

Do men and women differ in time-use? Analysing the complexity of activity patterns in Germany

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ABSTRACT

Individuals' participation in daily routine activities varies according to the situations they live in. Gender roles and marital status drive them to take part in various economic, leisure and travel activities. Married (or cohabiting) individuals, in comparison to singles, juggle activities interdependently with their partners' resources and work allocation, resulting in potentially complex intersecting schedules. The primary aim of this research is to explore the complexity (measured using Shannon's entropy) of individuals' activity patterns by considering diverse factors such as demographics, job/education, residential location, travel behaviour, gendered multitasking behaviour, time use preferences and partner interactions. To examine variations in complexity, we developed three separate models for single and partnered respondents, and all respondents, respectively. We used German Time Use Survey 2012/13 data and employed multilevel linear regression models. Gender interaction variables were additionally included in the analysis to examine the gender differences in coefficients. In general, our results suggest that activity pattern complexity is positively associated with demographics (being women, having young children), job/education (high levels of education, working in non-market sector), travel behaviour (number of trips, car, public transport and cycling), time spent on unpaid multitasking, preference for time use (leisure and unpaid work) and additional work hour preferences, whereas full-time/overtime working, paid multitasking negatively affects the complexity. For partnered respondents, factors such as increase in age, increase in income, working in shifts and time spent on paid multitasking have significant negative effects on the complexity of activity patterns, while partners' time spent on unpaid work and leisure activities positively affects respondents' complexity. The gender interaction with multitasking behaviour reveals that men's activity patterns are increasingly complex with more time spent on unpaid multitasking, while for women, the complexity of activity patterns is positively associated with more time spent on paid multitasking.

1. Introduction

Individuals' complex daily lives encompass duties and chores, ranging from personal care to market work and care for others. Such complexity may be reflected in performing various activities that are spatially and temporally distributed, activities that involve a number of fragments or multitasking, complex trip chains or multiple travel modes (Scheiner and Holz-Rau, 2017).

Gender and marital status significantly influence the complexity of activity patterns throughout one's life. For instance, partnered couples have a different range of complexities compared to those who are single. For couples without children, both men and women tend to similarly allocate time to personal care and leisure, but the gender difference remains in employment and household work reflecting the dissimilarity

in time use and activity patterns (Birch et al., 2009, p.80; Zhang et al., 2005). For couples with children, gender roles change among couples, even among those who pursued relatively equal work-sharing before, leading to re-traditionalisation among couples (Grunow et al., 2012). For single households, both men and women exhibit a high degree of similarity in allocating time to household work, but they are however known to have different activity patterns due to differences in time allocation and preferences in leisure and employment (Birch et al., 2009, p.42).

Decades of gender research suggests that time use is both cause and consequence of gender inequality, where women face more complex daily lives than men (Susilo et al., 2019; Scheiner and Holz-Rau, 2017; Baxter, 1992). The main reason is that women's activity patterns are constrained by time and space limits on their commitments with

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multiple duties like employment, housework, childcare and family care (Bianchi et al., 2006). Working women, in particular, shoulder both labour participation and domestic work to meet the demands of work and family (Craig and Jenkins, 2016). Because of this dual burden, women extend their activity spaces to day care and shopping beyond their workplaces and compromise their leisure hours. Such complex activity patterns generate more anchor points such as the home, the workplace, or children's school(s) or nursery. For this reason, women make more complex trip chains than men, and this leaves them using flexible modes of transport such as the car to juggle all their duties (Scheiner, 2010; Crane, 2007). In contrast, men spend most of their housework time in discretionary activities that can be scheduled to their flexible, convenient time. During non-working days (e.g. weekends) or hours, working women are much more likely to do unpaid work, while working men are more likely to undertake leisure activities (Patchett, 2022; Ferrari, 2021).

Various studies across the world have shown traces of gender convergence in time use (Sani and Treas, 2016 for 11 countries, 1965–2011; Altintas and Sullivan, 2016 for nine countries, 2005–2011; Gershuny and Kan, 2012 for 12 countries; Sayer, 2010 for nine countries, ca. 1965–2003). They commonly found that the proportion of unpaid work in total working time has reduced for women and has gradually increased over the decades for men. In particular, they observe convergence in patterns of childcare, where men have increased their childcare time. Nevertheless, the gender difference in division of labour still remains, especially among parents in Germany (Chidambaram and Scheiner, 2021).

Understandings of the complexity of individual activity patterns remain limited for the following reasons. First, many time use studies include gender only as a control variable, and descriptively compare time use spent on activities throughout the day (Dharmowijoyo et al., 2018; Erlandsson, 2006). Second, from a travel behaviour standpoint, a comprehensive understanding of how individuals use their time is essential for the development of activity-based modeling as a means of forecasting travel demand (Hasnine and Nurul Habib, 2021; Nayak and Pandit, 2022; Rovira et al., 2022). However, some studies of complexity – especially in the transport field – use data that do not include information on domestic activities (Scheiner and Holz-Rau, 2017; Scheiner, 2014). Third, various factors such as job characteristics, multitasking behaviour, gender roles and preferences, shape individuals' daily routines in performing activities. However, little is known about how these factors influence the complexity of activity patterns.

In this paper, we consider the realised temporal distribution of activities and thus measure the complexity of activity patterns using Shannon's entropy, a variable constructed from time-use diaries completed for a random three days by a nationwide sample of respondents from Germany in 2012/2013. First, we compare mean values of entropy and the time use of individuals classified by marital status (single vs. partnered) and gender (men vs. women). Second, we explore the association between the complexity of activity patterns and diverse factors such as socioeconomic status, individual and household demographics, spatial and travel attributes, gender interaction with multitasking behaviour, time use preferences and partner interactions.

The following section introduces the state of the research. Section 3 describes the data, the modelling approach and the variables used for analysis. In Section 4, we discuss the results, and conclusions are drawn in Section 5.

2. Previous research

2.1. Complexity of activity patterns – measures

Individual activity patterns have been studied extensively in the past (Hafezi et al., 2019; Scheiner and Holz-Rau, 2017; Oakil et al., 2014; Sharmeen et al., 2014). These patterns involve multifaceted aspects, potentially resulting in complex schedules. Complexity in activity

patterns is measured by various observable patterns, such as the multitasking (activities undertaken simultaneously), fragmentation of activities in space and/or time (disintegration of activities into smaller sets of acts), the number of transitions between different activities (Alexander et al., 2011), the variety of activities performed, or the number and/or distribution of spatially and/or temporally fixed anchor points in daily life (Scheiner and Holz-Rau, 2017). Only few studies considered multitasking (Offer and Schneider, 2011; Cao et al., 2021) and fragmentation of activities (Alexander et al., 2011) from a gender perspective. These studies altogether suggest that women's daily lives are considerably more turbulent than men's, and have more strained and contaminated leisure by interruptions and combined with unpaid work than men's. Moreover, women tend to not only multitask more often than men, but experience more negative effects and stress from multitasking than men.

Due to the limited number of studies, the evidence to date is rarely conclusive. Moreover, there is hardly any research that focus on the association between various aspects (multitasking behaviour, time use preferences, partner interaction) and complexity of activity patterns from a gender perspective. The novelty of this paper is threefold. First, the study explicitly studies the gender difference in complexity in activity pattern that includes both in-home and out-of home activities in Germany. Second, we constructed the variable from German Time Use data (2012/13) using Shannon's entropy to explicitly study complexity in activity patterns in German context. Third, we examine how the various factors (socio demographic, job characteristics, residential location, travel behaviour, multitasking behaviour, time use preferences, partner interaction) affect the complexity of activity patterns and in particular we explore the association between complexity of activity patterns and gender interactions with income, multitasking behaviour (i.e. multitasking during paid work and unpaid work) and work hour preferences. In the following section, we discuss various variables that determine the complexity of activity patterns and present framed hypotheses.

2.2. Factors determining the complexity of activity patterns

2.2.1. Demographic indicators

Individuals' household and sociodemographic characteristics provide opportunities to take part in certain activities. A recent study suggests that women, younger age groups and those with children have more complex activity patterns (Scheiner and Holz-Rau, 2017). The younger age groups spend most of their time on education, media and internet-based applications (Beckmann et al., 2014); middle-aged groups engage in diverse activities such as errands, childcare, employment or sports; and older people pursue stationary and passive leisure activities like watching TV, reading or chatting (Sayer et al., 2016). The number and age of children are consistently identified as key impact factors on mothers' family obligations (Carson et al., 2018). More precisely, couples with young children participate in various activities such as household tasks, childcare, shopping and family care while those with older children join in job-related activities. Ekert-Jaffé (2011) found that the time cost of having three or more children is equal to having a full-time job. Presumably, this represents the fact that having young children increases individual participation in various activities, thus increasing the complexity.

Based on the above review, we test if factors such as middle-aged groups, women and presence of young children positively affect the complexities (H1).

2.2.2. Job/education

An increase in economic opportunities improves individuals' quality of life but at the expense of family time. Such individuals experience temporal conflicts between work and family. In this regard, both income levels and working hours are determining factors. For instance, because of irregular working hours, low-income workers struggle with finding

the economic resources to outsource the day care for their children and are forced to do unpaid activities, while the middle/upper-income groups who are mostly occupied with overtime working hours have less time to spend with the family (Williams and Boushey, 2012).

Concerning job type, workers have obligatory routine activities (work/school/drop off/pickup) that are spatially and temporally fixed and repetitive (Susilo and Kitamura, 2005). Part-time jobs often allow flexibility to juggle between various activities such as work, household and family obligations. Many studies discovered that working mothers, irrespective of their employment status, spend more time on housework leading to them having less free time than men (Aguiar and Hurst, 2007).

Weekends are often free of paid work and are characterised by free time and a slowing down of daily life (Dharmowijoyo et al., 2018; Ho and Mulley, 2013). They may thus exhibit lower levels of complexity.

Overall, we can therefore expect that an increase in personal income and education levels, working full time, fixed working schedules and weekends negatively affect the complexities for both men and women (H2).

2.2.3. Residential location

Urban dwelling may encourage an independent lifestyle, however, the increase in socioeconomic status, constrained physical environment and perception of traffic safety hinder individuals from taking part in various activities. For instance, van Diepen and Musterd (2009) found that individuals in urban regions outsource domestic and childcare activities to invest more time in paid work. Also, Matz et al. (2015) found that individuals living in rural areas spend most of their time in outdoor activities and inside vehicles, as they travel longer to well-paid jobs. Besides travelling, suburban individuals have an active lifestyle as they take part in diverse activities such as household maintenance, gardening and agriculture, neighbouring and social participation, volunteering activities (Jakubec et al., 2019), engaging children in outdoor activities such as library trips, sports and athletics (Nally et al., 2022). In this regard, we expect that individuals living in suburban regions have higher complexities than those living in urban areas (H3).

2.2.4. Travel behaviour

The availability of travel options largely determines participation in and time allocation to out-of-home activities (Millward et al., 2019; Chen et al., 2011). Travel attributes, such as travel distance and trip frequency by modes, capture the complexity of travel-related activity patterns (Susilo et al., 2019). The transport modes used may affect the complexity of activity patterns, but reverse causality may also apply. For instance, owning a car increases the probability of performing out-of-home activities but at the same time complex activity patterns may explain the mode choice. Hence it is reasonable to expect that individuals with access to private transport could perform more multiple trips (also activities) than those without such access. Based on this thought, we expect that number of trips and driving are positively associated with activity pattern complexity (H4).

2.2.5. Paid and unpaid work multitasking

Individuals multitask¹ (i.e. secondary activities performed alongside primary activities at the same time) as a strategy to cope with the time pressure that arises from work and family (Offer and Schneider, 2011). Unpaid work multitasking involves taking on several unpaid responsibilities as secondary tasks, such as household chores, taking care of children and family members, and running errands in addition to primary tasks. On the other hand, paid work multitasking refers to

carrying out paid work-related tasks concurrently with primary tasks.

Unpaid work multitasking represents a time management strategy to balance work and family demands. For instance, certain subgroups (e.g. women, those working part-time, mothers of small children) allocate their additional household and caring work to their leisure time (Sullivan and Gershuny, 2013). Though leisure quality is impacted by unpaid work multitasking, individuals have sufficient time left for other market/travel-related activities (e.g. job, commuting).

Individuals with high socioeconomic status (high income and education levels, longer working hours) mostly do paid multitasking to deal with job pressure (Schieman and Young, 2015), and outsource domestic tasks to avoid unpaid activities (Sullivan and Gershuny, 2013). Here, productivity increases due to the similar tasks performed, however, there is little time left for unpaid work and discretionary activities.

Unpaid work multitasking involves task switching between diverse activities, while paid work multitasking involves switching among job-related activities. With this notion, we assume that unpaid (or paid) multitasking is positively (or negatively) associated with activity pattern complexity. As there is a general claim that women do more unpaid multitasking than men (Offer and Schneider, 2011), we therefore expect that performing unpaid multitasking may be positively associated with women's complexity, while performing paid multitasking may be negatively associated with men's complexity (H5).

2.2.6. Time use preferences

The level of satisfaction that individuals exhibit about the time spent on a particular activity depends on how effectively they utilised the time. If an individual enjoys doing an activity, apparently, he/she will desire to spend time on that particular activity. For instance, men who dislike the housework are those who spend less time on housework (Stratton, 2012), and women's preference for unpaid care work is shown in their enjoyment of maternal care (Cherchye et al., 2012). In a daily routine, non-market activities such as unpaid work (from domestic maintenance to childcare) and leisure (from sports to media usage) encompass broad ranges of activities and comprise a significant proportion of time. It therefore seems reasonable to expect that individuals with a desire to spend time on unpaid work or leisure have a higher complexity than those who prefer paid activities (H6).

A desire to work additional hours shows an individual's preference to work longer than the actual working hours. Recent studies in Germany have shown disparities between actual and preferred working hours. Men, who are mostly in full-time employment, increasingly want to reduce their working hours, while women, especially mothers, who tend to be concentrated in part-time or short-term jobs, would prefer to increase their working hours (Abendroth and Pausch, 2018; BMFSFJ, 2015; Pollmann-Schult, 2011). In this regard, we expect that women with a preference for additional working hours have higher complexities than men (H7).

2.2.7. Partner interaction

Recent years have witnessed abundant research on intrapersonal interaction focusing on a gendered division of labour and the effects of cohabitation and shared resources on travel (Scheiner, 2020; Lai et al., 2019; Ji et al., 2018). However, not much is known about the effect of partners' work sharing on respondents' participation in activities. For instance, Scheiner and Holz-Rau (2017) confirm that living with a partner increases men's complexity but not women's.

Moving beyond the effect of the partner's presence, we consider two aspects are necessary to understand how a partner's work sharing affects an individual's complexity. First, the effect of a partner's time spent on paid and unpaid work on an individual's participation in activities. For instance, in a traditional household pattern, male partners with long work hours have less time available for household maintenance, causing their female partners to shoulder household responsibilities (Radcliffe and Cassell, 2014). Second, the time a partner spends on leisure activities affects individual participation in daily activities. For instance,

¹ Multitasking by itself may be considered a measure of complexity (Scheiner and Holz-Rau, 2017). However, in our study, we measured complexity by only considering individuals' share of time spent on primary activities. As such, the secondary activities have no direct effect on the complexity measure.

when a partner enjoys their leisure time (sports, hobbies or media), individuals undertake additional household responsibilities (Kamp Dush et al., 2018).

Recognising these two aspects, we presume that partner's time spent on paid/unpaid work negatively affects the individual's complexity, while partner's time spent on leisure activities positively affects the individual's complexities (H8).

3. Method

3.1. Data

The study uses a sub-sample of data from the nationwide representative German Time Use Survey (GTUS), conducted by the Federal Statistical Office in 2012/2013 (Forschungsdatenzentren, 2013). It is a cross-sectional survey, repeated once every ten years, after 1991/1992 and 2001/2002. The data comprises specific socioeconomic, demographic and activity, travel and mode-use patterns for three random days. Similar to other time use surveys (e.g. UK Time Use Survey, General Social Survey for Canada, American Time Use Survey for the US), the respondents self-report the daily activity and travel mode in the activity diary for a continuous 24 h (i.e. from 4 am to 4 am the next day) over three random days (two weekdays and one weekend day), with ten-minute intervals.

The GTUS is a reliable measure of time use patterns and allocation, covering a broad range of activities on various aspects such as labour market participation, household maintenance, care and services and active and passive leisure. However, the fixed ten-minute time intervals in the activity diary leads to underreporting of shorter activities or trips (under 10 min) which, at least in part, accounts for the limitation of the data.

3.2. Sample setting

An individual's time use is reflected in his/her pattern of activities over 24 h. The time use diary comprises a sequence of episodes of varying lengths, starting at 4 am, with a total duration of 1440 min, leading to 144 episodes per day. Each episode has information on the respondent's primary activity (e.g., personal care, work, education, household tasks, shopping, childcare, social, sport, voluntary, media, travel), secondary activities and – for trip times – primary travel mode used.

Our analysis includes respondents that self-reported the activity diary over three random days, comprising 25429 days (M:11601; F:13828) reported by 8480 (M: 3869; F:4611) respondents. We hypothesised that the diversity of family types might have varied activity patterns. Compared to single respondents, partnered respondents have additional responsibilities related to work-family integration. For this, they need to negotiate, interact and share the job (or job-related activities) and unpaid work such as children, housekeeping and other services. Such interdependence may tend to increase (or decrease) their participation in activities. Single men/women do not have such negotiation as they are solely responsible for income generation and for raising their children. For these reasons, we believe that singles and partners may have different activity patterns, showcasing the complexities of activity patterns at a different level. Hence, we split our sample in the study to consider estimates for single respondents (M:3617; F:5754 days) and different-sex partnered respondents (M:7984; F:8074 days).²

² We do not have information on same-sex couples nor on subjective gender identities. We do not aim to discuss the limitation of restricting our analysis to traditional different-sex couples in the main text as we feel it distracts readers. However, readers may refer to the scant literature on this, e.g. Smart et al. (2017) and Seabra and Azzoni (2022).

3.3. Variables description

Measuring activity pattern complexity in social science commonly involves using various indices of qualitative variance or heterogeneity, e.g. the index of qualitative variation, index of diversity, and Shannon's entropy. However, the index of qualitative variation presents a limitation as it focuses solely on the proportion of cases in the modal category while disregarding the distribution of cases across other categories. In contrast, the index of diversity, which comprises squared values, highlights strong categories rather than weakly presented categories. Scheiner and Holz-Rau (2017) suggest that activities conducted in-between or side activities can extensively influence the complexity of daily activity patterns as a whole and should, thus, be proportionately overrepresented in measures of complexity. Therefore, Shannon's entropy, which provides emphasis on weakly presented categories as it is based on logarithms, is the preferred measure of complexity in this study.

The outcome variable for our regression analysis is Shannon's entropy, which we use as a measure of complexity, following Scheiner and Holz-Rau (2017). We calculated Shannon's entropy using the formula $H = -\sum (p_i \cdot \ln(p_i))$, where p_i is the share of the individual's time spent on activities in the day of report (accounting to 24 h).³ Six activity classes (both in-home and out-of-home) are available in the data for analysis: personal care (including sleeping), paid work, education, unpaid work, leisure and unspecified travel. For the calculation, we extracted 22 primary activities and associated travel (see Table 2 for details) using a code identifier in the data. We excluded secondary activities (concurrent activities at the same place/time) and did not consider the fragmentation of activities.

The graphical illustration (Figs. 1–4) explains how the complexity of activity-travel patterns (measured using Shannon's entropy) vary with various factors such as number of activities participated (Fig. 1); number of trips per day (Fig. 2); number of travel modes (Fig. 3) and working status (Fig. 4). In Fig. 2, zero entropy denotes that an individual's daily life is devoted to only one activity (minimum complexity). In contrast, the highest entropy (1.90) represents that individual devote equal time to all sixteen activities (maximum entropy, see Fig. 2). For instance, an individual who spreads his/her time evenly over job and leisure has lower entropy than someone who organises their time evenly over job, leisure and errands. At the same time, that individual has more entropy than someone who devotes time unequally to job and leisure. Moreover, it can be observed (Figs. 1–3) that entropy (i.e., complexity) linearly increases with the number of activities performed, number of travel modes used per day, and number of trips performed per day. For working status (Fig. 4), it can be noted that entropy is high for part-time workers and low for over-time workers.

The explanatory variables consist of large range of variables, including the interaction terms with gender, were reduced to 25 variables for the final analysis using stepwise regression models. These variables were grouped in six categories (as shown in Fig. 1): (1) individual and household sociodemographic, (2) job characteristics, (3) spatial and travel patterns, (4) multitasking, (5) time use preferences

³ To understand the complexity of activity patterns using entropy formula, let us consider a person has participated in five activities per day and assuming that out of 24 h the person spent about 10 h of personal care (including sleeping); 8 h of job; 3 h of housework; 2 h of watching tv and a hour of commuting. The entropy (H) is here calculated as the sum of probability of time spent on each activity multiplied by the natural logarithm of this probability, which is expressed as follows: $H = -\{[p_{\text{personal care}} \cdot \ln(p_{\text{personal care}})] + [p_{\text{job}} \cdot \ln(p_{\text{job}})] + [p_{\text{housework}} \cdot \ln(p_{\text{housework}})] + [p_{\text{watching tv}} \cdot \ln(p_{\text{watching tv}})] + [p_{\text{commuting}} \cdot \ln(p_{\text{commuting}})]\} = -\{(-0.365 - 0.366 - 0.260 - 0.207 - 0.132)\} = 1.33$ It is to be noted that the minus sign in the formula takes care of the fact that natural logarithm of any number less than 1 is negative, and hence the entropy is always positive that ranges from zero to 2.

Table 1
Variables used in the analysis.

	Singles		Gender Gap	Partners		Gender gap
	Men	Women		Men	Women	
1. Demographics						
^a Age group 20–30 (%)	36.27	21.12	***	0.86	1.97	***
Age group 30–40 (%)	12.50	12.65		10.92	16.39	
Age group 40–50 (%)	18.99	25.90		30.62	33.33	
Age group 50–60 (%)	15.59	18.72		26.03	25.07	
Age group 60 and above (%)	16.64	21.62		31.56	23.25	
^a Gender: M (%)	38.60	na		49.72	na	
F (%)	na	61.40		na	50.28	
No of children above 18 years: m(s.d)	1.38 (0.59)	1.39 (0.62)		1.31 (0.56)	1.32 (0.56)	
^b No. of children less than 3 years: m(s.d)	1.38 (0.55)	1.54 (0.73)		1.98 (0.75)	1.98 (0.75)	
^b No. of children between 4 and 6 years: m(s.d)	1.77 (0.74)	1.73 (0.74)		1.96 (0.62)	1.96 (0.62)	
^b No. of children between 7 and 10 years: m(s.d)	1.53 (0.67)	1.61 (0.72)		2.0 (0.67)	2.0 (0.67)	
^b No. of children between 11 and 18 years: m(s.d)	1.83 (0.74)	1.60 (0.68)	+***	1.82 (0.68)	1.82 (0.68)	
2. Job/education						
^b Personal monthly income (€/month): m(s.d)	1578.3(1022)	1369.8(849)	+***	2587.3(1238)	1195.4(819)	+***
^a Education level: low (ISCED 1–3) (%)	65.52	66.06		50.40	65.31	***
Education level: high (ISCED 4–6) (%)	34.48	33.94		49.60	34.69	
^a Economic sector: industry (mining, manufacturing) (%)	29.22	10.94	***	34.89	12.46	***
Economic sector: market (retail, bank, hospitality) (%)	41.09	33.74		32.68	31.90	
Economic sector: non-market (health, education) (%)	29.70	55.32		32.43	55.64	
^a Working time: part-time (<34 h/week) (%)	13.85	32.78	***	7.69	46.66	***
Working time: full-time (34–48 h/week) (%)	46.94	30.50		51.65	15.87	
Working time: overtime (>48 h/week) (%)	8.46	2.55		11.95	1.26	
Working time: not employed (%)	30.74	34.17		28.71	36.22	
^a Working schedule: fixed start and end (%)	46.42	53.41	***	42.07	53.72	***
Working schedule: flexible work hours (%)	27.88	29.23		33.13	28.10	
Working schedule: free organisation (%)	25.70	17.36		24.80	18.19	
^a Work in shifts: yes (%)	17.61	19.08		15.23	14.75	
Work in shifts: no (%)	82.39	80.92		84.77	85.25	
^a Days of the week: weekday (Mon-Fri) (%)	64.47	64.03		64.40	64.44	
Days of the week: weekend (Sat-Sun) (%)	35.53	35.97		35.60	35.56	
3. Residential location						
^a Urbanity: urban (%)	30.08	31.96		24.80	24.75	na
Urbanity: semi-urban (%)	39.34	38.93		42.47	42.42	
Urbanity: semi-rural (%)	15.73	15.22		18.71	18.76	
Urbanity: rural (%)	14.85	13.89		14.02	14.07	
^a Region: west (%)	77.55	77.04		80.35	80.25	na
Region: east (%)	22.45	22.96		19.65	19.75	
4. Travel behaviour						
^b Number of trips per day: m (s.d)	2.36 (1.97)	2.68 (2.20)	-.***	2.45 (2.07)	2.63 (2.35)	-.***
^a Travel by car = yes (%)	56.54	54.85		64.04	61.79	***
^a Travel by public transport = yes (%)	17.09	17.33		8.29	7.85	***
^a Travel by cycling = yes (%)	8.29	10.11	***	8.05	8.11	***
^a Walking = yes (%)	17.83	23.91	***	14.09	18.02	***
5. Multitasking behaviour						
^b Paid work as multitasking (h/day): m(s.d)	0.13 (0.33)	0.09 (0.27)	+***	0.13 (0.34)	0.06 (0.22)	+***
^b Unpaid work as multitasking (h/day): m(s.d)	0.20 (0.65)	0.64 (1.27)	-.***	0.37 (0.92)	0.87 (1.47)	-.***
6. Time use and work hour preferences						
^a Wish to spend more time: none (%)	59.00	47.08		55.85	50.63	***
Wish to spend more time: personal care (%)	1.58	2.76		1.09	2.01	
Wish to spend more time: paid/education (%)	1.74	2.40		0.75	1.37	
Wish to spend more time: unpaid (%)	2.79	6.99		5.56	6.54	
Wish to spend more time: leisure (%)	33.23	39.16		34.76	37.70	
Wish to spend more time: travel (%)	1.66	1.62		1.99	1.75	
^b Preference for add. working hours (h/day): m(s.d)	-0.44 (1.72)	0.02 (1.89)	-.***	-0.71 (1.69)	0.20 (1.79)	-.***
^a Preference for working hours: more (%)	11.97	18.49		7.24	20.01	***
Preference for working hours: equal (%)	58.34	60.18		57.33	64.31	
Preference for working hours: less (%)	29.69	21.32		35.43	15.68	
7. Partner interaction						
^b Partner's income (€/month): m(s.d)	na	na	na	1191.2 (812)	2588.5 (1237)	-.***
^b Partner's time spent on paid work (h/day): m(s.d)	na	na	na	1.79 (3.03)	3.33 (4.19)	-.***
^b Partner's time spent on errands (h/day): m(s.d)	na	na	na	2.83 (2.02)	1.56 (1.78)	+***
^b Partner's time spent on shopping (h/day): m(s.d)	na	na	na	0.91 (1.24)	0.71 (1.17)	+***

(continued on next page)

Table 1 (continued)

	Singles		Gender Gap	Partners		Gender gap
	Men	Women		Men	Women	
^b Partner's time spent on childcare (h/day): m(s.d)	na	na	na	0.73 (1.46)	0.35 (0.88)	+***
^b Partner's time spent on family care (h/day): m(s.d)	na	na	na	0.42 (0.80)	0.35 (0.75)	+***
^b Partner's time spent on leisure (h/day): m(s.d)	na	na	na	5.62 (2.82)	6.10 (3.23)	-.***
Number of Observations N (days)	3617	5754		7984	8074	
N (respondents)	1207	1919		2692	2692	

Note: Values in bold are significant: SD in parentheses; ^aChi-square independence test (χ^2), ^bgap (2-tailed *t*-test); gender gap (2-tailed *t*-test): + Men > Women; – Women > Men; Significance: *** *p* < 0.001, ** *p* < 0.01, * *p* < 0.05; na- Not applicable.

Table 2

Mean time spent on activities (h/day) and corresponding entropy (weighted average⁶).

Variables	Single		Gender gap (M-F)	Partners		Gender gap (M-F)
	Men	Women		Men	Women	
Number of observations N (days)	3617	5754		7984	8074	
N (respondents)	1207	1919		2692	2692	
1. Personal care (h/day)	10.82 (1.70)	11.06 (1.60)	-.***	10.80 (1.60)	11.09 (1.44)	-.***
Paid total (h/day)	3.65 (3.51)	2.74 (3.02)	+***	3.93 (3.55)	2.12 (2.59)	+***
2. Job: A (h/day)	3.24 (3.15)	2.43 (2.70)	+***	3.51 (3.20)	1.89 (2.33)	+***
3. Job: T (h/day)	0.40 (0.56)	0.31 (0.01)	+***	0.42 (0.58)	0.23 (0.35)	+***
Education total (h/day)	0.62 (1.74)	0.44 (1.39)	+***	0.04 (0.36)	0.06 (0.43)	-.**
4. Education: A (h/day)	0.53 (1.49)	0.38 (1.21)	+***	0.04 (0.33)	0.05 (0.36)	-.**
5. Education: T (h/day)	0.09 (0.34)	0.06 (0.27)	+***	0.01 (0.06)	0.01 (0.10)	-.***
Unpaid total (h/day)	2.15 (1.74)	3.65 (2.10)	-.***	2.96 (1.84)	4.92 (2.17)	-.***
6. Errands: A (h/day)	1.13 (1.18)	2.04 (1.46)	-.***	1.53 (1.34)	2.82 (1.53)	-.***
7. Errands: T (h/day)	0.01 (0.08)	0.02 (0.10)	-.**	0.02 (0.11)	0.02 (0.00)	+***
8. Shopping: A (h/day)	0.46 (0.54)	0.64 (0.57)	-.***	0.53 (0.59)	0.69 (0.58)	-.***
9. Shopping: T (h/day)	0.19 (0.32)	0.24 (0.30)	-.***	0.18 (0.28)	0.22 (0.27)	-.***
10. Childcare: A (h/day)	0.10 (0.41)	0.29 (0.81)	-.***	0.29 (0.62)	0.61 (1.16)	-.***
11. Childcare: T (h/day)	0.02 (0.08)	0.07 (0.21)	-.***	0.06 (0.17)	0.13 (0.29)	-.***
12. Family care: A (h/day)	0.24 (0.37)	0.33 (0.48)	-.***	0.33 (0.49)	0.41 (0.55)	-.***
13. Family care: T (h/day)	0.01 (0.06)	0.01 (0.08)	-.*	0.02 (0.10)	0.02 (0.09)	+***
Leisure total (h/day)	6.49 (2.56)	5.84 (2.27)	+***	5.99 (2.43)	5.54 (2.02)	+***
14. Voluntary: A (h/day)	0.27 (0.67)	0.27 (0.64)	–	0.32 (0.77)	0.29 (0.67)	+**
15. Voluntary: T (h/day)	0.05 (0.16)	0.07 (0.19)	-.***	0.07 (0.21)	0.06 (0.17)	+**
16. Social: A (h/day)	1.58 (1.41)	1.64 (1.25)	-.*	1.43 (1.23)	1.55 (1.20)	-.***
17. Social: T (h/day)	0.28 (0.45)	0.28 (0.42)	+	0.20 (0.37)	0.22 (0.38)	-.**
18. Hobby: A (h/day)	0.99 (1.30)	0.69 (0.87)	+***	0.77 (0.96)	0.68 (0.82)	+***
19. Hobby: T (h/day)	0.08 (0.19)	0.06 (0.16)	+***	0.06 (0.16)	0.06 (0.16)	–
20. Media use: A (h/day)	3.23 (2.06)	2.82 (1.72)	+***	3.12 (1.83)	2.68 (1.53)	+***
21. Media use: T (h/day)	0.00 (0.03)	0.00 (0.02)	+*	0.00 (0.00)	0.00 (0.00)	+
22. Unspec Travel (h/day)	0.27 (0.64)	0.27 (0.63)	–	0.28 (0.62)	0.28 (0.63)	–
Shanon's entropy	1.19 (0.19)	1.26 (0.18)	-.***	1.22 (0.19)	1.28 (0.18)	-.***

A activity, T travel.

Note: Values in bold are significant: SD in parentheses. Significance: *** *p* < 0.001, ** *p* < 0.01, * *p* < 0.05.

⁶ For weighted average for each respondent, we have calculated the number of hours spent on each activity on each day multiplied by respective weight of time spent on each day for each respondent (as mentioned in German time use diary) and divided by the sum of the weights of three days.

and (6) partner interactions.

3.3.1. Demographics

There are four variables for individual and household demographics: age group, gender, household type and the number of children. We categorised the direct information on age in five age groups from 20 to 30 to 60 and above. Gender was included as a dummy variable (Men = 0 and women = 1). The number of children was included as separate continuous variables according to the following age groups: day care (less than three), preschool (4–6), elementary school (7–10), middle/high school children (11–17), 18 and above.

3.3.2. Job/education

We used the direct information on personal monthly income for the analysis. For education, the converted variable ISCED available in the data combines the direct information of German school and professional education; this was classified into two subgroups for our analysis: low (primary to upper secondary) and high (post-secondary to secondary stage tertiary). The economic sector was classified into 21 categories which we summarised in three categories: industry, market and non-market, as described in Table 2. The direct information on working hours (from the personal questionnaire) was converted into the categorical variable working time, divided into four subgroups: part-time (less than 30 h/week), full-time (30–48 h/week), over-time (48 h and

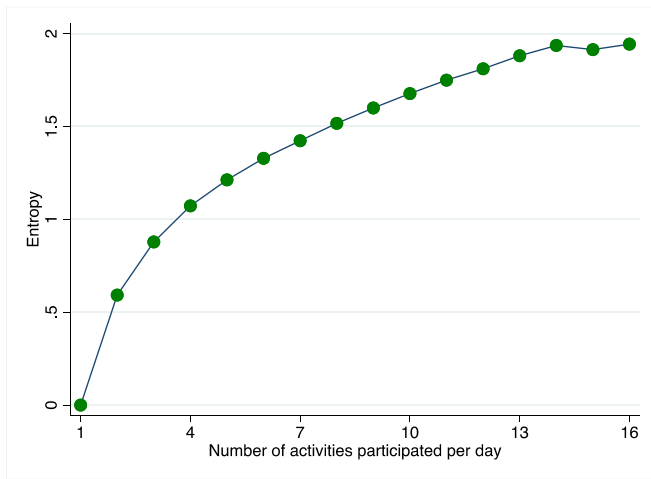


Fig. 1. Entropy vs. number of activities per day. Source: Authors' calculation from GTUS data.

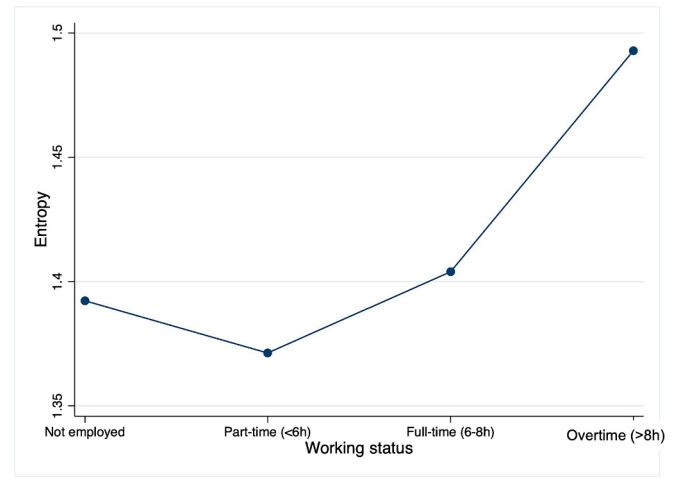


Fig. 4. Entropy vs. working status. Source: Authors' calculation from GTUS data.

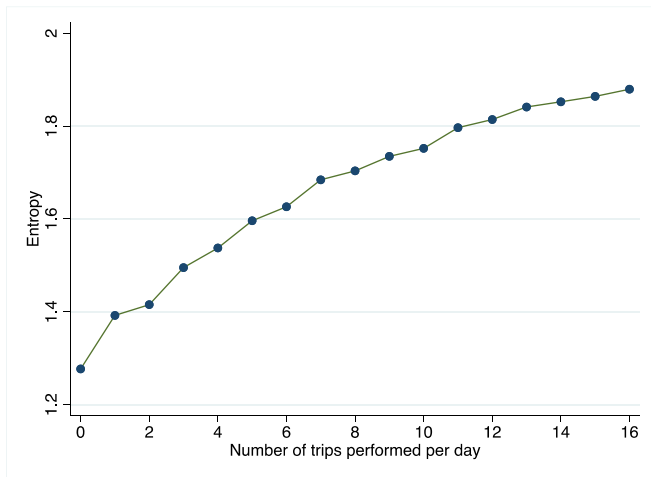


Fig. 2. Entropy vs. number of trips per day. Source: Authors' calculation from GTUS data.

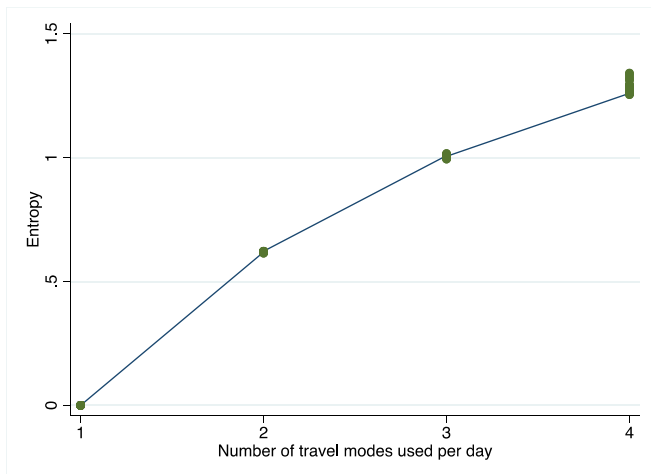


Fig. 3. Entropy vs. number of travel modes per day. Source: Authors' calculation from GTUS data.

above/week) and not employed. In addition, we created gender interaction variables for income and working time. We classified the work schedules with three dummy variables: fixed, flexible and free organisation (see Table 2 for details). Also, working in shifts was included as a dummy variable. We grouped the days of the week in weekdays (Monday-Friday) and weekend (Saturday-Sunday). Other job characteristics, such as working status and secondary jobs, were excluded due to the lack of significant effects.

3.3.3. Residential location

This include the level of urbanity and region. The level of urbanity, according to the Federal Agency for Building, Urban and Spatial Research (*Bundesamt für Bau-, Stadt- und Raumforschung, BBSR*) (BBSR, 2016), was classified into four categories in the data: large cities, semi-urban, semi-rural and rural (see Table 2 for details). Regions were classified into east and west Germany.

3.3.4. Travel behaviour

The travel characteristics include details on travel modes used and the number of trips. We converted the travel modes used on a day (yes/no) into four separate dummy variables: 1. car, motorbike, 2. public transport, 3. cycling, and 4. walking. Note that an individual may have used several modes on one day, i.e. the modes are not mutually exclusive. Also, we included the total number of trips per day. We counted trip stages rather than trips, as this arguably better captures complexity in trip making. Note that the average number of trip stages is low compared to travel surveys. This may be a result of missing mode information and/or underrepresentation of short trips due to the 10-min slots in the survey instrument. Other travel variables, such as commute distance (due to non-significance) and commute time (to avoid over-representation of its relationship with entropy), were excluded from the analysis.

3.3.5. Multitasking attributes

In the time use data, respondents were asked to report “what else they were doing during the episode”, which is coded as the secondary (multitasking) activity. We used such secondary tasks in two metric variables: time spent multitasking in paid work and time spent multitasking in unpaid work (hours per day, respectively). Also, we included gender interaction variables for both the variables.

3.3.6. Time use preferences

To explore time use preferences, we included two types: subjective feelings of preferred activity and the working hours preferred. The open question in the time use survey captures the subjective feelings of

respondents about one activity that they prefer to spend their time on. The preferred activities were grouped as personal care, job/education, unpaid, leisure and travel. If no such activity was mentioned, then it was grouped under none. This variable provides direct information about respondents' preferences for an activity.

Preference for additional working hours per day is the difference between the direct measurement of preferred working hours per day and actual working hours per day. A positive finding indicates a preference for more than actual working hours, and vice versa.⁴

3.3.7. Partner interactions

To explore partner effects, we included the variables that represent the partner's monetary resources and responsibilities such as partner's monthly income, partner's time spent on paid work (primary and secondary job) and partner's time spent on unpaid work (shopping, childcare, errands and leisure). We tested partner's income in various forms (categories, continuous scale) but finally excluded it due to its strong correlation with individual monthly income.

3.4. Analysis

We performed a descriptive analysis of the above variables to explore gender differences among single and partnered respondents. We tested the gender differences using independent sample t-tests and chi-square independence tests. As the complexity of activity patterns, measured using Shannon's Entropy is a continuous variable that ranges from 0 to 2 in our study, we employed a series of multilevel linear regression analysis to examine the association between entropy, i.e., the complexity of activity patterns, and the explanatory variables listed in Table 1.

As there are repeated observations (days) for each respondent, the regression analysis addressed the problem of clustering of measures and correlation of error by observation unit. As such, our sample structure allows for two level linear regression as the days are nested within respondents (clusters). We treated the personal identification number (id_persx) of the respondents as the clustering variable. In our model, the fixed effects were measured by the coefficients, while the random part of the model was estimated by variance. The coefficients (B) (i.e., the population average estimates) and the exponentiated coefficients (Exp (B)) (i.e. the percentage changes in the dependent variable for a one-unit change in explanatory variable) are reported. The intra-cluster correlation coefficient (ICC)⁵ (also known as variance partition coefficient (VPC)) denotes the percentage of the variance that lies between level-2 units, i.e., within days per person in our study. It is a measure of the variation at each level, indicating how much variation there is within each level and the value is commonly found to be between 0.05 and 0.25. It is recommended to use a multilevel model when the ICC exceeds 0.1. The likelihood-ratio test comparing the multilevel linear regression model with ordinary linear regression is provided and is highly significant for our models. This suggests that there is enough variability between respondents to favour multilevel model. In addition, we calculated the following statistics to assess the better fit model: statistics for all models (Akaike information criterion and Bayesian information criterion).

For comparison, we have estimated multiple linear regression with clustered robust regressions for the same sub samples. A comparison of the cluster-robust regressions with the two-level linear regression shows

⁴ There are other variables that reveal respondents' subjective feelings of time use satisfaction. These variables are about if they are satisfied or dissatisfied about time spent on activities: paid, unpaid, childcare, family. They are not significant, and the model does not improve. Hence, we excluded these variables.

⁵ Intra-cluster Correlation Coefficient (ICC) = (Between group Intercept variance / (Between group Intercept variance + Within group Residual variance)).

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 results are provided upon request. We have reported the R2 values from the multiple linear regressions in the Table 3.

We checked for multicollinearity among independent variables using the variance inflation factor (VIF). All independent variables included in the model fulfil the measurement criteria as the mean VIF values of all variables is 1.86 and maximum VIF is 5, which is less than the maximum threshold value of 10 (Hair et al., 2011). Also, an endogeneity test was performed by using instrumental variable regression to assess endogeneity of travel variables in the model. With the help of IVREG functions in Stata (Baum et al., 2015), we calculated a two-stage least square (2SLS) ($F = 1.37$, $p = 0.24$). The test results are non-significant, which confirms that the variables are exogenous. We conducted three quality tests (underidentification test, $p < 0.000$, weak identification test (critical values less than Cragg-Donald Wald F statistic: 78.165, and Sargan-Hansen test for over-identifying restrictions, $p = 0.83$) to confirm the appropriateness of the IVs for these estimations. The results validate the appropriateness of selected IVs.

For our analysis, we included three models: all, single and partnered respondents for the same sample to understand the interindividual difference and group differences (single vs. partners) in the association between the various factors and the complexity. Additionally, we included the partner variables for the partner models to examine if the partner's variables affect the complexity of individual activity patterns.

4. Results

4.1. Descriptive summary of the variables

Table 1 shows the descriptive summary of the variables used in the analysis. The mean and proportions of variables are presented separately for four groups: single men, single women, partnered men and partnered women.

Across the groups men have higher socioeconomic status than women: they earn more and work longer hours for pay. Partnered respondents have higher income than singles, but they also have a larger gender gap in monthly income (€1392 gap) than singles (€208 gap). Based on working time, men are more often full-time workers than women, while women are more often part-time workers than men. It is noteworthy that single women more often have full-time jobs than partnered women (31 % vs 16 %), while for men it is the other way round (52 % vs 47 %). Regarding economic sector, men are more or less equally distributed among industry, market and non-market sectors. However, women (across groups) predominantly work in the non-market sector, e.g. in health, education and public administration (about 55 %).

Women on average make more trips per day than men, with single women undertaking the most trips (2.7 trips per day) across the groups. In comparison to singles, partnered respondents drive more and travel less by other modes like public transport, cycling and walking. In case of driving and walking, partners have a significant gender gap, where men drive more than women (64 % vs 62 %), while women walk more than men (14 % vs 18 %). Single women do more cycling (10 % vs. 8 %) and walking (24 % vs 18 %) than single men.

With regards to multitasking, partnered respondents spend considerably more time on unpaid work than singles. The gender gap in multitasking is significant across the groups. Men spend more time on paid multitasking than women, i.e. performing the job and job-related activities as secondary activities. In contrast, women spend more time on unpaid multitasking than men, i.e. performing unpaid work such as household errands, shopping, childcare and family care as secondary activities.

Table 3
Regression models of entropy for all single and partnered respondents.

	(1) All		(2) Singles		(3) Partners	
	B	Exp. (β)	B	Exp. (β)	B	Exp. (β)
Demographic						
1. Age group (ref: 30–40)						
20–30	−0.057***	0.945	−0.056	0.945	0.011	1.011
40–50	0.001	1.001	0.005	1.005	−0.011	0.990
50–60	0.002	1.002	0.020*	1.020	−0.018*	0.982
60 and above	0.017*	1.017	0.038+	1.028	−0.000	1.010
2. Gender (ref: Men)						
Women	0.025**	1.025	0.023	1.024	0.025*	1.025
3. Number of children bet 0 and 3	0.024***	1.024	0.049***	1.050	0.019***	1.019
4. Number of children bet 3 and 6	0.012**	1.012	0.004	1.004	0.014**	1.014
5. Number of children bet 6 and 10	0.018***	1.019	0.025**	1.026	0.016***	1.016
6. Number of children bet 10 and 18	0.005*	1.005	0.007	1.007	0.005+	1.005
7. Number of children above 18	−0.001	0.999	0.004	1.004	0.001	1.001
Job /education						
8. Respondent's income (€/month)	−0.003	0.997	0.007	1.007	−0.006*	0.994
Respondent's income* Women	−0.007+	0.993	−0.010	0.990	0.012*	0.988
9. Education (ref. low)						
High vs. low	0.014***	1.014	0.004	1.004	0.021***	1.021
10. Economic sector (ref: industry)						
Market vs. industry	−0.003	0.997	−0.016+	0.984	0.006	1.006
Non-market vs. industry	0.018***	1.018	0.014	1.014	0.020***	1.021
11. Working time (ref: part-time)						
Full-time	−0.053***	0.950	−0.065***	0.937	−0.048***	0.953
Over-time	−0.080***	0.923	−0.079***	0.924	−0.081***	0.922
Unemployed	−0.038	0.962	0.046	1.047	−0.050	0.952
Full-time *Women	0.010	1.010	0.022	1.022	0.004	1.004
Over-time *Women	0.037*	1.037	0.026	1.026	0.053**	1.055
Unemployed *Women	0.023	1.023	−0.055	0.946	0.024	1.025
12. Working schedule (ref: Fixed Start-End time)						
Flexitime	0.015***	1.015	−0.022**	1.022	0.013*	1.013
Free time	0.005	1.005	0.008	1.008	0.002	1.002
13. Work in shifts (=yes)	0.007	1.007	−0.005	0.995	0.015*	1.015
14. Days of week(ref: weekdays -Mon-Fri)						
weekend- Sat-Sun	−0.054***	0.947	−0.060***	0.942	−0.056***	0.945
Residential location						
15. Urbanity (ref: urban)						
Semi-urban	0.010*	1.010	0.001	1.001	0.017**	1.017
Semi-rural	−0.007	0.993	−0.011	0.989	−0.003	0.997
Rural	−0.005	0.995	−0.001	0.999	−0.006	0.994
16. Region (ref: West)						
East	0.002	1.002	−0.014+	0.986	0.013*	1.013
Travel behaviour						
17. Travel by car = yes	0.070***	1.073	0.069***	1.072	0.069***	1.072
18. Travel by public transport = yes	0.037***	1.038	0.058***	1.060	0.013+	1.013
19. Travel by cycling = yes	0.048***	1.050	0.057***	1.060	0.044***	1.045
20. Travel by walking = yes	0.008+	1.008	0.008	1.008	0.007	1.007
21. Number of trips per day	0.043***	1.044	0.045***	1.046	0.042***	1.043
Multiasking behaviour						
22. Multitasking unpaid (h/day)	0.022***	1.023	0.028***	1.028	0.021***	1.021
Multitask unpaid*Women (h/day)	−0.009***	0.991	−0.010	0.990	−0.010**	0.990
23. Multitasking paid (h/day)	−0.029***	0.971	−0.006	0.994	−0.037***	0.964
Multitask paid*Women (h/day)	0.029***	1.029	0.004	1.004	0.043***	1.044
Time use preferences						
24. Wish to have more time for activities (ref: None)						
Personal care	0.002	1.002	−0.012	0.988	0.008	1.008
Paid work /education	0.010	1.010	0.044*	1.044	−0.039+	0.962
Unpaid work	0.020**	1.021	0.019	1.019	0.020*	1.021
Leisure	0.017***	1.017	0.019**	1.019	0.015***	1.015
Travel	0.011	1.011	0.059*	1.060	−0.013	0.987
25. Preference for additional work hours (h/day)	0.004*	1.004	0.007*	1.007	0.004+	1.004
Preference for add. work hours*Women (h/day)	0.000	1.000	−0.004	0.996	0.001	1.000
Partner interaction						

(continued on next page)

Table 3 (continued)

	(1) All		(2) Singles		(3) Partners	
	B	Exp. (β)	B	Exp. (β)	B	Exp. (β)
26. Partner's time spent on paid work (h/day)					0.001	1.001
27. Partner's time spent on errands (h/day)					-0.000	0.100
28. Partner's time spent on shopping (h/day)					0.011***	1.011
29. Partner's time spent on childcare (h/day)					0.001	1.001
30. Partner's time spent on family care(h/day)					0.015***	1.015
31. Partners time spent on leisure (h/day)					0.003***	1.003
Constant	1.26***	3.51	1.25***	3.49	1.23***	3.43
Var (cons[id_persx])(Between group variance)	0.073	0.007	0.007	0.007	0.007	0.007
Var ([e.entropy]) (Within residual variance)	0.026	0.027	0.029	0.029	0.025	0.025
ICC	0.21		0.20		0.21	
Adj. R2 (from Multiple linear regression)	37.3 %		36.9 %		38.8 %	
AIC	-8836.723		-2803.919		-6100.517	
BIC	-8481.736		-2494.943		-5724.082	
N (diary days)	25,429		9371		16,058	
N (respondents)	8480		3126		5354	

Note: Values in bold are significant. Significance: *** p < 0.001, ** p < 0.01, * p < 0.05, It is to be noted that exponentiated coefficient (Exp (B)) values are smaller than 1 if coefficient (B) is negative and vice versa.

Preferred working hours show that more than half of Men and women respondents are satisfied with their actual working hours (singles: M: 58 % and F: 60 %; partners: M: 57 % and F: 64 %). We also observe that women would prefer to work additional hours more than men (for singles 12 % versus 19 %; for partners 7 % vs 20 %), while men would prefer to reduce working hours more than women (for singles 30 % vs 21 %; for partners 35 % vs 16 %). In absolute terms, partnered men want reduced working hours (-0.71 h/day on average), while partnered women desire additional working hours (0.20 h/day), suggesting a transition towards more equality in activity patterns, even more so for men than for women.

The preferred activity shows that nearly half of the respondents did not report any activity across the groups. Within reported activities, it is observed that both men and women would prefer to spend more time on leisure, and women dominate men in both the groups. Also, both partnered men and women equally wish to spend more time on unpaid work (6 % vs 7 %, singles: 3 % vs. 7 %).

As expected, the partners of Men respondents have less income, lower working and leisure hours, and they spend more time on unpaid work (errands, shopping, childcare and family care) and leisure activities than the partners of women respondents.

4.2. Mean time spent on daily activities-single versus partnered respondents

Table 2 reports the mean time spent on activities throughout the day. The activities are grouped in four main categories: personal care (eating, sleeping, personal care), productive (job or paid work, education), unpaid work (errands, shopping, child and family care) and leisure (voluntary, social, hobby, media).

In both the groups, women on average spend more time on personal and unpaid work activities than men, while men spend more time on productive and leisure-based activities than women, which is in line with many research findings (Wallace and Young, 2010; Krantz-Kent, 2009).

Both men and women exhibit traditional labour characteristics where men mostly work longer hours, while women spend more time on unpaid care work, errands and shopping (for more details, see Chidambaram and Scheiner, 2020). Within leisure subgroups, men undertake more voluntary work, hobbies and media use than women, while

women do more social activities than men, which is in line with many studies in the German context (Foster and Walker, 2013; Jonsson et al., 2020; Boll and Leppin, 2011).

Between groups,⁶ we can see that the partnered respondents spend more time on unpaid work and less time on education and leisure than single respondents. This is because partnered respondents offset some of their free time for work and family, as suggested by recent studies (Adams and Golsch, 2021; Craig and Churchill, 2020) and because singles include many young people (trainees, students). Also, it can be noted that the time spent on errands, shopping, family care and childcare is substantially increased for partners compared to singles. The time spent on childcare increases the overall time spent on unpaid work for partnered women. On average, they spend nearly five hours every day on housework including raising children and housekeeping, while partnered men spend slightly closer to three hours a day on the same activities, which is in line with Haberkern (2007) and Schulz and Blossfeld (2006).

In summary, the results suggest that the gender gap is strong and significant for both single and partnered respondents in all activities. Such a gap does not primarily lie in the number of different activities which people pursue, but in the distribution of time spent on different activities, as pointed out by Scheiner (2014). As such, the complex measure of activity patterns shows that women have slightly higher entropy than men. Compared to single women, the activity patterns of married women revolve around spouse, children, family and job. What is more, partnered men are also more engaged with work and family obligations such as childcare and family care activities than single men. In contrast, single men spend more time on improving their qualifications through education-related activities and discretionary activities such as social connections, voluntary activities and media usage (presumably due to age effects). To better understand the variation in complexity between men and women with respect to diverse factors, we discuss the results of a series of regression models in the following section.

4.3. Regression analysis

Table 3 shows three models that estimate entropy, with an adjusted R2 range from 0.369 to 0.388.

The row labeled var(e.entropy) denotes the estimated variance of the level one errors, also called residuals (ranges from 0.025 to 0.029).

⁶ These inter-group comparisons between singles and partnered respondents are based on our descriptive inspection.

Regarding AIC and BIC values, the lower values (more negative) are better and denotes the model is less complex. The intraclass correlation (ICC = 0.21) denotes that 21 % of the total variance occurred at the group level (respondents) and justifies the adoption of multilevel model. The model for partnered respondents fits the data somewhat better than that for singles (higher adjusted R², lower residuals and lower AIC and BIC values), indicating the usefulness of considering the partner interactions.

4.3.1. Interindividual differences – all respondents

Here, we discuss how the factors associated with complexity among all respondents (see Table 3, model 1). Important findings are discussed below.

Being women and having young children results in higher entropy, which is in line with the findings of Scheiner and Holz-Rau (2017) (also in line with H1). The negative effect of young age respondents (20–30) on entropy suggests that younger people have lower complexities than the middle-aged group. However, the oldest group (60+) has the highest complexity, which does not match H1.

Higher education, working in the non-market sector and flexitime working schedules positively affect entropy. Full time (or overtime) working has a more negative effect on men's entropy than on women's (in line with H2). This suggests that men with long working long hours are time-constrained when it comes to non-work activities, as suggested by Williams and Boushey (2012) and Scheiner and Holz-Rau (2017). The combination of these findings suggests that working type is linked to control in organising family and employment, which further increases individual complexity.

At weekends individuals have lower entropy than on weekdays. This finding suggests that on weekdays individuals perform a balanced mix of activities, while at the weekends they mostly take part in non-work/educational activities, as pointed out by Ho and Mulley (2013).

Living in semi-urban areas increases an individual's entropy compared to those living in urban areas (in line with H3). This finding partly contradicts the findings of Scheiner and Holz-Rau (2017), who suggest that an increase in municipality size increases the entropy. Apparently, the findings imply that polycentric suburban centres with fairly accessible transport systems, and the forced mobility and active lifestyle necessary to meet daily needs could jointly increase the complexity of suburban dwellers. For other residential variables, we found no significant relationship with complexity. Perhaps, this could be due to the lack of information on geocodes or postal codes of residence in our data. Such information would permit to link the data to rich information on the geographical and social environment.

The travel attributes such as number of trips and daily travel modes considerably increase individuals' entropy, driving being the highest among travel modes (in line with H4). These findings suggest that driving increases participation in out-of-home activities and hence increases complexity, as suggested by recent studies (Susilo et al., 2019; Matz et al., 2015; Scheiner, 2014; Chen et al., 2011). However, reverse causality may also be true because the association does not clarify whether travelling leads to the juggling of more activities or the high entropy positively affects the travel behaviour. It is noteworthy that the use of all modes (except walking) is associated with higher entropy, suggesting that more complex activity schedules are associated with the use of multiple modes (i.e. multimodal behaviour).

Both paid and unpaid multitasking variables are significantly associated with entropy, but in different directions. The time spent on paid multitasking decreases men's but not women's entropy, while the time spent on unpaid multitasking more strongly increases men's entropy than women's (partly in line with H5). Perhaps this association hints that performing dissimilar tasks concurrently increases the complexity.

Regarding the time use preferences, individuals who desire to spend more time on unpaid work, leisure and prefer to work for additional hours have higher entropy levels than those without a preference for any activity (in line with H6 and H7). This finding suggests that individuals

who enjoy performing unpaid work or leisure activities or aim to spend more time on their jobs, exhibit complex ways of life.

4.3.2. Group differences-single versus partners

We discuss the important differences between single and partnered respondents (see Table 3 for model 2 and model 3).

Compared to the middle-aged group, older singles show more entropy, while partners do not (partners aged 50–60 even show less entropy). Personal income is negatively related to complexity for partners but not for singles, for partnered women even more so. An increase in the level of education increases the entropy, but only for partners. For singles, working in the market sector strongly decreases the entropy, while working in the non-market sector increases the entropy for partners.

Working in shift and flexible working arrangement is positively associated with complexity for partners, while for singles it is negatively associated. Living in a semi-urban settlement (versus urban) positively determines the activity pattern entropy of the partnered respondents. There is an interesting divergence between East and West Germany. Living in East Germany reduces complexity for singles, but increases complexity for partners. Perhaps this difference lies in the fact that an egalitarian household pattern prevails in the East German regions, while western couples still tend to follow a more traditional division of labour (Cooke, 2006). Performing unpaid multitasking is positively associated with the entropy of both single and partnered men. Conversely, paid multitasking is positively associated with partnered women (contradicts H5). Perhaps this indicates the partnered women (multitasking paid work) and partnered men (multitasking unpaid work) are more likely to experience complex activity schedules to balance both work and family demands. The desire to spend time on unpaid and leisure activities is positively correlated with complexity of partnered (also single) respondents, while a preference for job activity is negatively associated with complexity for partners (in line with H6) but this is the opposite to single respondents (contradicts H6). A preference for additional working hours has a positive association with complexity in both groups. Partners' work sharing positively influences individuals' entropy. In particular, partners' time spent on shopping, family care (contradicts H8) and leisure (in line with H8) has significant positive relationships with individuals' entropy. This suggests the idea that a partner's work sharing in job, household and family care roles is highly associated with the individual's complex lifestyle.

5. Conclusion

Using the GTUS data, the study has explored the complexity of activity patterns of all, single and partnered respondents. The interindividual differences reveal that individuals' activity pattern complexity is positively associated with factors such as being women, belonging to the oldest group, the presence of young children, high education levels, flexitime work schedules, semi-urban areas, daily trips and daily travel modes (except walking), unpaid multitasking and a preference for unpaid or leisure activities. In contrast, high incomes and working longer negatively affect complexity. Between groups (single versus partnered respondents), the effects are more similar than different. However, some variables (age, personal income, region, respondents' partners time spent on unpaid work) explain the complexities differently for partnered than for single respondents.

- A positive association between a preference for unpaid work and entropy represents the link between activity preference and activity participation for partnered respondents. For instance, partnered women's time use shows a predominant share in unpaid work, mainly childcare and escorting, and less time spent on physical development such as hobbies and sports, and they have the (relatively) highest entropy across groups.

- From a quality of life perspective, unpaid domestic work involves work carried out for oneself and for other members of the household, which contributes to both individual and family well-being (Duran, 2015). In this context, many studies have demonstrated that married women have higher life (also job) satisfaction than single women as they balance work, family and leisure (Potarca and Bernardi, 2020; Georgellis and Lange, 2007). All these results point to partnered women (predominantly working mothers), as efficient organisers in scheduling complex activities and trips, as pointed out by many researchers (Susilo et al., 2019; Scheiner and Holz-Rau, 2017; Paletti et al., 2012).
- Importantly for this research, intra-household work sharing of unpaid and paid work allows the individual to organise and take part in activities, i.e. an equal share of paid, unpaid and recreation activities.
- The gender interaction variables reveal egalitarian intra-household relations. For instance, women's activity patterns (also men's) are becoming less complex with the increase in economic autonomy and increased bargaining power (e.g. income, working hours).
- Men's (or women's) activity patterns are increasingly complex with an increase in time spent on unpaid (or paid) multitasking. Also, partnered men on average wish to scale down their working hours while, in contrast, partnered women wish to increase their working hours. Equally, men want to spend more time on unpaid work (relatively near to partnered women's preferences for unpaid work). Specifically, some fathers wish to engage in an active fathering role when the child becomes older or when the number of children increases (Reimer, 2017).

From a policy perspective, the transition in women's labour status in Germany can be partly attributed to welfare and labour market policies that foster gender fairness and work-family integration. Such policies include the parental leave policy (introduced in 2007), which allows new parents to stay home for up to three years; monetary incentives for new parents (*Elterngeld*, *Erziehungsgeld*, see Blum et al., 2016); the Act to Support Children (of 2008) providing day care facilities for children below the age of three; and employment and social security to enable paid work beyond retirement for older groups. All these policies not only enable women to re-enter (or balance) work after a maternity break, but also allow fathers to spend time with children as 'daddy months' and older people to engage in paid voluntary activities. Also, these policies support inclusive opportunities beyond economics (Hank and Erlinghagen, 2009; McBride, 2006). The partnered men hold gender-egalitarian views on working hours, but their share in the unpaid workload reveals gender-traditional behaviour, as pointed out by Olah and Gahler (2014). This is because, in certain areas, Germany still adheres to the conservative welfare regime and abides by cultural and social norms (e.g. joint taxation system, restrictions in opening hours/ places available in childcare facilities which penalise married women) (Bergmann et al., 2019). The differences in wages, taxes and insurance system negatively impact women's economic strength, especially within the gender-traditional couple.

Considering transportation aspects, this study provides valuable insights into developing sustainable and effective transport policies. Our study emphasizes the need to move away from traditional transportation policies that prioritize pricing and subsidies towards gender-sensitive policies that address complex work-family dynamics within different subgroups of men and women, such as career women or working mothers, households with young children. This includes measures like promoting flexible work hours, urban form policies, and sustainable mobility options. Moreover, our research has identified new avenues for future research to better understand the intersection of gender, activity complexity, and travel patterns.

Our study has some limitations. First, the complexity of activity patterns provides insight into participation in and sharing of primary activities but does not cover secondary activities. Our results show that

these are strongly linked to complexity of activity patterns, but we cannot determine the direction of causality in effects. Second, methodologically the regression analysis cannot control for unmeasured factors (other mobility attributes, better representations of time-use preference), we could not be sure if the associations are influenced by third variables. For example, we were unable to examine how other dimensions of identity than those available in the data, such as non-binary gender, race/ethnicity, and physical/emotional disabilities, may impact the complexity of activity patterns. Third, there can be little doubt that a preference to spend more time on unpaid work or leisure activities positively affects the complexity of activity patterns. It remains possible that other unmeasured personal and social circumstances beyond the scope of this study may interact with time use on preferences. Fourth, although a negative link has been found between multitasking and contaminated leisure on the one hand, and quality of life – in terms of psychological distress, negative emotions and feeling rushed – on the other (Craig and Lyn, 2017; Offer and Schneider, 2011), the links between complexity in daily life and quality of life may be more ambiguous, as very low levels of complexity may well be linked to boredom and underchallenging. Finally, the data collection for our study was conducted approximately ten years prior; we would have preferred more recent data. Nevertheless, social change happens gradually, and we consider that the transformation of gender relations in Germany in past decades was primarily in the years following the turn of the millennium when women increasingly entered the workforce. We leave these limitations as suggestions for future research in exploring the complexity of activity patterns.

CRediT authorship contribution statement

Bhuvanachithra Chidambaram: Conceptualization, Methodology, Software, Validation, Formal analysis, Writing – original draft, Writing – review & editing. **Joachim Scheiner:** Writing – review & editing, Supervision, Resources.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share data.

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References

- Abendroth, A.K., Pausch, S., 2018. German fathers and their preferences for shorter working hours for family reasons. *Community Work Fam.* 21, 463–481. <https://doi.org/10.1080/13668803.2017.1356805>.
- Adams, A., Golsch, K., 2021. Gender-specific patterns and determinants of spillover between work and family: the role of partner support in dual-earner couples. *J. Family Res.* <https://doi.org/10.20377/jfr-373>.
- Aguiar, M., Hurst, E., 2007. Measuring trends in leisure: the allocation of time over five decades. *Q. J. Econ.* 122, 969–1006. <https://doi.org/10.1162/qjec.122.3.969>.
- Alexander, B., Hubers, C., Schwanen, T., Dijst, M., Ettema, D., 2011. Anything, anywhere, anytime? Developing indicators to assess the spatial and temporal fragmentation of activities. *Environ. Plann. B Plann. Des.* 38, 678–705. <https://doi.org/10.1068/b35132>.

- Altintas, E., Sullivan, O., 2016. Fifty years of change updated: cross-national gender convergence in housework. *Demogr. Res.* 35, 455–470. <https://doi.org/10.4054/DemRes.2016.35.16>.
- Baum, C., Schaffer, M., Stillman, S., 2015. IVREG210: stata module for extended instrumental variables/2SLS and GMM estimation (v10). *Statistical Software Components*.
- Baxter, J., 1992. Power attitudes and time: the domestic division of labour. *J. Comp. Fam. Stud.* 23, 165–182. <https://doi.org/10.3138/jcfs.23.2.165>.
- BBSR [Bundesinstitut für Bau- Stadt- und Raumforschung], 2016. Laufende Raumbearbeitung- Raumabgrenzungen-Siedlungsstrukturelle Kreistypen.
- Beckmann, P., Rehbein, F., Seidel, M., Mölle, T., 2014. Media protect – a programme targeting parents to prevent children’s problematic use of screen media. *J. Children’s Services* 9, 207–219. <https://doi.org/10.1108/JCS-10-2013-0036>.
- Bergmann, N., Scheele, A., Sorger, C., 2019. Variations of the same? A sectoral analysis of the gender pay gap in Germany and Austria. *Gen. Work. Organ.* 26, 668–687. <https://doi.org/10.1111/gwao.12299>.
- Bianchi, S.M., Robinson, J.P., Millie, M.A., 2006. *Changing Rhythms of American Family Life*. The Russell Sage Foundation.
- Birch, E., Le, A., Miller, P.W., 2009. *Household Divisions of Labour: Teamwork, Gender and Time*. Springer.
- Blum, S., Erler, D., Reimer, T., 2016. Germany country note. *Int. Rev. Leave Policies Res.* 2.
- B.M.F.S.F.J. [Bundesministerium für Familie, Senioren, Frauen und Jugend Referat Öffentlichkeitsarbeit], 2015. *Trends. Publikationsversand der Bundesregierung, Benefits, Effects*.
- Boll, C., Leppin, J., 2011. *Zeitverwendung von Eltern auf Familie und Beruf im internationalen Vergleich. Hamburgisches Weltwirtschafts Institut*.
- Cao, H., Lee, C.-J., Iqbal, S., Czerwinski, M., Wong, P., Rintel, S., Hecht, B., Teevan, J., Yang, L., 2021. Large scale analysis of multitasking behavior during remote meetings. <https://doi.org/10.48550/arxiv.2101.11865>.
- Carson, V., Adamo, K., Rhodes, R.E., 2018. Associations of parenthood with physical activity, sedentary behavior, and sleep. *Am. J. Health Behav.* 42, 80–89. <https://doi.org/10.5993/AJHB.42.3.8>.
- Chen, J., Shaw, S.-L., Yu, H., Lu, F., Chai, Y., Jia, Q., 2011. Exploratory data analysis of activity diary data: a space-time GIS approach. *J. Transp. Geogr.* 19, 394–404. <https://doi.org/10.1016/j.jtrangeo.2010.11.002>.
- Cherchye, L., De Rock, B., Vermeulen, F., 2012. Married with children: a collective labor supply model with detailed time use and intrahousehold expenditure information. *Am. Econ. Rev.* 102, 3377–3405. <https://doi.org/10.1257/aer.102.7.3377>.
- Chidambaram, B., Scheiner, J., 2020. Understanding relative commuting within dual-earner couples in Germany. *Transp. Res. Part A Policy Pract* 134, 113–129. <https://doi.org/10.1016/j.tra.2020.02.006>.
- Chidambaram, B., Scheiner, J., 2021. Leisure quality among german parents—exploring urbanity, mobility, and Partner Interaction as determinants. *Sustainability* 13. <https://doi.org/10.3390/su13115883>.
- Cooke, L.P., 2006. Preferences, and patriarchy: the division of domestic labor in East Germany, West Germany, and the United States. *Soc. Polit.* 13, 117–143. <https://doi.org/10.1093/sp/jxj005>.
- Craig, L., Churchill, B., 2020. Dual-earner parent couples’ work and care during COVID-19. *Gen. Work. Organ.* <https://doi.org/10.1111/gwao.12497>.
- Craig, L., Jenkins, B., 2016. The composition of parents’ and grandparents’ child-care time: gender and generational patterns in activity, multi-tasking and co-presence. *Ageing Soc.* 36, 785–810. <https://doi.org/10.1017/S0144686X14001548>.
- Craig, J.E., Lyn, B., 2017. Feeling rushed: gendered time quality, work hours, nonstandard work schedules, and spousal crossover. *J. Marriage Fam.* 79, 225–242. <https://doi.org/10.1111/jomf.12320>.
- Crane, R., 2007. Is there a quiet revolution in women’s travel? Revisiting the gender gap in commuting. *J. Am. Plann. Assoc.* 73, 298–316. <https://doi.org/10.1080/01944360708977979>.
- Dharmawijoyo, D.B.E., Susilo, Y.O., Karlström, A., 2018. On complexity and variability of individuals’ discretionary activities. *Transportation* 45, 177–204. <https://doi.org/10.1007/s11116-016-9731-5>.
- Diepen, A.M.L., Musterd, S., 2009. Lifestyles and the city: connecting daily life to urbanity. *J. Hous. Built Environ.* 24, 331–345. <https://doi.org/10.1007/s10901-009-9150-4>.
- Duran, M.-A., 2015. The contribution of unpaid work to global wellbeing. In: Glatzer, W., Camfield, L., Møller, V., Rojas, M. (Eds.), *Global Handbook of Quality of Life: Exploration of Well-Being of Nations and Continents*, International Handbooks of Quality-of-Life. Springer, Netherlands, Dordrecht, pp. 381–411. https://doi.org/10.1007/978-94-017-9178-6_16.
- Ekert-Jaffé, O., 2011. Are the real time costs of children equally shared by mothers and fathers? *Soc. Indic. Res.* 101, 243–247. <https://doi.org/10.1007/s11205-010-9642-3>.
- Erlandsson, L.K., 2006. Levels of complexity in patterns of daily occupations: relationship to women’s well-being. *J. Occup. Sci.* 13, 27–36. <https://doi.org/10.1080/14427591.2006.9686568>.
- Ferrari, A.R., 2021. The invisibility of women’s unpaid work in gender policies. *Policy Perspectives*. <https://doi.org/10.4079/pp.v28i0.4>.
- Forschungsdatenzentren (FDZ), 2013. *der Statischen Ämter des Bundes und der Länder Zeitverwendungserhebung 2012/2013*.
- Foster, L., Walker, A., 2013. Gender and active ageing in Europe. *Eur. J. Ageing*. <https://doi.org/10.1007/s10433-013-0261-0>.
- Georgellis, Y., Lange, T., 2007. Participation in continuous, on-the-job training and the impact on job satisfaction: longitudinal evidence from the German labour market. *Int. J. Hum. Resour. Manag.* 18, 969–985. <https://doi.org/10.1080/09585190701321112>.
- Gershuny, J., Kan, M.Y., 2012. Half-way to gender equality in work? Evidence from the multinational time use study, in: Scott, J., Dex, S., Plagnol, A. (Eds.), *Gendered Lives: Gender Inequalities in Production and Reproduction*. pp. 74–94.
- Grunow, D., Schulz, F., Blossfeld, H.-P., 2012. What determines change in the division of housework over the course of marriage? *Int. Sociol.* 27, 289–307. <https://doi.org/10.1177/0268580911423056>.
- Haberern, K., 2007. *Zeitverwendung und arbeitsteilung in Paarhaushalten. Zeitschrift Für Familienforschung* 19, 159–185.
- Hafezi, M.H., Liu, L., Millward, H., 2019. A time-use activity-pattern recognition model for activity-based travel demand modeling. *Transportation* 46, 1369–1394. <https://doi.org/10.1007/s11116-017-9840-9>.
- Hair, J.F., Ringle, C.M., Sarstedt, M., 2011. Partial least squares (PLS): indeed a silver bullet. *J. Mark. Theory Pract.* 19, 139–151. <https://doi.org/10.2753/MTP1069-6679190202>.
- Hank, K., Erlinghagen, M., 2009. Volunteering in “old” Europe: patterns, potentials, limitations. *J. Appl. Gerontol.* <https://doi.org/10.1177/0733464809333884>.
- Hasnine, M.S., Nurul Habib, K., 2021. Tour-based mode choice modelling as the core of an activity-based travel demand modelling framework: a review of state-of-the-art. *Transp. Res.* 41, 5–26.
- Ho, C., Mulley, C., 2013. Tour-based mode choice of joint household travel patterns on weekend and weekday. *Transportation. Amst.* 40, 789–811. <https://doi.org/10.1007/s11116-013-9479-0>, 10.1016/j.cities.2022.103720.
- Jakubec, S.L., Olfert, M., Choi, L.L.S., Dawe, N., Sheehan, D., 2019. Understanding belonging and community connection for seniors living in the suburbs. *Urban Plan.* 4, 43–52.
- Ji, Y., Liu, Y., Liu, Q., He, B., Cao, Y., 2018. How household roles influence individuals’ travel mode choice under intra-household interactions? *KSCIE J. Civ. Eng.* 22, 4635–4644. <https://doi.org/10.1007/s12205-018-1821-9>.
- Jonsson, K.R., Oberg, G., Samkange-Zeeb, F., Adjei, N.K., 2020. Determinants and Impact of Role-Related Time Use Allocation on Self-Reported Health among Married Men and Women: A Cross-National Comparative Study. <https://doi.org/10.21203/rs.3.rs-15606/v1>.
- Kamp Dush, C.M., Yavorsky, J.E., Schoppe-Sullivan, S.J., 2018. What are men doing while women perform extra unpaid labor? Leisure and specialization at the transitions to parenthood. *Sex Roles* 78, 715–730. <https://doi.org/10.1007/s11199-017-0841-0>.
- Krantz-Kent, R., 2009. *Measuring time spent in unpaid household work: results from the American time use survey. Monthly Lab. Rev.* 132, 46–59.
- Lai, X., Lam, W.H.K., Su, J., Fu, H., 2019. Modelling intra-household interactions in time-use and activity patterns of retired and dual-earner couples. *Transp. Res. A Policy Pract.* 126, 172–194. <https://doi.org/10.1016/j.tra.2019.05.007>.
- Matz, C.J., Stieb, D.M., Brion, O., 2015. Urban-rural differences in daily time-activity patterns, occupational activity and housing characteristics. *Environ. Health* 14, 88. <https://doi.org/10.1186/s12940-015-0075-y>.
- McBride, A.M., 2006. Civic engagement, older adults, and inclusion. *Generations* 30, 66–71.
- Millward, H., Hafezi, M.H., Daisy, N.S., 2019. Activity travel of population segments grouped by daily time-use: GPS tracking in Halifax, Canada. *Travel Behav. Soc.* 16, 161–170. <https://doi.org/10.1016/j.tbs.2019.05.005>.
- Nally, S., Ridgers, N.D., Gallagher, A.M., Murphy, M.H., Salmon, J., Carlin, A., 2022. “When you move you have fun”: perceived barriers, and facilitators of physical activity from a child’s perspective. *Front. Sports Active Living*. <https://doi.org/10.3389/fspor.2022.789259>.
- Nayak, S., Pandit, D., 2022. A critical review of activity participation decision: a key component of activity-based travel demand models. *Int. J. Urban Sci.* 1–34.
- Oakil, A.T.M., Ettema, D., Arentze, T., Timmermans, H., 2014. Changing household car ownership level and life cycle events: an action in anticipation or an action on occurrence. *Transportation* 41, 889–904. <https://doi.org/10.1007/s11116-013-9507-0>.
- Offer, S., Schneider, B., 2011. Revisiting the gender gap in time-use patterns: multitasking and well-being among mothers and fathers in dual-earner families. *Am. Sociol. Rev.* 76, 809–833. <https://doi.org/10.1177/0003122411425170>.
- Olah, L.S., Gahler, M., 2014. Gender equality perceptions, division of paid and unpaid work, and partnership dissolution in Sweden. *Soc. Forces* 93, 571–594. <https://doi.org/10.1093/sf/sou066>.
- Paleti, R., Pendyala, R.M., Bhat, C.R., Konduri, K.C., 2012. Joint Tour-Based Model of Tour Complexity, Passenger Accompaniment, Vehicle Type Choice, and Tour Length.
- Patchett, H., 2022. Who Cares? The Gendered Distribution of Unpaid Care Work in Jordan. <https://doi.org/10.21201/2022.9493>.
- Pollmann-Schult, M., 2011. Marriage and earnings: why do Married men earn more than single men? *Eur. Sociol. Rev.* 27, 147–163. <https://doi.org/10.1093/esr/jcp065>.
- Potarca, G., Bernardi, L., 2020. The Inter-marriage life Satisfaction premium. *J. Happiness Stud.* <https://doi.org/10.1007/s10902-020-00278-w>.
- Radcliffe, L., Cassell, C., 2014. Flexible working, work-family conflict, and maternal gatekeeping: the daily experiences of dual-earner couples. *J. Occup. Organ. Psychol.* <https://doi.org/10.1111/joop.12100>.
- Reimer, T., 2017. Measuring German fathers’ involvement in childcare. *Men Masculinities* 20, 588–608. <https://doi.org/10.1177/1097184X17728318>.
- Rovira, Y.L., Imani, A.F., Sivakumar, A., Pawlak, J., 2022. Do in-home and virtual activities impact out-of-home activity participation? Investigating end-user activity behaviour and time use for residential energy applications. *Energ. Build.* 257, 111764.
- Sani, G.M.D., Treas, J., 2016. Educational gradients in parents’ child-care time across countries, 1965–2012. *J. Marriage Fam.* 78, 1083–1096. <https://doi.org/10.1111/jomf.12305>.

- Sayer, L.C., 2010. Trends in housework. In: Treas, J., Drobnic, S. (Eds.), *Dividing the Domestic: Men, Women and Household Work in Cross-National Perspective*. Stanford University Press, pp. 19–38.
- Sayer, L.C., Freedman, V.A., Bianchi, S.M., 2016. Chapter 8 - gender, time use, and aging. In: George, L.K., Ferraro, K.F. (Eds.), *Handbook of Aging and the Social Sciences*. Academic Press, San Diego, pp. 163–180. <https://doi.org/10.1016/B978-0-12-417235-7.00008-1>.
- Scheiner, J., 2010. Social inequalities in travel behaviour: trip distances in the context of residential self-selection and lifestyles. *J. Transport Geogr.* 18, 679–690. <https://doi.org/10.1016/j.jtrangeo.2009.09.002>.
- Scheiner, J., 2014. The gendered complexity of daily life: effects of life-course events on changes in activity entropy and tour complexity over time. *Travel Behav. Soc.* 1, 91–105. <https://doi.org/10.1016/j.tbs.2014.04.001>.
- Scheiner, J., 2020. Changes in travel mode use over the life course with partner interactions in couple households. *Transp. Res. A Policy Pract.* 132, 791–807. <https://doi.org/10.1016/j.tra.2019.12.031>.
- Scheiner, J., Holz-Rau, C., 2017. Women's complex daily lives: a gendered look at trip chaining and activity pattern entropy in Germany. *Transportation* 44, 117–138. <https://doi.org/10.1007/s11116-015-9627-9>.
- Schieman, S., Young, M., 2015. Who engages in work-family multitasking? A study of Canadian and American workers. *Soc. Indic. Res.* 120, 741–767. <https://doi.org/10.1007/s11205-014-0609-7>.
- Schulz, F., Blossfeld, H.P., 2006. Wie verändert sich die häusliche arbeitsteilung im ehverlauf? *Koelner Z.soziol.u.soz.psychol* 58, 23–49. <https://doi.org/10.1007/s11575-006-0002-0>.
- Seabra, D.M.S., Azzoni, C.R., 2022. Social norms and commuting-to-work time of straight and gay couples in Brazilian metropolitan areas. *Cities* 127, 103720.
- Sharmeen, F., Arentze, T., Timmermans, H., 2014. An analysis of the dynamics of activity and travel needs in response to social network evolution and life-cycle events: a structural equation model. *Transp. Res. A Policy Pract.* 59, 159–171. <https://doi.org/10.1016/j.tra.2013.11.006>.
- Smart, M.J., Brown, A., Taylor, B.D., 2017. Sex or sexuality? Exploring household labor and travel among gay, lesbian, and straight households. *Travel Behav. Soc.* 6, 75–82.
- Stratton, L.S., 2012. The role of preferences and opportunity costs in determining the time allocated to housework. *Am. Econ. Rev.* 102, 606–611. <https://doi.org/10.1257/aer.102.3.606>.
- Sullivan, O., Gershuny, J., 2013. Domestic outsourcing and multitasking: how much do they really contribute? *Soc. Sci. Res.* 42, 1311–1324. <https://doi.org/10.1016/j.ssresearch.2013.05.004>.
- Susilo, Y.O., Kitamura, R., 2005. Analysis of day-to-day Variability in an individual's action space: exploration of 6-week mobidrive travel diary data. *Transp. Res. Rec.* 124–133 <https://doi.org/10.1177/036119810519015>.
- Susilo, Y.O., Liu, C., Börjesson, M., 2019. The changes of activity-travel participation across gender, life-cycle, and generations in Sweden over 30 years. *Transportation* 46, 793–818. <https://doi.org/10.1007/s11116-018-9868-5>.
- Williams, J.C., Boushey, H., 2012. The Three Faces of Work-Family Conflict: The Poor, the Professionals, and the Missing Middle, SSRN Electronic Journal. Social Science Research Network, Rochester, NY. <https://doi.org/10.2139/ssrn.2126314>.
- Zhang, J., Timmermans, H.J.P., Borgers, A., 2005. A model of household task allocation and time use. *Transp. Res. B* 39, 81–95. <https://doi.org/10.1016/j.trb.2004.03.001>.