

**Time use diary design for our times - an overview, and an example of a ‘drag-and-drop’ diary instrument for online application.**

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## **Time use diary design for our times - an overview, presenting a Drop-and-drag diary instrument for online application.**

### **Introduction**

The recent global pandemic, involving restrictions on movement, social distancing and the displacement of many work activities to the home, has created an upsurge of interest in changes in the distribution and sequencing of our daily activities. Time use diary data is recognised as the leading source of evidence on this topic. The purpose of this paper is to provide a timely overview of the current state-of-the-art in respect of the design of time use surveys for rapid, online or smartapp deployment. It has three parts: firstly, for those who are looking for an overview of the various diary designs in use, we briefly summarise the main methods currently deployed to collect time use data. Secondly, for those interested in learning more about the development of time use diary data collection, we present an overview of the history of the development of the various kinds of diary designs and purposes, from their origin in the late 1800s. Finally, we present a detailed example of a specific kind of diary design, the ‘Drag-and-drop diary’, that may be of particular interest in respect of the sudden demand for new data on time use as it is both user-friendly to complete and capable of rapid online adaptation and deployment.

### **Time diary survey design: overview**

Everything we do, we do in time. Just as in physics and spatial navigation, so in social science, public health and the study of environmental sustainability, the measurement of activities in real time is of central importance. The appropriate measurement technique for this type of data is the time use diary: the collection of uninterrupted accounts of the continuous stream of daily activities, with estimated start/finish times, from which researchers can estimate both durations and sequences. Time use diary data is by now recognised as the ‘gold standard’ for the collection of information about people’s use of time (Cornwell, Gershuny and Sullivan 2019; Gershuny et al 2020 forthcoming). Questionnaire approaches based on recall of time-allocation (asking how much time a respondent spent in a particular activity over the past week, for example) are of

limited use for this purpose, since respondents are in general unaware of totals of time devoted to specific activities, and are rarely asked about their activity sequences. In order to pinpoint the main considerations involved in designing a time use diary survey, it is, however, necessary first to consider the survey-questionnaire based alternative, as this is the commonly used standard ‘time-use’ add-on to many major nationally-representative surveys.

### **Survey time-allocation questions**

These are usually framed in two different ways: 1) an estimate of the frequency with which one undertook a particular activity over a given reference period – for example, the past week or month (as used, for example, in the Millennium Cohort Study and the Avon Longitudinal Study of Parents and Children) and 2) an estimate of how much time one spent in a given activity over a given reference period (for example in the U.S. Panel Study of Income Dynamics, the U.K. British Household Panel Study/Understanding Society and the Australian Household Income and Labour Dynamics survey to look at housework time). Such measures are widely used, but all involve assumptions about how accurately we remember our time; methodological work comparing diary responses with questionnaire responses shows that the latter are far less accurate. For example, it has been found that men tend to overestimate their housework time, while women may underestimate theirs (Kan and Pudney 2008, Schultz and Grunow 2012). Similarly, men who work longer hours tend to overestimate their working time, while part-time employed women tend to underestimate theirs (Walthery and Gershuny 2019). These sorts of inaccuracies are understandable, because while we are aware of the *passage* of time we generally do not remember *how much* of it we devote to each different activity. So, for example, the question “How many hours did you spend in your job last week?” or “how many hours did you spend doing general housework” – is not necessarily easy to answer. It tends to unreliability partly due to a failure of recall; we do not, as part of our normal routines, undertake the various mental processes that would be necessary to answer this sort of question accurately: firstly classifying activities into groups—deciding for example what belongs in the category of ‘paid work’ or ‘housework’—then adding the duration of each successive episode to the accumulated total for that category. And finally, deciding what constitutes ‘a week’, and starting to accumulate a new total of time as a result. Not knowing the answer, we make a guess, which is likely to be influenced by a desire to *represent ourselves* in particular ways, as for example the

*sort of person* who works long hours at her job or cooks, or does not cook, who plays a sport or goes to the theatre, by exaggerating or reducing our estimates of the time we devote to particular activities. These two sources of error, respectively, measurement error and normative bias, are known to distort the responses that people give to these sorts of questions (Juster and Stafford, 1985).

### **Time use survey design - considerations**

There are several initial considerations to be taken into account when designing a time use diary survey:

- Mode of collection (paper, online, smartphone).
- Number of activity categories ('full' = own-word, or 'light' = pre-coded activity list diary)
- Diary information fields (main activity only, or additional information like secondary activities, who with, where, enjoyment etc.)
- Time-slot length (user-defined start/finish times, or defined time-slots eg 10 minutes, 15 minutes etc.)
- Number of diary days collected (single day, weekday and weekend day, other)

Below we outline the main design alternatives that are currently in use, focussing first on the above considerations in relation to traditional pen-and-paper-based diaries, and then discussing new methodologies designed for deployment online or with smart-apps. Time use diary research has a long history, discussed briefly in the following section, and current best practice in diary design is the outcome of this long traditional of data collection.

#### *Paper-based time use diaries*

Time use diaries have traditionally been pen-and-paper based, in the form of a small booklet left behind by an interviewer for respondents to complete on a designated day or days, or completed in retrospect ('day before interview') by an interviewer during an arranged call-back interview.

This has been the standard method of collection, and all the over 100 nationally-representative time use diary surveys of the Multinational Time Use Study archive assembled, harmonized and disseminated by the UCL Centre for Time Use Research were collected in this way (including the most recent nationally-representative UK 2014-15 Time Use Diary Survey – the UKTUS 2015). In respect of the number of activities recorded both options are available for paper diaries;

- 1) in ‘full’ diaries respondents record (write up) in their own words what they are doing, and, post -survey, coders code up their responses into typically up to 300 categories of different activities (which may then of course be amalgamated into smaller clusters of activities). These full diaries are the gold standard for large-scale nationally representative surveys, such as the UKTUS 2015 and the rest of the Harmonised European Time Use Survey (HETUS). Figure 1 shows an example of this type of diary – that used in the UKTUS 2015 (Gershuny and Sullivan 2017). The diary has rows representing successive 10- minute periods, and separate columns in which respondents record: “what were you doing?” (main or main activity); “were you doing anything else at the same time” (secondary activity); “where were you?” (location); and “who else was engaged in this activity with you?” (co-presence). The two activity columns are each coded into over 250 distinct activity categories. An innovation of this particular survey was that we added two columns recording whether the respondent was using an electronic device (screen, laptop, tablet or smartphone), and how much she/he enjoyed each ten-minute period. Note that this diary is pre-formatted into 10-minute time-slots. This level of granularity of time-slots is considered the optimum compromise for reducing respondents’ burden (in terms of having to remember exact start and finish times), while enabling them to complete a full record of their activities (it also facilitates the process of subsequent transposition into a data file). Activities that last longer than 10 minutes can be recorded with a line drawn across the relevant time slots – as in the example shown in Figure 1. The obvious ambiguity here lies in how respondents will record activities lasting *less* than 10 minutes; will they ignore them, record them as secondary activities or record them as lasting the full 10 minutes? This ambiguity necessitates a trade-off between the complexity and length of the diary (if time-slots lasted only one minute, for example), and accuracy of record. The general judgement is that 10-minute time-slots are optimum, and time-slots of longer durations than 10

minutes are considered less reliable because it increases the chances that respondents will have to choose (in some way that is not accessible to the researcher) between different activities that they have done during that time.

The UKTUS 2015 comprised a two-day diary, collecting information for a randomly-selected weekday and a weekend day from each respondent. Two-day diaries of this kind are regarded as the optimum compromise, reducing cost and respondent burden in comparison to a week-long diary, but collecting information for the types of days of the week that are most different in terms of activities – weekdays and weekend days – and so increasing the reliability of the data. This is model used for the HETUS; the American Time Use Survey, by contrast, relies on a single day diary per respondent (thereby losing the option to distinguish weekdays from weekend days for the same respondent).

**Figure 1. Completed diary example: The UK time use diary 2015**

**Day 1**  
Time: 7am – 10am  
Morning

Time: 7am–10am Morning (am)	What were you doing? Please write down one main activity.	If you did something else at the same time, what else did you do?	Did you use a smartphone, tablet, or computer?	Where were you? Location, or mode of transport
7am–7:10	Woke up the children		<input type="checkbox"/>	At home
7:10–7:20	Had breakfast	checked emails	<input checked="" type="checkbox"/>	↓
7:20–7:30	" "	Talked with my family	<input type="checkbox"/>	
7:30–7:40	Cleared the table	Listened to the radio	<input type="checkbox"/>	
7:40–7:50	↓	↓	<input type="checkbox"/>	
7:50–8am	Helped the children dressing	Talked with my children	<input type="checkbox"/>	
8am–8:10	" "	↓	<input type="checkbox"/>	↓
8:10–8:20	Went to the day care centre	↓	<input type="checkbox"/>	on foot

**Day 1**  
Time: 7am – 10am

Were you alone or with somebody you know?  
Mark all relevant boxes

People who live with you							How much did you enjoy this time? 1 = not at all 7 = very much
Alone	Spouse / partner	Mother	Father	Child aged 0-7	Other person	Others you know	
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	5
<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	6
<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	5
<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	4
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	↓
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	↓
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1

Use an arrow or quote marks to record that an activity lasted longer than 10 minutes.

- 2) So-called ‘light’ diaries are designed to lower both respondent and coder burden, and include a restricted menu of activities from which respondents may select, rendering it, in its paper form, less detailed than the full diary. The diary is formatted into a day’s sequence of time-slots across the page, and respondents indicate by marking on the diary (with a tick or continuous line) which activities they were doing at what times. The aim is to restrict the size of the diary and make it simpler to complete, so the number of activities available for respondents to choose from is generally limited to 30-40. This diary format, developed by the UCL Centre for Time Use Research (CTUR), was used in the Understanding Society Innovation Panel diary in 2013, and in the Millenium Cohort diary add-on of 2014 (where pen-and-paper administration was compared with both online and app-based instrumentation in a mixed mode experiment among young people - Chatzitheochari et al. 2018). Figure 2 shows the light diary used in the Understanding Society Innovation Panel 7 survey.

**Figure 2: Completed diary example, Understanding Society IP7 diary**

Activity groups	Activity codes and descriptions (Also see notes on right hand page)		Early morning									
			4am		5am		6am		7am			
			30		30		30		30			
Personal care	1	Sleeping	1	X		X						
	2	Resting (doing nothing, 'time out')	2									
	3	Washing, dressing/undressing, etc	3			X	X					
Eating, drinking	4	Eating or drinking/ having a meal (at home)	4				X	X				
Housework and other household tasks	5	Preparing food and drinks, cooking, washing up	5				X					
	6	Cleaning, tidying house	6									
	7	Washing, ironing or mending clothes etc	7									
	8	Maintenance of house, DIY, gardening, pet care	8									
	9	Other household tasks	9									
Travel	10	Travelling	10					X	X			
	10a	How you travelled (enter letter - see right page)	10a					P	P	T	T	
Work for paid job	11	Work for job (include paid and unpaid overtime and work brought home)	11							X	X	
Education and courses	12	Formal education	12									
	13	Recreational courses and study	13									
Voluntary work	14	Voluntary work for or on behalf of an organisation, charity or sports club	14									
Caring for children and adults	15	Caring for/ looking after and playing with own children	15									
	16	Caring for/looking after other children	16									
	17	Helping or caring for adults who live with you	17									
	18	Helping or caring for other adults who don't live with you (not as voluntary or paid work)	18									
Shopping and appointments	19	Shopping (incl. internet shopping), banking (incl internet banking), post-office, appointments with the doctor, dentist, hairdresser, plumber etc.	19									
Leisure	20	Watching TV and DVDs, listening to radio or music	20									
	21	Reading (including e-books)	21									
	22	Playing sports, exercising	22									
	23	Going out to eat/drink (e.g. to the pub, restaurant etc.)	23									
	24	Spending time with friends, family or neighbours	24									
	25	Contact with friends and family by telephone, text, e-mail, instant message or letter	25									
	26	Visits to cinema, theatre, concerts, sporting events, museums, galleries, historical monuments, library etc.	26									
	27	Attending church, temple, mosque, synagogue, or other religious meetings, praying alone, attending political or other meetings	27									
Computer and internet use	28	Hobbies and other leisure activities	28									
	29	Using a computer or accessing the internet - Code as secondary activity. Record what the computer is being used for as primary activity e.g. internet shopping or banking - code 19; playing games - code 28; e-mailing friends - code 25	29									
Other	30	Other activities not listed (please write in below)	30									
			4am	5am		6am		7am				
ENJOYMENT	31	How much did you enjoy this activity? 1=not at all 7=very much (enter score 1-7)	31									
CO-PRESENCE	32	Who were you with? (enter letter - see right page)	32									
			4am	5am		6am		7am				



In an era when life is inexorably moving online, and in which online surveys and smartphone apps have been increasingly prominent in producing rapid (if not always accurate) results, attention has switched more recently to considerations of how it might be possible to collect time use diary data of good quality in a digital format.

### *New device-based instruments to collect time diary data*

Attempts to collect time use data using apps and online devices are a relatively recent development. In terms of design there are currently three main approaches, that vary in terms of the completeness of their collection strategies. An advantage of internet or app-based techniques is that they are able to overcome one of the restrictions of the light diary format by providing the possibility of using ‘unfolding’ (sequentially nested) lists of activity with levels of detail about activities potentially rivalling those of full own-words surveys. The first two approaches (the survey-like Modular approach and the diary-like Drag-and-drop approach) collect the full sequence of activities across the day; necessary if one wants to analyse the timing or ordering of activities (for example, the duration of leisure activities, and what activity interrupts them, by gender). The third (Point-estimate approach), developed for a different purpose, relies on the sampling of a few activities through a designated day or days, so that mean distributions of the different daily activities may be calculated, but activity durations and sequence information is not available (see Gershuny 2004). We describe each of these in turn, using examples, below:

1. Survey-like Modular approach (e.g. Modular Online Time Use Survey - MOTUS): This method has been developed by the TOR research group at Vrije Universiteit Belgium (e.g. Minnen et al. 2014; for a recent online example designed for collecting information in the current Covid-19 crisis see <https://www.everydaylife.eu/>).

This approach involves respondents initially selecting the start and end time of their first main activity of the day, and then the activity itself from drop-down menus. This is followed by the collection of further information for that activity period, such as secondary activities, who with and location information. And so on through each main activity of the day. Figure 3 illustrates in the left hand screen the time log information (taken from the app version of the instrument) for main (‘primary’) and any secondary activities done at the same time, and the collection of the context information for the same main activity episode in the right hand screen.

**Figure 3. MOTUS. Diary example using the Modular approach**

TIMELOG

From

Mo, 3 Jul 2017

00:27

Is your activity still ongoing?

To

Mo, 3 Jul 2017

06:08

PRIMARY ACTIVITY

Sleeping

SECONDARY ACTIVITY

Opened a window due to dry air

Connected and ready to sync

SAVE

CONTEXT

With whom did you do this activity?

Alone

Partner

Child(ren)

Parent(s)

Other family member(s) < 18y old

Other family member(s) >= 18y old

Friend(s)

Neighbor(s)

SUBMIT

Figure 4 illustrates the final main activity time-line for the day.

**Figure 4: MOTUS timeline for diary day**



MOTUS is available in both online and app modes, and EUROSTAT is considering implementing this approach for the online version of the HETUS, while the UK Office of

National Statistics are developing a version to trial as an online approach to time use diary surveys.

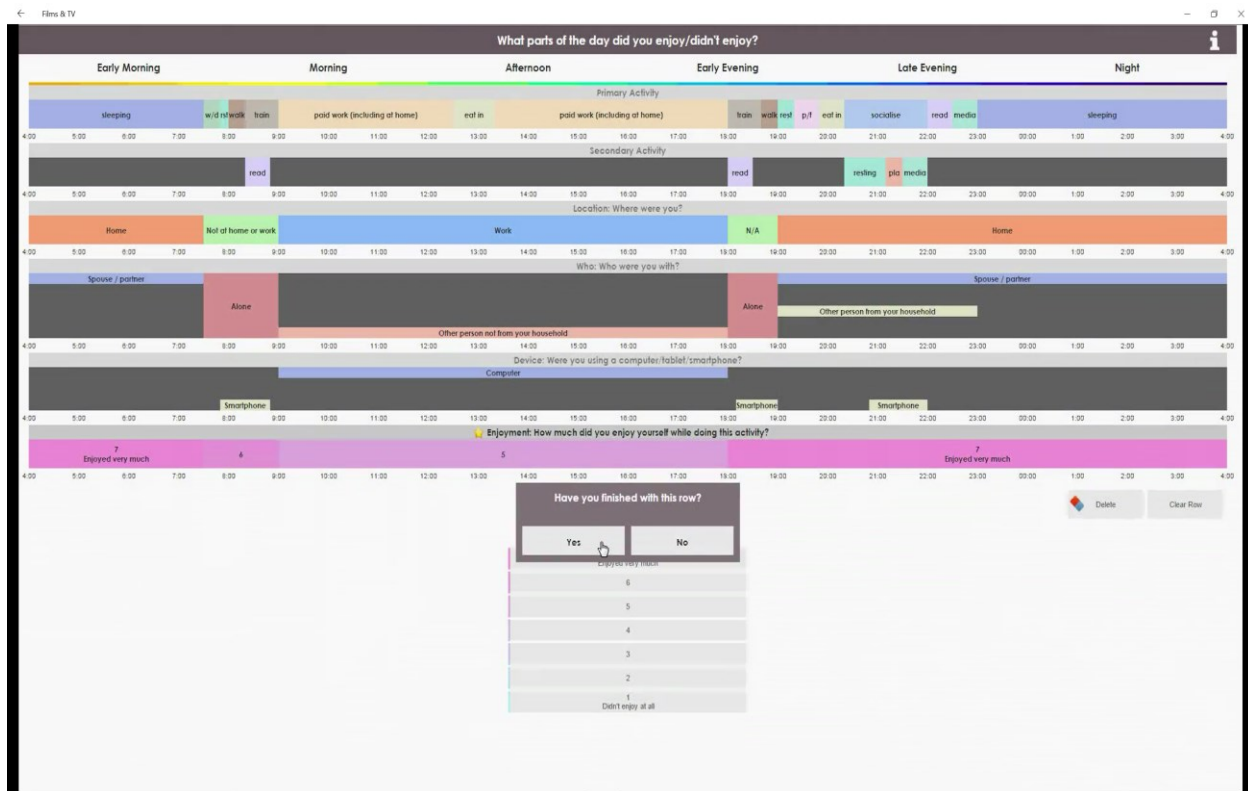
2. Diary-like Drag-and-drop approach (e.g. Drag-And-Drop Diary Instrument – DADDI).

The Drag-and-drop approach is a direct development of the light diary format, designed specifically for online use. The approach was developed by the CTUR and implemented, in collaboration with Trajectory Partnership, in a 9-country time diary survey designed to collect cross-country comparative information on the enjoyment of activities (Trajectory Partnership 2016). Respondents use a Drag-and-drop tool, initially dragging a pointer across a horizontal timeline bar (marked up in time-slots across the hours of the day) to create a record of the length of time they spent doing each main activity. Activities are identified using drop-down menus and are shown on the timeline bar in different colours. The screen is filled in the same way with successive rows of information showing, for example: secondary activities; who the respondent was with at the time; where they were; and how they were feeling at the time, so that the total picture represents in visual form a day's worth of time use (see Figure 5).

This alternative to the modular model is intuitive to complete, and may be less costly in terms of repetitiveness for respondents, avoiding the burden of having to enter each main activity time-log, followed by iterated lists of drop-down menus to complete the remaining diary fields for each main activity episode. In this sense the drag-and-drop approach is more similar to a paper-based diary, and also facilitates a data structure familiar from the analysis of sequential life-course data – in which a change in any one of the fields identifies a new 'episode' (i.e. a point in time at which the situation changes – the location, perhaps, or who the respondent is with at the time), permitting more flexibility in analysis. The substantive implications of these two approaches to data structure are illustrated in the final section of this article.

We describe the DADDI in more detail in a later section of the article, and a video demonstrating its completion is included as a MP4 file in the supplementary materials. We are currently in the process of designing a matching app-based instrument to accompany the online version.

**Figure 5. Completed diary example, Drag-and-drop Diary Instrument (DADDI - see final section of paper for full description)**



### 3. Point-estimate approach

This approach, often referred to as the ‘Experience sampling method’ has been used recently to collect information on the subjective experience of activities. Respondents are alerted (sampled) by smart devices at random points during the day and asked to complete a series of questions about what they are doing and how they are feeling. The American Time Use Survey (ATUS) used a variant of this method to collect information on ‘mood’ in its well-being module (fielded from 2010 to 2013), in which respondents were asked to recall how they were feeling at 3 randomly-selected points of the day during the interviewer-collected ‘day-before’ ATUS diary. This technique was adapted from the ATUS and promoted as a means of collecting time use information by Kahneman and Krueger in their ‘Day Reconstruction Method’ (Kahneman et al. 2004).

A prominent UK example, collecting big data from a non-random volunteer survey, is the ‘Mappiness’ project which relies on a smartphone app to collect feelings of subjective affect (including ‘happiness’), together with co-presence, location and activity (Bryson and MacKerron 2017; see the website at <https://www.mappinessapp.com/>).

The obvious difference of this approach from the previous two (modular, and drag-and-drop), and its disadvantage in respect of the full potential of time use data analysis, is that only a limited range of activities per day are sampled and identified. Although populations distributions of time spent in different activities may be estimated in this way, there is no option for analysing episode durations (for example, the experience of longer versus shorter periods of leisure) or activity sequences (such as, for example, the enjoyment of a particular activity when it is preceded or succeeded by another activity).

### **A brief history of time use diaries**

There is a surprisingly long history of time-use diary surveys. It appears that the original innovators were Russian researchers, observing peasant households at the end of the 19<sup>th</sup> century. The results however survive only in the form of calculations of the balance of different sorts of peasant work (Chayanov, 1966). In Britain, the Fabian Socialist Maud Pember-Reeve persuaded a small sample of London women to complete time-use diaries. The chapter describing these results in her *Round About a Pound a Week* (1912) is the first English-language time-use diary publication. The Soviet Russian economist Stanislav Strumilin published a time budget account of Russian workers in 1925. And almost simultaneously the US Department of Agriculture—we may speculate about connections with the earlier Russian agricultural extension applications—started a substantial collection of time diaries from farm, town, and later elite educated “college” women (Kneeland 1929). These provide the earliest time diary dataset whose original individual-level data survives for use by modern researchers (Gershuny and Harms 2017).

The first major US academic study of time use (Lundberg *et al* 1934) explicitly identified Kneeland’s USDA work as the source of its methodology. Their study of leisure in a suburban

community, was followed by Sorokin and Berger's (1939) investigation of the activity patterns of young people—the former of these two authors had been a colleague of Strumilin in Moscow in the early 1920s. The first time-diary-type research in the UK was conducted by the Mass Observation organisation in 1937 (more than 1000 of the original diaries survive to the present), closely followed by the BBC which conducted its first “listener availability” study in 1938.

During the 1950s more media broadcasters in Europe, North America and the Pacific rim followed the BBC example of deploying large samples of diarists to estimate the daily habits of radio listeners, and later television viewers, used both as a guide to appropriate programming through the day and the week, and also to provide a basis for estimating audience sizes so as to guide the pricing of advertisements. Converse and Robinson (1974) among others, made constructive use of studies by the Columbia Broadcasting Company in their early study of historical change in US time use. By the early 1960s large diary-based time-use studies were underway in Czechoslovakia, France, Hungary, Poland, Japan, the UK and others.

This extensive pre-history means that by the time of the first properly designed, *ex-ante* (pre-fieldwork) harmonised cross-national time use study, funded in the mid-1960s by UNESCO and led by the Hungarian sociologist Alexander Szalai (1972) there was already a considerable international convergence of research practice. The 12-country dataset that emerged from the Szalai study, one of the first cross-national comparative studies on any subject available to social scientists, popularised a design of time use diary surveys that continues, with variations, to the present time.

This common underlying design means that *ex-post* harmonisation of the micro-level data of all the subsequent time-diary based studies whose samples have survived to the present time is, while painstaking and protracted, essentially straightforward. And the next substantial exercise in *ex-ante* harmonised cross-national comparative time diary research, organised by Eurostat from the mid-1990s, started from the same Szalai-based model (Gershuny 1995, Eurostat 2009); the two tranches of national data collected (1999-2006 and 2009-2015) for the Harmonised European Time Use Survey so far include all the larger EU countries. The US started to collect the American Time Use Study as the seventh wave of the General Population Survey in 2003.

This departs from the basic Szalai architecture, in particular by collecting only a single activity category per time-slot. But it is collected continuously, with annual releases of data, and is the largest source of time diary data collected anywhere.

The Multinational Time Use Study (MTUS) archive is by far the largest available collection of comparative and historical time-use materials, with 1.5M days from 85 surveys from 26 countries, all harmonised *ex post*, most of the data freely downloadable for use by academic researchers ([www.timeuse.org/mtus](http://www.timeuse.org/mtus); see Fisher and Gershuny 2016).

### **Online time use diary surveys for rapid deployment: a Drag-and-drop example**

The recent global pandemic has created an upsurge in interest in the ways in which people are using their time under conditions of lockdown and social distancing. The requirement is for a diary instrument with an online format that can be rapidly administered, and in which respondent burden is not too onerous.

The CTUR 9-Country Drag-and-drop Diary Instrument ('DADDI') was initially designed for deployment among an international online market research panel covering 9 different countries. The original aim was to fill the gap in national comparative data on the enjoyment of different activities (the UKTUS 2015 was among the first national-level time use diary survey to include a field asking respondents how much they were enjoying the different time-slots of the day). Nine nationally comparative populations in Europe and the USA were covered, representing 4 different 'policy regime types': UK; USA; France; Germany; Netherlands; Sweden; Finland; Italy and Spain. The data was collected between November 2015 and May 2016 using quotas on socio-demographic factors such as age, gender, education and employment, with a minimum number of respondents guaranteed according to nationally representative quotas. Each country provided over 1,000 'diary days' of data, with a total sample of more than 10,000 days of data across the 9 countries, based on interviews with 6,000 respondents, most of whom completed 2 diary days.

The Drag-and-drop format proved to be an effective instrument. Respondents completed a 10-minute recruitment/profiling survey including the standard range of socio-economic and demographic questions, and then completed two diaries, one for a weekend day and one for a weekday. Instructions consisted of a simple 3-minute visual online demonstration, and the average time taken to complete the diary was 10 minutes per diary day. Response quality was at a level to be expected of on-line diaries, and with unusually low levels of missing primary activity data.

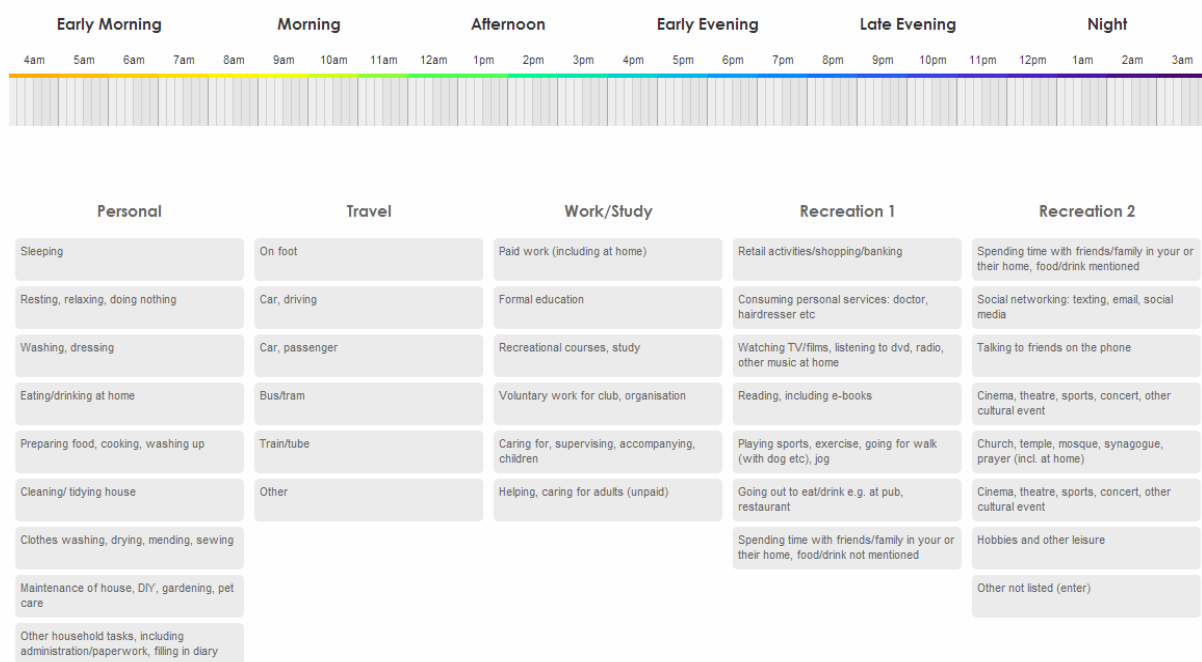
The main advantage of this instrument for online deployment is that it collects the entire sequence of activities and a complete set of information fields through the whole diary day, while being intuitively easy to follow as respondents move graphically along the day's timeline. The complete diary (as shown in Figure 5) creates a visually interesting and informative picture of the day's activities for the respondent. All of these features recommend it for adaptation and use in a context where rapid deployment of an instrument for the collection of time use data is needed.

While we opted for a range of diary information fields for the 9-Country Study to match the specifications of the UKTUS 2015 (main activity, secondary activity, location, who with, device use and enjoyment), the design enables amendment either to include fewer fields (in which case time of completion could be reduced), or to enhance, expand or amend the range and number of fields. For example, in the current Covid-19 crisis, during which the extent of social contact has become a major issue in research on transmission of the virus, the 'who you were with at the time' field could be significantly expanded to include a wider range of possible social contacts, and amended to give an indication of what kind of contact was involved (e.g. 2 metre distance only; or closer than that). Similarly, fields describing other aspects of 'affect' could be added to the enjoyment field, indicating levels of stress, anxiety or boredom judged relevant to the current situation. An webapp version of the instrument is currently under development for these purposes.

An illustration is given in the following sequence of figures (Figures 6 to 13) of the completion of the Drag-and-drop diary instrument (DADDI). (The MP4 file from which these screen-shots were taken is available in the supplementary materials for this paper: Diary\_example\_v2).



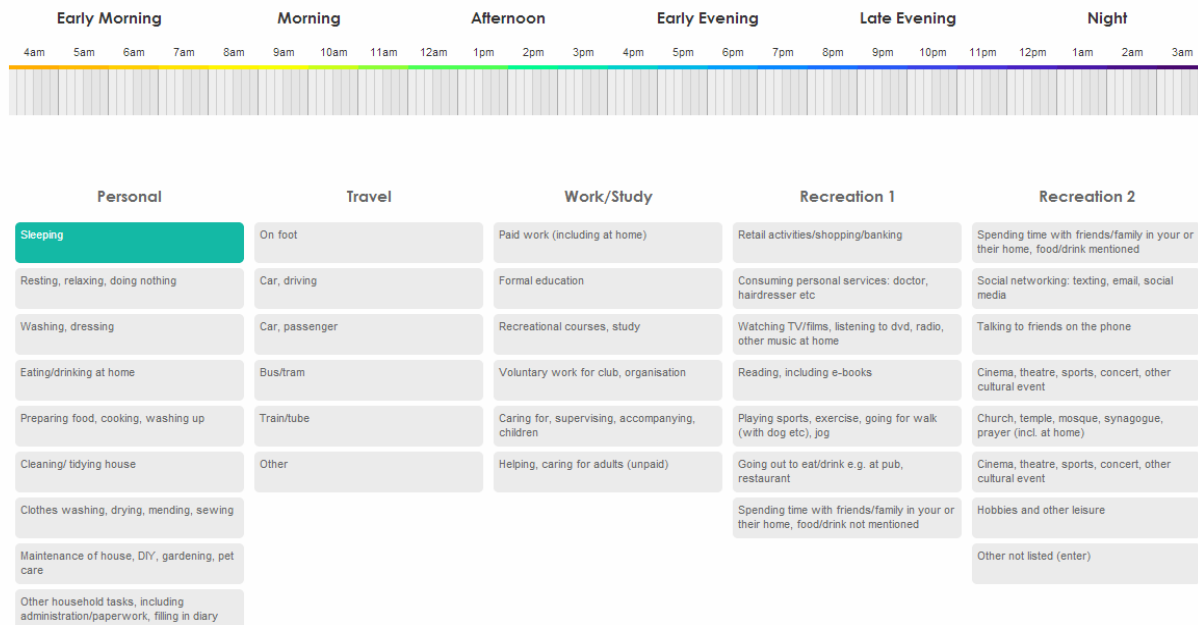
**Figure 6: Filling in the main activity: initial screen view, Drag-and-drop diary instrument (DADDI)**



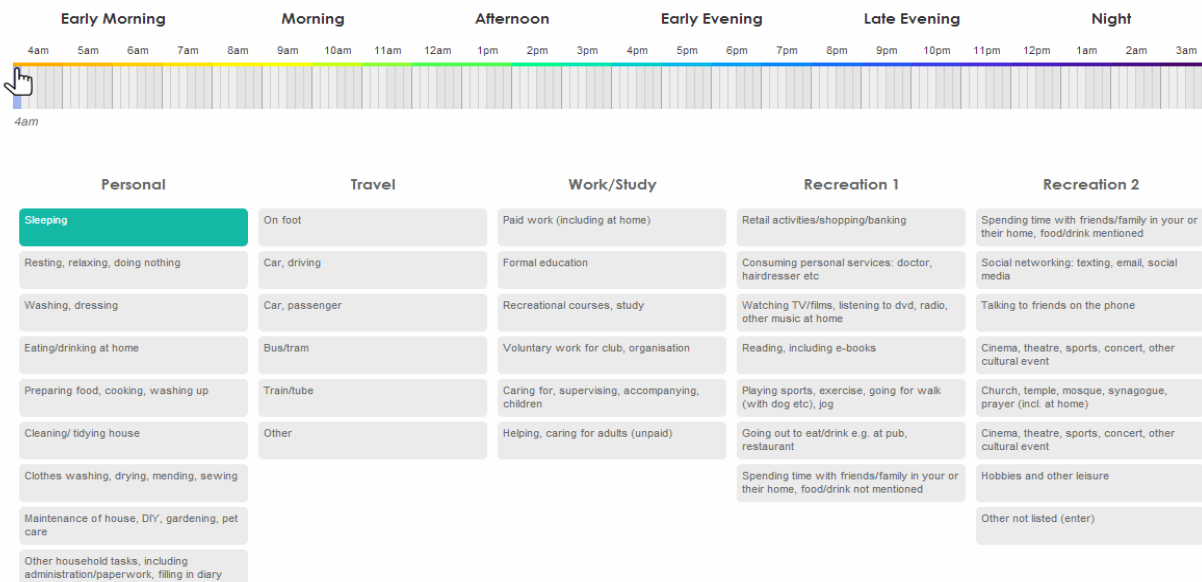
Notes: The instrument is designed to be both attractive and as user friendly as possible.

- Each time-slot is equal to 10 minutes. Colours are used as visual aids.
- The timeline will fit automatically to the width of the screen, shrinking or growing depending on screen size.

**Figure 7: The respondent selects an initial activity category (DADDI)**



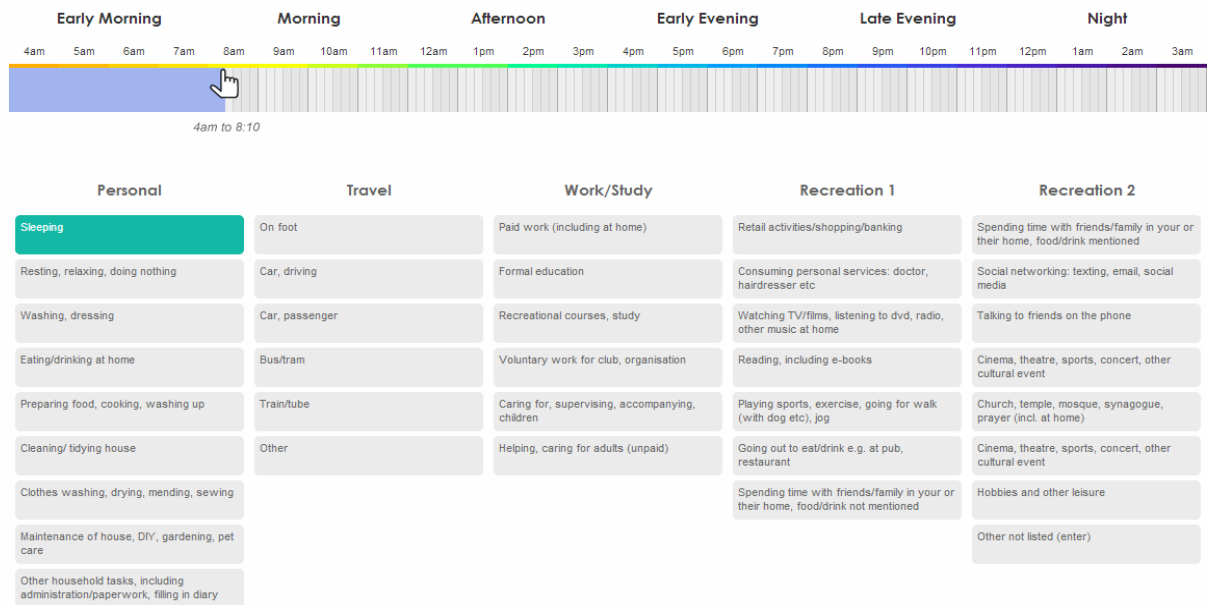
**Figure 8: clicking on the start time of the selected activity (DADDI)**



Notes: Once a category has been chosen, the user can begin dragging the cursor anywhere along the timeline.

- The start time of the activity is indicated below the timeline

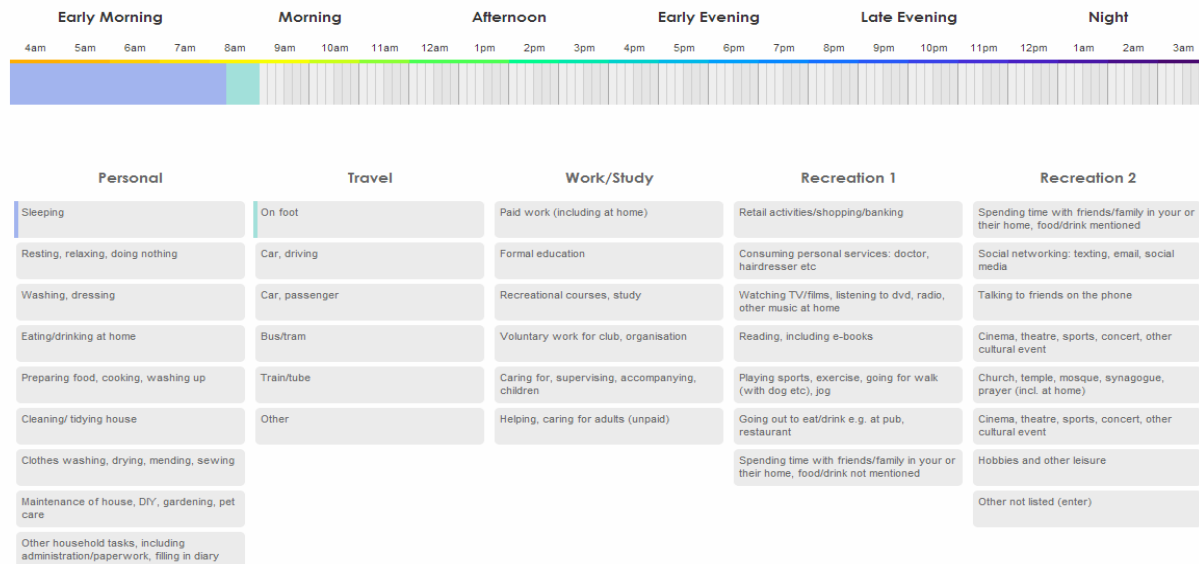
Figure 9; dragging the cursor along the timeline to the finish time of the activity (DADDI)



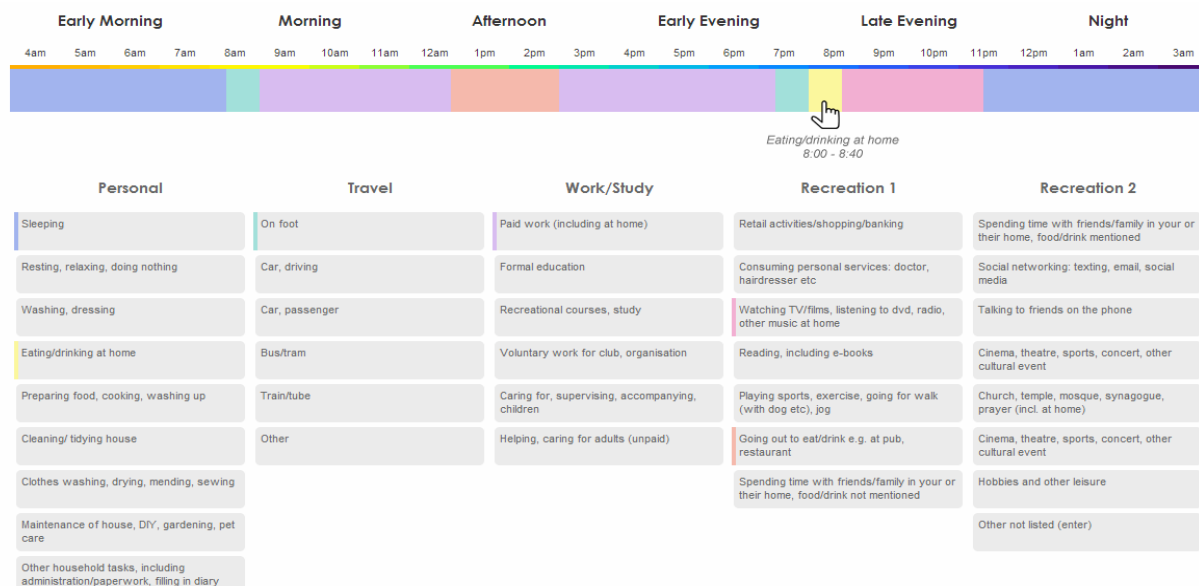
Notes: The user releases on the finish time of the activity

- The start and end time of the activity are indicated below the timeline.

**Figure 10; the respondent continues selecting and drag-dropping activities along the timeline (DADDI)**



**Figure 11: Completed main activity timeline (DADDI)**



Note: The respondent can hover the cursor over any time-slot to receive details and make edits

- Once the timeline is filled, the user is prompted to submit their data.

**Figure 12; Automatic prompting for additional diary information (eg who with, location)  
(DADDI)**

Early Morning Morning Afternoon Early Evening Late Evening Night

4am 5am 6am 7am 8am 9am 10am 11am 12am 1pm 2pm 3pm 4pm 5pm 6pm 7pm 8pm 9pm 10pm 11pm 12pm 1am 2am 3am

Were you alone or with someone else while you were doing this activity?

Car, Driving: 8:10 to 9:00

Alone

Spouse/Partner

Not at home or work

Child under 12 from your household

Young person 12-16 from your household

Other person from your household

Child/young person aged up to 16 not from your household

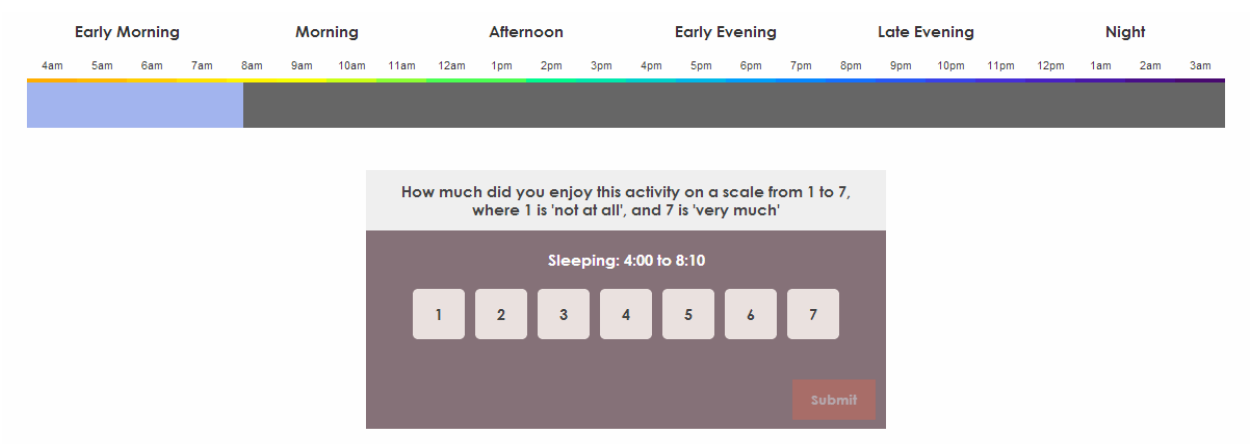
Other person not from your household

Submit

Notes: Multiple questions can be asked per activity, to suit

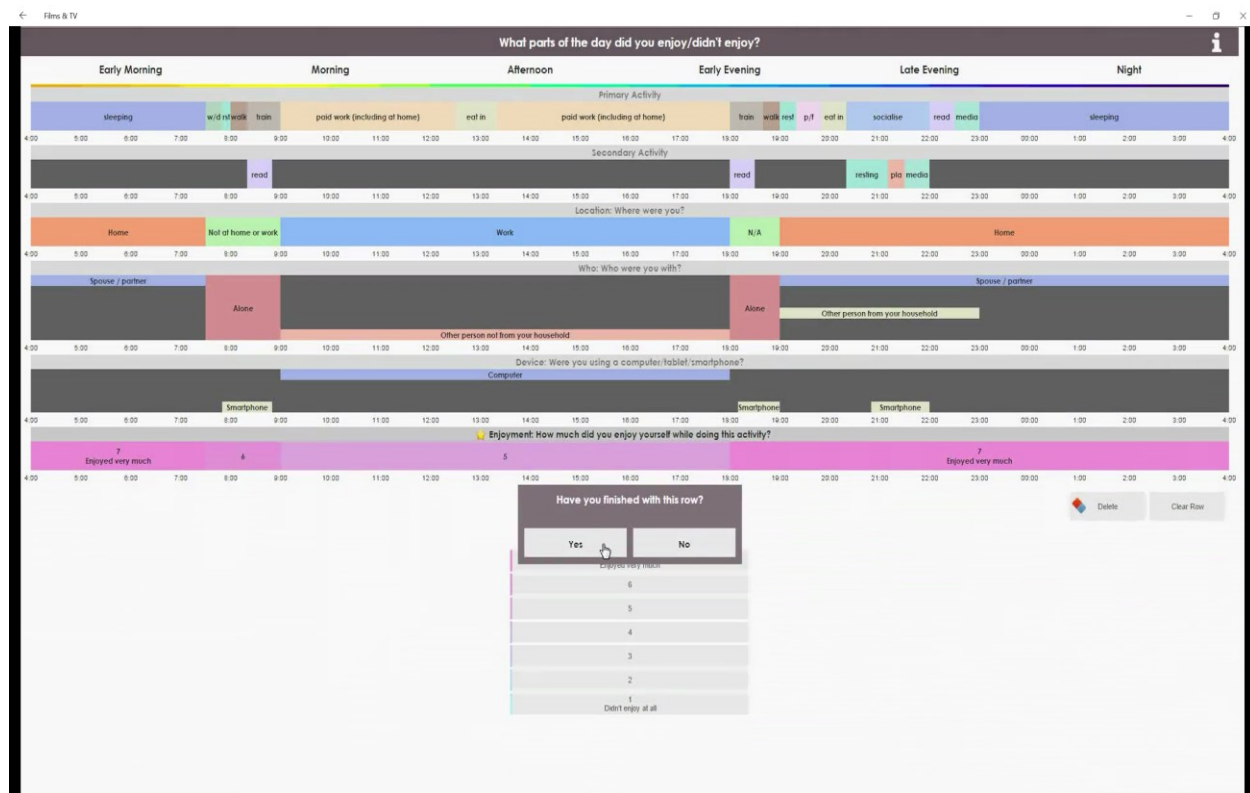
- The instrument will automatically select and highlight relevant activities for additional questions

Figure 13: Completion of the final, enjoyment, field (DADDI)



Notes: here activity periods are automatically selected in sequence through the day and the user is prompted for an enjoyment score for each

**Figure 14: Completed diary (DADDI)**



Notes: Information for the entire day's record is displayed graphically, in colour, allowing easy visualization across the day and permitting the identification of any gaps, errors or inconsistencies.

### The online Drag-and-drop diary instrument: some methodological observations

Analysis of the 9-Country diary data illustrates a couple of methodological points relevant to the design of an online or smart-app diary instrument that were referred to briefly in the section above on design issues:

- Independent timings for diary fields
- 'Affect' data recorded continuously throughout the day

*Independent timings for diary fields*

Following the methodology used in life-course analysis for longitudinal data where there are multiple fields of evidence, ‘episodes’ are conventionally defined as periods during which all fields remain unchanged. In contrast to some other diaries (such as those used in the ATUS and MOTUS) in which the start and finish times of the main activity serves to structure the timing of the other diary fields, the drop-and-drag instrument facilitates the independent timing of each of the diary fields. Where any one field takes a new value, a new episode starts. A single main activity period may therefore form part of several episodes, during which a different secondary activity might be done, or the ‘who with’ field might change. Main activities can have different lengths to secondary activities, enjoyment levels can vary where the main activity is unchanged, telephones devices can be used during just part of a main or secondary activity, and so on. This flexibility not only better reflects our lived experience of time, it also accords with the accepted convention for life-course data, from which analytic techniques are directly transposable (e.g. multichannel sequence analysis; Gauthier et al 2010).

From the 9-Country study data we can show that this difference has important implications for analysis. If, for example, we take only the duration of the main activity as defining an episode in the 9-Country Study data we find an average of 13.9<sup>1</sup> episodes across the survey, with some national variation—Italian respondents with average of 15.4, US respondents with an average of 12.6. But following the convention of defining episodes as periods of time in which *no* field of the diary changes, the overall mean count of daily diary episodes rises from 13.9 to 16.3 (again with USA respondents -15.0 episodes per day- at the bottom, and Italian respondents- 18.7 episodes per day- at the top).

The independence of the timing of fields has important substantive consequences. Certain activities are particularly prone to being recorded as secondary, such as snacking or watching TV. The ‘using a device’ field may well also feature as a secondary activity accompanying a non-screen main. Therefore, where episodes are defined according only to main activities this will have one of two consequences: *either* the secondary activity is recorded as lasting the duration of the main activity (e.g. a snack eaten for only 15 minutes at work is recorded as lasting the full 5-hour work episode); *or* the secondary activity is simply omitted (e.g. using a smartphone for 5 minutes is not considered worth recording during a 30-minute period where the main activity is eating). There is no way of knowing which of these options might be adopted by



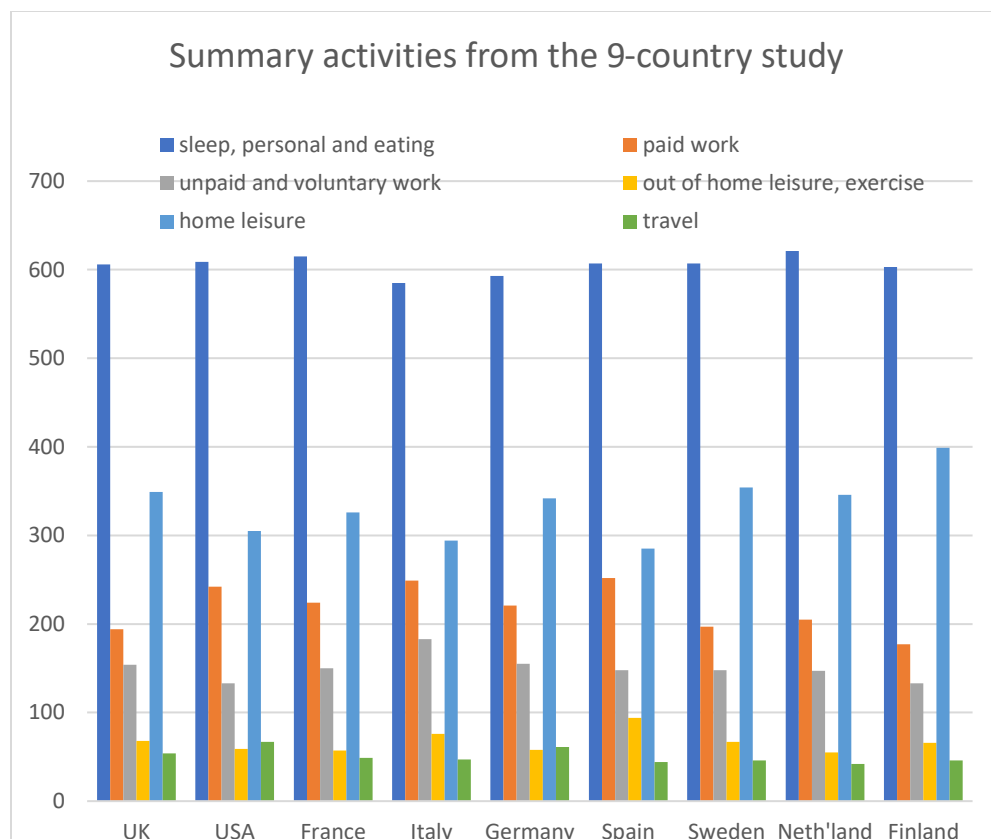
respondents, and in both cases the diary record will be inaccurate, in the first case vastly exaggerating the time spent snacking, in the second under-estimating the use of mobile devices.

### *Continuous recording of 'affect' fields*

It has become popular to collect information on affect (either positive or negative) through the 'experience sampling method' (e.g. the 'Day Reconstruction Method' – Kahneman et al. 2004). But the continuous recording of affect fields, which was pioneered by Robinson for the U.S. 1985 time use survey (and referred to, for example, in Robinson and Godbey, 1997) has advantages from an analytic perspective. For example, it permits standardisation of enjoyment scores at the level of the individual diarist, in order to mitigate individual and cultural differences in reporting standards (we can 'normalise' each diarist's responses to produce a daily individual mean enjoyment of zero, with a standard deviation of 1). It also permits the modelling of duration effects in relation to affect. For example, in analysis of the 9-Country study data, we are able to provide support, across certain activities, for the fundamental economic postulate of diminishing marginal utility. So, for example in the case of sleep, a positive coefficient for enjoyment across activity duration coupled with a negative duration-squared term combine to produce downward-turning modelled marginal utility curves. The enjoyment curve for sleeping across activity duration reaches its maximum level at a very plausible seven and a half hours (450 minute) duration, and turns downwards thereafter (see also Gershuny, 2012).

Finally, the 9-Country Study dataset, using a single instrument and an identical (apart from language) instructional video for all the different countries is uniquely well placed for international comparison. Comparative research often focusses on international differences. Perhaps too easily forgotten is the more general overall observation: the overall cross-national similarity in mean times in various daily activity totals as shown in Figure 15.

**Figure 15: Summary mean time in major activities, 9-Country Study**



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<sup>1</sup> Excluding those 12% of diaries with fewer than 4 episodes, and/or no record of a main and secondary activity done simultaneously (an *ad hoc* definition of ‘bad diaries’), the mean overall number of episodes rises to 17.5