0.328	1.389	0.047
Entry into labour market * female	C	0.064	1.066	0.014	-0.401	0.670	0.018
Leaving labour market (no retirement)	C	0.023	1.023	0.419	-0.112	0.894	0.167
Leaving labour market (no retirement) * female	C	-0.112	0.894	0.002	0.153	1.165	0.375
Retirement	C	-0.074	0.929	0.002	-0.084	0.920	0.113
Retirement * female	C	0.058	1.060	0.044	0.027	1.027	0.714
Change in access to place of work or education							
PT connection to place of work or education gets...							
... worse / much worse	C	0.025	1.025	0.024	-0.052	0.950	0.147
... better / much better	C	-0.003	0.997	0.777	-0.076	0.927	0.084
... worse / much worse * female	C	-0.019	0.982	0.213	0.070	1.073	0.152
... better / much better * female	C	0.019	1.019	0.191	0.016	1.016	0.759
Parking situation at place of work or education gets...							
... worse / much worse	C	0.007	1.007	0.527	-0.010	0.990	0.786
... better / much better	C	0.002	1.002	0.860	-0.086	0.918	0.040
... worse / much worse * female	C	-0.008	0.992	0.594	0.019	1.020	0.745
... better / much better * female	C	0.000	1.000	0.987	0.097	1.102	0.068

Mobility and associated changes							
Gaining driving license	C	0.047	1.048	0.050	0.116	1.123	0.361
Loss of driving license	C	-0.051	0.951	0.097	-0.102	0.903	0.148
Gaining driving license * female	C	-0.042	0.958	0.198	-0.152	0.859	0.267
Loss of driving license * female	C	0.062	1.064	0.117	0.077	1.080	0.546
Car availability (reference: no)							
Occasionally / after agreement	B	0.006	1.006	0.644	0.023	1.024	0.557
Regularly	B	0.031	1.032	0.000	0.116	1.123	0.000
Occasionally / after agreement * female	B	0.009	1.010	0.549	0.071	1.074	0.331
Regularly * female	B	-0.005	0.995	0.653	-0.059	0.943	0.175
Loss in car availability	C	-0.025	0.976	0.085	-0.025	0.976	0.682
Increase in car availability	C	0.020	1.020	0.207	0.092	1.096	0.069
Loss in car availability * female	C	0.002	1.002	0.916	0.069	1.071	0.553
Increase in car availability * female	C	-0.027	0.973	0.176	-0.140	0.870	0.038
Change in driving (share in trips made as a car driver)	C	0.074	1.077	0.000	-0.252	0.777	0.000
Change in spatial context at residence							
Change in urbanity	C	0.000	1.000	0.973	0.014	1.014	0.199
Change in urbanity * female	C	0.004	1.004	0.287	-0.006	0.994	0.688
Cohort and period and baseline values of behaviour							
Cohort (94 yrs in 1994 = 0)	B	0.004	1.004	0.000	0.009	1.009	0.003
Cohort, squared, div. by 100	B	-0.002	0.998	0.001	-0.006	0.994	0.035
Year of survey (1994 = 0)	B	-0.007	0.993	0.001	0.033	1.034	0.000
Year of survey (1994 = 0) * 2000 or later	B	0.004	1.004	0.023	-0.026	0.975	0.001
Baseline entropy / trips per tour	B	-0.632	0.531	0.000	-0.709	0.492	0.000
(Scale)		0.069			1.425		
QICC		1,191.6			22,404		
QICC (intercept model)		1,618.8			32,809		
R² adj (from OLS regressions)		0.323			0.309		
n (observations)		15,699			15,699		
n (individuals)		9,533			9,533		

Table 5: Cluster-robust regression models of changes in entropy and tour complexity

B = baseline variable; C = change variable.

The results suggest, firstly, that changes in complexity are affected by some state variables that capture the respondents' life situations in the year prior to change. For instance, women increase their tour complexity over time more than men. This may sound somewhat surprising as there is no obvious reason to expect changes in activity and trip pattern when circumstances remain stable. One reason may be that some changes in circumstances are not adequately represented in the data. Another reason may be that people continuously adjust their behaviour even without obvious and massive changes in circumstances. This has been reported similarly in a companion paper on mode choice (Scheiner and Holz-Rau, 2013).

Secondly, some life course events and changes in the transport system significantly affect entropy or tour complexity. Household-related key events were not significant in the regression models in any case. In a descriptive analysis childbirth has been found to significantly and negatively affect entropy in activity patterns, but this finding could not be reproduced in regression modelling. Other, if non-significant, descriptive results suggested a difference between the birth of the first or a further child in a family. A detailed look at the family cycle and its consequences for travel would seem to be well worth further inquiry.

Other significant key events refer to employment. Entry into the labour market results in increased entropy, for women even more so than for men. At the same time, tour complexity increases for men but not for women, although both effects just fail to achieve significance. Conversely, leaving the labour market reduces entropy only for women, suggesting that men who leave the labour force fill the 'void' with other out-of-home activities. Entry into retirement decreases entropy for both men and women. Tour complexity also decreases, particularly for men.

Thirdly, increased car use is associated with increased entropy and reduced tour complexity. It has to be noted that these associations do not impose a clear-cut cause-impact relationship between mode choice and complexity in activity or trip patterns.

Fourthly, it has to be noted that only relatively few life course events are significant. Most events under study have been excluded from analysis in the course of modelling for reasons of parsimony. This is particuarly noteworthy because activity patterns are directly related to life situations and, hence, the effects of key events were expected to be relatively strong. Even fewer events exhibit distinct gender specifics. This suggests that, in general, key events seem to be relatively loosely associated with changes in complexity, and only few events appear to be strongly gendered.

Three reasons may be offered for interpretation. Firstly, the period of observation of any household is relatively short, and changes in complexity may be delayed. Secondly, travel behaviour is known to involve strongly habitual elements (e.g. Bamberg et al., 2003), and the structure of an individual's activity pattern may depend more on what she or he simply has to do than on external circumstances. Thirdly, the measures used may not capture complexity as accurately as necessary. Even if, say, activity pattern entropy remains on a stable level, much change may go on under the surface, e.g. in terms of the sequencing of activities, the destinations visited, or the actual activities performed within a broad category such as 'leisure'.

This paper suggests various directions for future research. Firstly, the relatively minor life course related effects found do not imply that life course perspectives in travel studies are not a worthwhile field of inquiry. The idea of mobility biographies includes a broad spectrum of topics and methodological approaches, and it may serve as a framework for other fields in transport research such as the debate on residential self-selection (Scheiner, forthcoming(a)).

Secondly, there is growing research on the role of preferences or attitudes in travel behaviour. As in most other travel surveys, the data used here do not include information on preferences, but these may play an important mediating role between opportunities and other 'hard' circumstances, life events, and activity/travel behaviour (see the debate on residential self selection, Cao et al., 2008; Scheiner, forthcoming(a)).

Thirdly, extending the approach used to other measures of activity and travel behaviour could be worthwhile. A companion paper on mode choice also yielded relatively loose associations with life course-related events (Scheiner and Holz-Rau, 2013). Still, the framework could be used to study the sequencing of activities, activity spaces and destinations visited, actual activities rather than broad activity categories, or composite measures of activity/travel. The latter could also combine different facets of activity/travel behaviour by using advanced measures such as Levenshtein distances that capture differences between two sequences.

Fourthly, it would be valuable to extend the analysis of change to longer periods to capture anticipated and delayed effects (e.g. Dargay, 2001; Oakil et al., forthcoming). People may react to changing circumstances slowly, or they may react in advance of an expected event, and they may react in very different ways, because changes in some respects are superimposed on the steady habits of daily life in other respects.

Finally, an important issue is to tackle interpretation of such empirical results in terms of sustainability, particularly with respect to its gender equity dimension. Gender specific travel behaviour changes over the life course may suggest gendered worksharing in childraising, housework or employment, they may show gendered adaptations to spatial context, or they may be the outcome of powered negotiations between two partners over access to the car (Scheiner and Holz-Rau, 2012). However, they may also be the outcome of gender specific preferences deliberately developed by individuals rather than of power relations. If this were ascertained, then there would be no point in complaining about inequality just because there is difference. Thus, more research is needed on the emergence of gender differences or similarities, rather than just on the behavioural outcome, and a focus should be on the extent to which unequal power relations are at play. Only thus will it be possible to ascertain whether there is reason to criticise a deficit in sustainability in terms of gender inequality.

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