Towards a platform for time use research

An analysis of time use research methodology to develop new ways of collecting time use data

JOERI MINNEN

Brussels

2023

JURY	
Supervisor	Prof. dr. Ignace Glorieux (VUB)
Chair	Prof. dr. Bram Spruyt (VUB)
Other members	Prof. dr. Christophe Vanroelen (VUB)
	Prof. dr. Ike Picone (VUB)
	Dr. Anne Roeters (Netherlands Institute for Social Research)
	Prof. dr. Nina Klünder (Universität Paderborn)

Dissertation submitted for the degree of Doctor of Sociology.

Brussels, 06 September 2023.

CONTENT

CHAPTER 1

Introduction. Four eras of conducting time use research

How to capture human behaviour?

Checking the time is perhaps the most common and unconscious moment of everyday life in modern societies. That is not difficult to do. We are surrounded by clocks. Not only on all our watches and smart devices, but also on our microwave, oven, dishwasher, refrigerator, extractor hood, hob, washing machine, dryer, and coffee machine. And not only at home, but also outside on the church tower, the information boards at train and bus stops, in our car, on billboards, on the scoreboards of sports club. Checking the time tells us "… not only where we stand vis-à-vis the rest of the day, but also how to respond" (Honoré, 2005, p. 19).

In modern societies, our notion of time is shaped strongly by the ordering of collective, social actions. In other words, time is derived from collective rhythms of jointly actions. The notion of time serves an impersonal set of indispensable guidelines for daily life that transcend the individual. Emile Durkheim concluded that time is a social fact, a characteristic of society and that "it is not my time that is thus arranged; it is time in general, such as it is objectively thought by everybody in a single civilisation' (Durkheim, 1965 [1912], p. 10).

It logically follows that the social life of the group is reflected in their time expressions and that whenever these expressions become generalized, temporal structures, they serve as mechanism for the coordination of everyday life (Schöps, 1980). In other words, if we are able to capture how people spend their time, we learn a lot about their daily behaviour. Enter time use research. Time use research aims at capturing human behaviour by having people register how they use their time.

Today we use standard (clock) time to coordinate daily life which makes conducting time use research convenient. We can use standard units of

measurement to expose temporal structures and thereby study the social organization of societies. The work of the American sociologist Eviatar Zerubavel provides a framework from which the social organization of daily life can be studied. Especially in his work on hidden rhythms, Zerubavel (1982b) argues that the organization of social life is subjected to temporal structures that are normative, institutional, and (techno)logical in nature. These temporal structures enable or constrain (daily) life in terms of when things happen, how long things last, how often things recur, and in what order things happen. The temporality of all our (daily) actions is thus expressed in their timing, duration, tempo, and sequence. Measuring these time characteristics of acting is precisely one of the greatest strengths of time use research. Time use research typically consists of a chronological record of sequential activities often for 24 hours per day and for several days in time diaries. So, these activity records say something about when certain activities take place, how long they last, how often they recur during, say, the day, and what preceded and followed them.

These elements, that is, *timing*, *duration*, *tempo* and *sequence* are often referred to as the parameters of time (Zerubavel, 1982a) and all data collection techniques that gather information about at least one of these four parameters are referred to as time use studies.

Whereas questionnaires are often used to collect information on how long (duration) or how many times (tempo) activities have been performed, time diary methodology (often referred to as time use surveys) is capable of capturing all four parameters of time at once and, is therefore, believed to be one of the most profound and valuable ways to capture human behaviour. Time use surveys draw a picture of how individuals use their time by utilizing a log or a time diary during at least twenty-four consecutive hours (Pronovost, 1989).

From the outset of time diary studies the focus laid on socio-economic issues and what started as small observational diary studies quickly grew into international comparative studies. Along with this, the number of stakeholders also increased: from individual, pioneering scholars to large research groups (e.g., the Centre for Time Use Research – CTUR, Tempus Omnia Revelat – TOR, and the Maryland Time Use Laboratory) and the International Association for Time Use Research (IATUR) and from pioneering policy planners such as Stanislav Strumilin to a coordinated network of National Statistical Institutions.

However, the time diary methodology is complex, costly, and burdensome and not seldom hard to match with the principles of the European Statistics Code of Practice with criteria as lowering respondent burden, being cost efficient, being accurate and reliable, and being timely and punctual (Eurostat, 2018). All these principles have been playing and still play a major role in the entire evolution of time diary research. Concessions and choices in methods and modes to meet these principles can often be traced back to discussions about the consequences of certain choices for the reliability and validity of the collected data.

Reliability and validity

Time reveals the "many interesting patterns of social life [that] are associated with the temporal distribution of human activities, with the regularities in their timing, duration, frequency, and sequential order" (Szalai, 1972, p. 1). Time use research is a quasi-observational research method in which the respondents' own observations approximate how they spent their time (Juster, 1986, pp. 398-399). The discrepancy between their actual time expenditure and their estimated time expenditure is the measurement error. When it comes to time use research, it is, in the words of Scheuch "very hard to collect answers that correspond to reality with at least some degree of accuracy. Representing the expenditure of time is one of those subject matters where the reliability and validity of data are extremely sensitive to details in the manner of data collection" (1972, p. 69). The total measurement error thus relates to the reliability or unsystematic error and validity or systematic error of the measurement method.

Reliability

The reliability of a research method presents itself in different forms. A first form of reliability refers to the ability of a measurement instrument to produce comparable results for various samples with the same characteristics. Reliability in this sense thus refers to the stability of the measurement. The random error is then not directly linked to the method per se but relies on erroneous observations by the respondents that would not repeat itself in the same way under the same circumstances.

A second form of reliability is typical for time use research and refers to random errors that are related to the number of observed or the observation length of the study. Suppose time use research that consists of a single diary day. The reliability of the sleep time estimates will be high (i.e., result in less random errors) because sleep is highly likely to occur every day. However, the reliability of time spent on cultural participation will be low because cultural participation is much less likely to follow a daily rhythm of occurrence. The unsystematic errors are then related to zero-observations (Gershuny, 2012).

The size of the random error then depends not so much on the research method itself, but on the research design, since, in addition to the number of diary days, the reliability of the measurement is also influenced by the length of the fieldwork period (e.g., inclusion of seasons), the distribution over different days (e.g., weekdays and weekend days), and the sample size (Harvey, 1993).

Validity

Validity subdivides into external and internal validity (Te Braak, Van Droogenbroeck, Minnen, van Tienoven, & Glorieux, 2022). External validity refers to the generalizability of the research results to the population from which the sample is drawn and the ability to draw conclusions about the real-world implications. Since external validity deals with ensuring that the results are not only applicable to the participating group of respondents, dealing with external validity relates to a large extent to sampling strategy (i.e., size, characteristics).

Internal validity focuses on the research method itself and the effect of the measurement tools on the collection of the research data and subsequently the results. Internal validity, thus, refers to the ability of a measurement instrument to produce accurate or valid data. A systematic error occurs when the measurement instrument does not measure what it is intended to measure.

Over the years, different research methods have been developed and employed to measure how people spend their time. Most common are (1) the diary method in which respondents keep a time diary in close to real time and record their activities chronologically for at least 24 hours, (2) the yesterday-recall method in which respondents are interviewed about their time expenditure on the day before over a period of 24 hours, and (3) the beeper-method in which respondents are beeped several times throughout the course of a day to record what they have

been doing, often in the past hour. In the absence of an objective evaluation method for the internal validity of these research methods, the internal validity of the different methods is often evaluated in relation to each other. To do this, face validity and content validity are often used. Face validity refers to the subjective acceptance and judgement of the credibility of the research method and is often a useful first indicator to assess internal validity. Content validity refers to the comprehensiveness of the research method by representing all relevant dimensions of the construct being measured.

To assess the internal validity of a diary method, several indicators have been developed (Juster, 1986). These indicators are constructed using the collected diary data (i.e., hence *content* validity). One diary method is less valid than the other diary method when respondents (1) record fewer primary activities, (2) record fewer secondary activities, (3) describe time spent using a limited number of different activities, (4) record more unspecified time, and (5) have more activities start and end at round times (Juster, 1986). These indicators are useful but should not be considered conclusive. As Scheuch points out, there is "no absolute measure to judge the results of any of the techniques used during the pre-test as 'true'. […] No one technique known to us will result in 'perfect' data" (1972, p. 74).

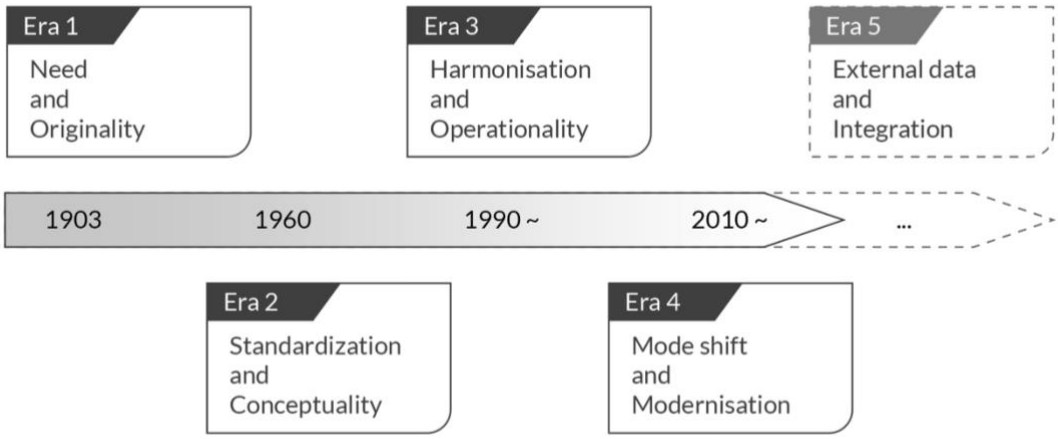
Reliability and validity studies between different research methods are scarce, often only apply to relatively small samples, and are seldomly conclusive. Diary methods seem to have the advantage over survey methods (Bonke, 2005; Gershuny & Sullivan, 1998; Robinson & Godbey, 1997), although occasionally survey estimates concur with time spent on activities in a diary (Frazis & Stewart, 2010). Similarly, a combination of a 'yesterday survey' method for day one and a diary method for days two to seven to produce weekly time estimates led Huysmans, Lammers, and Wester (1997) to conclude that there was no difference between the two methods for their study topic (media use). However, any evaluation of reliability and validity should always be interpreted with a certain caution because "ultimately, we cannot provide conclusive proof of the validity of our results, but their technical reliability can be tested, at least in part" (Fisher, Gershuny, Gauthier, & Victorino, 2000, p. 20).

Eras of time use research

As a research discipline, time use research appears to be dynamic, which allows for both different research questions and changes in the way of doing time use research over time. With the introduction of the two concepts that are relevant in all research methodologies but in particular in time use research, that is, reliability and validity, it is possible to speak of five eras of time use research (see Figure 1).

Historically, the first era arises from the need for time use research and is characterized by the originality of time use research methodology. The second era is characterized by a standardization of the methodology and the conceptuality of what constitutes the diary method. In the third era, the harmonization of time use research is central in function of an upscaling of the operationalization of time use research. The fourth era is the era in which the research community is now largely in and is characterized by a change in the way (i.e., mode) in which time use research is conducted in response to the need to modernize. The fifth era is seen as the next evolving stage where external data is captured and there is an integration of these different data streams into the overall data collection strategy. In this chapter we discuss the first four eras. The discussion of the fifth era, the future of time use research, is presented in the concluding chapter of this PhD and reaches out to both the 'real' strength of time use research but also the challenges that it faces.

Figure 1. Five eras of time use research



First era: need and originality

At the start of the 20th century, the need arises to collect reliable data on the relation between paid work on the one hand and unpaid work and leisure on the other. Before that, Frédérique Le Play (1877) published *Les ouvriers européen* which reported on 57 time reports from workers and their families from various industries across Europe and focussed on paid work and how the family as a unit provided an income based on the number of hours worked. However, the originality of the time use research methodology based on diaries can be attributed to the books *How Working Men Spend Their Time* by George Bevans (1913) and *Round about a Pound a Week* by Maud Pember-Reeves (1913). Both studies question social (in)justice. Bevans was interested in how leisure time was spent by men from four different industrial cities, and how their working conditions affected their leisure time. Feminist Pember-Reeves documented the life of working-class families in London from the perspective of the family and the woman within that family. The latter can be said to have initiated the use of time use research to study the gender division of labour at the household level.

However, it is the USSR that validated the diary method by using it to collect data on a representative scale for planning purposes and to make comparisons between groups of industrial workers. In the communist Soviet Union, under the leadership of Strumilin (1921-1923), time diaries were used to design and assess economic and social planning (Zuzanek, 1980). America followed later (1925-1931) with the Department of Agriculture (USDA) asking women to keep time diaries to chart work in the field and beyond (Stinson, 1999, pp. 12-14). Later, the academic world also jumped on the diary method with Sorokin, who – as a former student of Strumilin – with the publications "Social Time: A Methodological and Functional Analysis" (Sorokin & Merton, 1937) and "Time-Budgets of human behavior" (Sorokin & Berger, 1939) made the link between theory of time and empirical data.

The reliability and validity of the diary method continues to be valued after the Second World War. Once again, the Russians were the first to move forward with time use research. More than a hundred studies were carried out between 1958 and 1968 (Pronovost, 1989, p. 74). At about the same time, public media companies in the UK, US and Japan started using the diary method to collect data

on media use and thus chart emerging activities such as listening to the radio and watching TV (Robinson & Converse, 1972).

The methodology of time use research and the diary method to collect data in a reliable and valid way have secured their place in policy and scientific research.

Second era: Standardization and conceptuality

The real international breakthrough for time use research, though, came from the *Multinational Comparative Time-Budget Research Project*, funded by UNESCO and coordinated by Alexander Szalai. Between 1964 and 1966, respondents in 12 medium sized cities from different European countries were surveyed using the same diary format. The underlying goal was to understand and reduce the divide between Western-European and Eastern-European countries. The details and results of this study are described in the so-called "bible of time use research" *The Use of Time* (Szalai, 1972). The then-current decisions about the format of the diary and the organization of the fieldwork still have great resonance in contemporary time use research (Minnen & Glorieux, 2011).

For this project to succeed, the methodology of time use research had to be standardized to yield comparable results. This standardization entailed the acceptance of the diary methodology as the most reliable and most valid methodology to capture how people spend their time. The diary methodology consists of a chronological record of daily activities and their context such that daily life could be described in terms of the timing, duration, tempo, and sequences of actions. The American Sociological Association had the same providence and founded the Task Force on Time Budget Research in 1965 with the aim of new and, above all, comparable data collections. One of the results was the American Heritage Time Use Study (AHTUS) led by John P. Robinson, which provided a detailed understanding of how Americans use their time. It showed that Americans generally spend significantly more time on work-related activities than measured by stylized questionnaires, but also that those who work less than average underreport and those who work more than average overreport in the time diaries.

Although the diary methodology became standardized, the methods varied. Szalai used the time diary method, while AHTUS used the yesterday recall

method, also known as the daily reconstruction method. Questions about what is the most reliable and (internally) valid method must therefore be assessed in the context of the research question. A choice between methods is then based on the choice between intra- and inter-person variation, more participants versus more diary days per participant, and the need for detail (activities and spatial and social context). It would appear that when the goal is to collect data with a focus on inter-subject variation and comparisons between groups of respondents, continuous recording of the time diary method seems more appropriate, while with the focus on within-person variation and a broader activity definition, daily recall records are likely to be a better strategy.

Third era: Harmonisation and operationality

The success of the diary methodology to produce reliable and valid estimates of how people spend their time led the United Nations to further popularize time use research in the 1980s. A clear added value of this research at that time is that it can provide a picture of the invisible and largely undervalued unpaid work (Juster & Stafford, 1991, p. 472; Robinson & Godbey, 1997, p. 97). The diary methodology allows to include unpaid work in the System of National Accounts. This made visible the contribution of women to the economic development of societies, which should not be underestimated (Gershuny, 2003; Juster & Stafford, 1991).

For this to happen, time use research needed to be harmonized across different countries and operationalized at a much larger scale. Europe took a leading position in the *pre*-harmonization of time use research. Under the leadership of Eurostat and after a decade of debates and decision making, the guidelines on Harmonized European Time use Surveys (HETUS) were established (Eurostat, 2020). These guidelines include instructions for the diary method (e.g., activity coding list, interval of time recording, number and assignment of diary days, length of observation period) but also for the construction of the sample selection, the training of interviewers, and data imputing and cleaning. Eurostat promoted time use research in its Member States and associated countries, which resulted in comparable datasets of 20 countries several of which are available in different waves.

Not much earlier another long-standing dynasty of collecting time use data started in 1975 in The Netherlands. With intervals of five years and until 2005 the Netherlands Institute for Social Research together with Statistics Netherlands monitored the time use of the Dutch for eight waves in a row to report on the trends in the daily life of their inhabitants, using a largely unchanged design. The study setup differed from the Eurostat guidelines mainly in using a pre-coded activity list, but also in the length of the observation window (one week per participant) as well of the stretch of the fieldwork (only during two to four weeks in March/October/November) (Breedveld & van den Broek, 2011).

Less than a decade later, the Dutch diary method provided important input for one of the first academic research groups to start with their time use surveys. The Research Group TOR (Tempus Omnia Revelat – *Time Reveals Everything*) was established in 1982 and conducted small scale time use studies in 1984 (TOR84) (Elchardus, Enhus, Glorieux, & Van Rossem, 1984; Elchardus & Glorieux, 1987; Glorieux, 1995) and in 1988 (TOR88) (Elchardus & Glorieux, 1989; Elcardus & Glorieux, 1999; Elchardus, 1996). These studies were focussed on shorter working time arrangements, deprivation, the meaning of work, and more in general the conception and the meaning of time. As a result, the design of the booklet was strongly focused on collecting contextual data on various dimensions. Based on this experienced and what happened in the Netherlands, a new data collection was setup in 1999 (TOR99), with a representative sample of the Flemish population (Flanders and Dutch speaking inhabitant of the Brussels-Capital Region) between 16 and 75 years old and running from mid-April to mid-July and from beginning of September to mid-October. Again, a pre-defined activity list and extra context questions per activity on the location, mode of transport and the social context of the activity remained. Following the Dutch time diary, the TOR99 used a 7-day registration period. This study was repeated in 2004 (TOR04), albeit the lower age limit was now set at 18 years old (Glorieux, Koelet, Mestdag, Moens, Minnen, & Vandeweyer, 2006).

In 2005/06 The Netherlands started to follow more strictly the HETUS guidelines by letting respondents report in their own words and by collecting data over a period of one year. The 7-day period was kept. A comparison between the two methods was made afterwards (Kamphuis, van den Dool, van den Broek, Stoop, Adelaar, & de Haan, 2009). The comparison shows that despite the

considerable differences between the two methods quite similar time use results were produced, at least in broader terms. About 5% of the 168 hours covered different activities between the two methods. Otherwise, looking to some quality indicators it shows that the HETUS-version came out better than the original Dutch version: less unspecified time, more episodes per day, more short episodes and less missings on the primary activity. The results on the validity of the context questions were somewhat ambivalent.

Fourth era: Mode shift and modernization

The idea to develop and implement an online data collection tool is characteristic for the fourth era of time use research. This era signifies a change in the mode of collecting time use data under the wings of the process of modernization. This process is not only fueled by technological developments and the increasing use of ICT in an increasingly connected world but is also seen as an answer to the waning willingness to participate and the high costs of time use research (Minnen, Rymenants, Glorieux, & van Tienoven, 2023). Essentially, this era begins by progressing through the previous three eras, but at a much faster pace. Just not on the level of time use methodology, but on the level of a mode shift; of the way how time use data are collected.

At this point, the standardized and harmonized diary method consists of an interviewer conducting household and individual surveys and leaving behind two paper time-diaries per eligible household member with the dates on which both time-diaries must be completed. One diary concerns a weekday, and one diary concerns a weekend day. All eligible household members need to complete the same days. The interviewer also leaves behind a drop-off questionnaire, which is to be completed by all eligible household members after the time-diaries. At a prearranged date, the interviewer returns to check and collect the time-diaries and the drop-off questionnaire. The paper-and-pencil mode of data collection has at least three downsides: (1) it is very expensive due to interview visits, printing costs, and imputing and coding costs, (2) it is very burdensome for respondents to participate, and (3) processing the data is time consuming and does no longer answer to the quest of understanding the rapidly changing context of modern societies (Cai & Zhu, 2015).

As time use research yields highly valid and reliable data, rich in information and context, and allows comparison of regions, countries and cultures, the momentum of the "Big Data" challenged to modernize and digitize time use research to collect data in increasing volumes, with more speed and with more variation. Eurostat is again an accelerator in promoting this modernity showing their ambition in the DGINS Wiesbaden Memorandum 2011. This Memorandum is grounded in Eurostat's responsibility to provide reliable, valid, and comparable statistical information to the institutions of the European Union (EU). An important tool to achieve this is to promote - as far as possible - harmonized statistical methods in all Member States. The memorandum emphasizes the need for better data, both in terms of coverage and comparability. The process of modernizing the production of official statistics should contribute to this by a mode shift from paper-to-pencil to online data collection to improve the responsiveness of respondents and the effectiveness of collecting data.

Development of online data collection tools

Bonke and Fallesen (2010) were among the first to develop a prototype for data collection via a web interface, with funding from the Rockwool Foundation of Denmark. In addition to being online, the diary featured a search tag selectable pre-code list and reports for a weekday and a weekend day divided into 10-minute time slots. The first (native) mobile application on a smartphone was created in 2011 by the Netherlands Institute for Social Research, with the HETUS guidelines in mind. The app was tested in a feasibility study with a representative sample of the adult Dutch population via the LISS panel in 2012 (Sonck & Fernee, 2014). The backbone of the application was reporting on pre-stated HETUS-based activities in 10-minute intervals over two fixed days (weekday and weekend day) along with place and transport context and social context of the activity. The app also got into reality mining by using prompts to ask mood questions at different times of the day.

In 2012 and after receiving a Hercules grant, the Research Group TOR of the Vrije Universiteit Brussel compiled two paper-and-pencil methods into one web-based environment. These two methods are the TOR-method of the TOR84, TOR88, TOR99 and TOR04 studies and the HETUS-method of the 1999 and 2005 Belgian time use surveys conducted by Statistics Belgium. In 2013, the Modular

Online Time Use Survey (MOTUS) web application was tested in a yearlong large-scale data collection parallel to the then ongoing third round of the Belgian time use survey. This concurrency made it possible to differentiate between two designs and modes with a paper-and-pencil, 2-day diary, 10-minute intervals, post-coding, and household mapping (BTUS) on the one hand, and an online, 7-day diary, continuous time recording, pre-coding and individual sampling on the other hand. Compared to the Danish and Dutch development, MOTUS also takes into account the full ecosystem of a time use survey where respondents are invited to complete their questionnaires and diaries in the same application without the help/support of an interviewer as all communication is managed by the platform (Minnen et al., 2014). These strengths were further embodied in future updates and releases of MOTUS. MOTUS currently combines a web application with a mobile application.

More recently the Centre for Time Use Research of the London School of Economics (at the time located at Oxford or University) and the Time Use Laboratory at the University of Maryland developed and released their online implementation. CTUR's web-based CaDDI tool takes its name from its Click-and-Drag principle of reporting an activity by "dragging a pointer across a horizontal timeline bar to create a record of the duration" (Sullivan, Gershuny, Sevilla, Walthery, & Vega-Rapun, 2020, p. 8). The activity list to choose from is a light version with broader categories than known from the HETUS activity list, but the context questions are similar. These context details only populate after all the primary activities throughout a day have been registered instead of per primary activity as in the previous applications. In line with the HETUS guidelines, recording is done in 10-minute intervals on a weekday and a weekend day.

The Time Use Laboratory starts from the Daily Reconstruction Method where, as the name suggests, respondents are asked to reconstruct their previous day. They use mytimeuse.com for this, which is a responsive web application developed with a grant from the National Science Foundation (Rinderknecht, Doan, & Sayer, 2022). Activities are recorded continuously (i.e., not in intervals but with exact start and end times) and include a primary activity and the associated context of a secondary activity (as a percentage of the primary activity) as well as where the time was spent and with whom. The context was further expanded by also scaling emotions in the activity. The selectable activities are presented to the

respondent as they type the activity into a search field. Respondents may keep their own wording as a custom activity, which will be saved to the list for later use, but they must relate it to an already existing activity from the list.

At the University of New England in Australia, Michael Bittman continued to work with the beeper method. The "Intensive Hour" app or Random Time Sampling (RTS) "beeps" respondents at random times asking them to reconstruct the past hour into ten 6-minute entries (Wong et al., 2022). The advantage of this method is that it is less invasive and allows, in particular, to survey time spent on paid work in more detail. The HETUS guidelines only examine paid work in broad, generic categories to prevent participation in time use research from leading to conflicts in the workplace. In addition, recording randomized, beeped hours of work time prevents sensitive company information from being obtained or individuals from being monitored.

Another application worth mentioning is the i-log application from the University of Trento, available for smartphones with Android and recently also with iOS as an operating system (Zeni, Bison, Reis, Gauckler, & Giunchiglia, 2020). This application aims to collect sensor streams in a passive way (i.e., mainly to determine the position of the device, but also to capture para-data) in addition to asking respondents to actively fill out a small questionnaire and then a time diary for a weekday and a weekend day. Activities are selected from a pre-coded activity list, and context recording is similar to HETUS guidelines. No additional activities can be registered. Like the Danish, Dutch, Belgian and American application, each episode repeats the same logic of questions over and over. The application started as part of an EU Horizon project and was used, among others, as part of the Big Data Hackathon 2019 in Brussels.

Besides the above more initiatives exist and went into production as there are (e.g.) the Canadian (Statistics Canada; https://www.statcan.gc.ca/en/survey/household/4503) and Finnish (Statistics Finland; https://www.stat.fi/en/surveys/aja) online time use surveys and can be seen as variations on the given examples. Other initiatives took the route to develop a progressive web application rather than a web, native or hybrid solution so that a web diary performs equally well on larger and smaller screens like those of a Smartphone. Again, other initiatives start to develop from the discussion on light diaries (Houle, Benes, & Vaca Trigo, 2022).

There are many more applications that started a development path, but many did not reach the pilot or test phase, let alone were used in production. Only a few developments have been used multiple times, for multiple research questions, with different stakeholders. An overview can be found via the Eurostat inventory.[1] More importantly, all these different applications mean that the internal validity and comparability of the diary method have once again been called into question. While the method itself has remained relatively standardized and harmonized (i.e., in terms of activity lists, recording intervals, context query, diary days, etc.), the mode is anything but.

Data collection process

Having new tools with which respondents participate is only half the story; how studies are designed, data is collected, and databases are processed, and overall, how the entire data collection process is organised in an effective manner that saves costs in terms of budget and personnel is the other half.

One way to guide this process in a standardized way is to document these processes following an agreed model. The GSBPM or Generic Statistical Business Process Model is a (well-) known architecture developed by UNECE, Eurostat and OECD and aims to communicate how official statistics are produced in a standardized manner (Kuonen & Loison, 2019). The GSBPM considers a total of eight phases of which the design phase (phase 3), the construction phase (phase 4) and the process phase (phase 5) relate to the setup and implementation of the data collection itself, including the handling of the data files. This in particular also applies to time use research with its complex setup (Minnen, Rymenants, Glorieux, & van Tienoven, 2023).

Another way to create efficiency is through the development of a platform that incorporates (at least parts of these) various phases of the GSBPM but which is modular enough in design to meet country-specific requirements, yet at the same time harmonized enough to ensure comparability (Glorieux & Minnen, 2009; Salgado, Esteban, Novás, Saldaña, & Sanguiao, 2018; Stodden, 2014). Providing

1 Accessible through https://webgate.ec.europa.eu/fpfis/wikis/display/ISTLCS/TUS+TOOLS+MENU.

configurable time use design options within a platform to NSIs and their researchers is a way to standardize complexity.

However, it does not stop here, because to support standardization it is also important that these platforms can be shared. Shareability here refers to the ability of a platform to be integrated into a data collection architecture and/or process of another institution (e.g., NSI, academic institution, …). The simpler the implementation, the better the environment can be shared. A platform that is modular and has a high degree of (re)use, sharing and collaboration has overall lower costs in development and maintenance. Shared platforms mapped to a business architecture such as the GSBPM combine the power of modularity (internal validity) and power of standardization (reliability).

And it does not stop here either. The modernization of data collection based on technological progress and digitization has brought aspects like privacy and data security explicitly to the fore. When collecting data, personal data is essential, visible and stored in databases. In addition, the output of a time use survey leads to a detailed collection of activities timestamped and contextualized with additional personal information. Especially in light of the decreasing willingness of the population to participate, data collectors can no longer act overnight.

One way to answer this is to shift from "privacy by legal" to "privacy by design". For data collection platforms, this means that privacy and data security are taken into account from the very beginning of the platform's design. Privacy and security are an essential part of the development of the platforms, in the back office but also in the front office applications (web, mobile) to support participants' confidence to start with a set of minimal requests (privacy by default) and in the continuation of building up confidence proceed to collecting more highly detailed data even through sensors or the merging with other databases. Tools with a higher resolution of privacy and security will benefit from better response rates and data accuracy compared to tools that only declare privacy and security from legal documentation.

This is where time use research resides and the challenges of the fourth era are clear: developing on online tool that is modular yet harmonised, shareable yet standardized, smart yet secure. This is also where this PhD ends: in providing possible answers and solutions to these challenges. However, for the beginning of it, we have to go back to somewhere in the middle of the third era.

Mapping time use research

While there is a lot of consensus about the usefulness and qualities of time diary *methodology* to capture valid and reliable data on the daily lives of people, there is less consensus about (the design of) the *method* by which and the way in which it is collected (i.e., *mode*). Hence, this PhD is concerned with the differences in methods to capture information and with the change in modes to collect time use data, particularly, mode shift to online data collection, which reopened the design discussion in favor of a configuration of different time use diary parameters rather than the agreeing on a composite set of parameters. This output is produced over a period of about 15 years, where modernization of technology started to have and still has a large impact on mapping time, and the way time use research evolves.

Comparing two methods

The starting point of this PhD is the situation in Belgium where two methods are employed to collect time use data. The differences relate to both the question of validity and reliability. The first method follows the Harmonised European Time Use Survey guidelines recommended by Eurostat (Eurostat, 2020). Since the turn of the century Eurostat promotes these guidelines to harmonize the data collection strategy and processing of time diary data within its Member States. The goal is to arrive at reliable and comparable data to study cultural differences between countries and regions. Characteristic to this design is that respondents are asked to write down what they have done in their own words, for one weekday and one weekend day in a diary. Activities, primary and secondary, are registered per 10 minutes, and context is added by providing information on the location or transport mode, the use of ICT and with whom the activity took place (in categories). Every context can be registered separately from the other. A list of activities is used to post-code the descriptions written out in the diary. HETUS also recommends including the household level and the participation of all household members aged 12 years and over. This design was used by Statbel (current name) to collect data for 1999, 2005 and 2013 (Glorieux, Minnen, van Tienoven, Daniels, Weenas, Deyaert, Mészáros, & Van den Bogaert, 2015), with the Research Group TOR as their valorization partner.

As introduced higher up, the second time diary method has been designed by the Research Group TOR of the Vrije Universiteit Brussel and was used for data collection in 1999 and 2004. The diary layout is a booklet with every 2-pages (left/right) a new episode. An episode involves the registration of a primary and secondary activity (code), and the selection of a category answers to questions related to the place (if), the mode of transport (if), if someone else was present, who was present (if), and the motivation to perform the activity. Episodes were registered continuously on the minute precise for seven consecutive days (one week). Participants were individuals between 16 (18 in 2004) and 75 years old.

Both studies employed interviewers to invite and visit the participants two times, the first time to conduct a questionnaire on the individual and household level, and the second time to check and collect the diary.

A FWO funded project (*Tijdsbestedingsonderzoek in kaart gebracht* - Mapping Time use Research; 2008-2012) provided funding to compare and map the differences in validity and reliability in time use research in order select the best parts of the two methods. The conclusions of the project ran concurrently with the introduction of online research in a web browser and within applications that run on a smart device. Trusting the great possibilities of the methodology of time diary research and the great benefits of the outcomes for different research disciplines, the idea grew to use these findings as user stories to develop and implement an own online data collection tool. With the expertise on collecting and valorizing time use data within TOR it was immediately clear that both input (research questions, policy requests) and output requests (results and dissemination) show a large variation and that with the scope of further modernization this spread in requirements would even grow enormously.

Modular Online Time Use Survey

For the Research Group TOR, obviously, the business requirement and the main objective of an online data collection tool needed to be a modular platform that is able to handle the different requests of current and future study designs. At the same time, we opted to parameterize the different settings of a time use diary method and to expand the possibilities in capturing the context on what people do. This setup would make it possible to configure a different time diary design for each different study, for example, a HETUS-based method and a TOR-based

method. In this way the question of validity and reliability would become a matter of selecting the best design options (diary/fieldwork) related to the research question at hand. We did not limit the modularity to the time diary design, but expanded it to other aspects that are part of a time use research setup: questionnaires, communication, respondents, database cleaning, ….

Eventually, this idea culminated in a proposal submitted to the Hercules Foundation (Development of an infrastructure for a continuous Modular Online Time Use Survey, 2012-2016) which funds the development of medium and large-scale research infrastructures. In our case, the development of an infrastructure for a continuous Modular Online Time Use Survey (MOTUS). The first version of the MOTUS-platform resulted in a back-office, and a front-office running as a web application in a browser. Infrastructures have the ability to easier replicate studies, and so the reliability of recurring studies would be supported. The project included the valorization of the new tool by conducting the first online time use research in Belgium in sync with a traditional paper-and-pencil data collection run by Statbel for reasons of comparison. Key assets were the registration of activities in a diary for one week, and the tailored coupling of context questionnaire to predefined activities. Running a fieldwork successfully for one year where all interactions with the respondent run automatically via the platform sharpened the interest to further invest into the MOTUS-platform. Extra knowledge acquired from projects within the VUB and with external parties made us realize that not only the respondent but also the researcher should be better supported. The next aim, thus, was not only to refactor the front-office but also the back-office of MOTUS.

Habits tell more than words

The need for a modular and shareable platform of which privacy and security are an integrated part, formed the business idea and a blueprint of UI/UX (user interface/user experience) for both the back- and the front-office. New funds were acquired through a Launch call of Innoviris (OASIS, 2015-2018). This funding mainly focusses on transferring the knowledge outside of academics, and if promising to establish a spin-off company. Another key asset is the promise to collect data according to the academic *rigor*, via MOTUS and so keeping quality (and so validity and reliability) high. To market the MOTUS data collection

platform in a spin-off company, we realized a redesign of the back-office by translating all steps in setting up a time use study to so-called builders: a survey builder, a diary builder, a communication builder etcetera with the research flow or study builder being the main builder as it brings all research components together in one sequential flow. Next, to get a grip on the market we build a portfolio to show the large possibilities, and underlying values, of online time diary research via mobile and web applications. Data were collected in 2018 from about 10,000 teachers who completed a diary for one week on their working tasks. With the benefit of two extra funding extensions hbits CV was finally established as a spin-off of the Vrije Universiteit Brussel on the 30th of October 2018. The project resulted in a business and financial plan and a new version of the platform.

From then on, the MOTUS data collection platform goes two ways. On the one hand MOTUS continued to support academic time use research at the VUB. On the other hand, MOTUS started a process of continuous development cycles by hbits to service (also) other parties outside academia, to open-up MOTUS to other statistical domains and to incorporate new data streams (e.g., sensor data). The latter resulted in multiple iterations of MOTUS including redesigns of the UI/UX of the mobile and web application, a shift to the PHP framework Laravel (i.e., a web application framework), the inclusion of Household Budget Survey, the development and connectivity of microservices to capture external data, and the development and implementation of a container-based installation technology. With this technology, barriers were created between the components of MOTUS and to deliver better privacy, security, maintainability, scalability and high availability. Apart from the business opportunities created, all of these requirements are also essential to let MOTUS grow as a European Statistical Service (ESS) platform to be used by NSIs to collect data for official statistics. Not only because the platform supports many of the phases of the statistical process as described within the GSBPM, but also because it meets the harmonization requirements of modularity and shareability while at the same time incorporating privacy and security by design.

This PhD is the result of a long journey that started in 2008 aiming to find the most valid and reliable design in conducting time use research. It has been a journey that included conducting fieldwork, of coding, cleaning, valorizing,

disseminating data, of writing reports, project proposals, guidelines, and academic publications, and of developing, testing, redesigning, and, eventually, marketing the online data collection platform MOTUS. Throughout this journey, I researched many topics related to time use methodology, time use methods, and time use data collection modes, such as the pre- and post-coded activity list, the length of a diary, the grain of precision, registration in episodes or with independent contexts, effects on parameters of time based on a survey question, a work grid and a diary, quality indicators, intra-household correlation, inter-person variation, representativeness, recall bias, spreading and postponing of diary days, web and mobile registration, weighting on types of the day, months and seasons and many more did pass somewhere somehow. It is not possible to address all these topics within this dissertation. Appendix A includes an overview of the projects that I was part of and the publications that I co-authored and the topic(s) they investigated.

In this dissertation I included five chapters that highlight my scientific contribution to conducting time use research. The next three chapters relate to the era of harmonization and operationality – the era where it all started for me. Chapter 2 is about the quality of time use data collected from a 2- and 7-day diary and a weekly work grid. Chapter 3 is about the added value of time use data collected on the household level to get an understanding of the intra-household time relations. Chapter 4 is about the timing of work and the underlying working patterns that can be derived from a continuous reporting of activities.

The following two chapters relate to the era of mode shift and modernization – the era where I find myself in right now. Chapter 5 is about the first version of MOTUS and the first large-scale, online time use data collection of 2013. Chapter 6 is about the second version of MOTUS and highlights how MOTUS meets the criteria of modularity, shareability, privacy and security and thereby improves on the principles of the European Statistics Code of Practice such as the respondent burden, cost efficiency, accuracy and reliability, and timeliness and punctuality (Eurostat, 2018). These five chapters are based on peer-reviewed articles or book chapters of which I was the first author.

I conclude this dissertation with a final chapter in which I forecast what the next era of time use research will look like and what research agenda will take us there.

References

Bevans, G. E. (1913). *How working men spend their spare time*. New York: Columbia University Press.

Bonke, J. (2005). Paid work and unpaid work: Diary information versus questionnaire information. *Social Indicators Research, 70*, 349-368.

Bonke, J., & Fallesen, P. (2010). The impact of incentives and interview methods on response quantity and quality in diary-and booklet-based surveys. *Survey Research Methods, 4*, 2, 91-101.

Breedveld, K., & van den Broek, A. (eds.) (2001). *Trends in de tijd. Een schets van recente ontwikkelingen in tijdsbesteding en tijdsordening*. Den Haag: Sociaal Economisch Planbureau.

Cai, L., & Zhu, Y. (2015). The challenges of data quality and data quality assessment in the big data era. *Data science journal, 14*.

Durkheim, E. (1965 [1912]). *The Elementary Forms of the Religious Life*. New York: The Free Press.

Elchardus, M. (1996). De gemobiliseerde samenleving. Tussen de oude en de nieuwe ordening van de tijd. Brussel: Koning Boudewijnstichting.

Elchardus, M., Enhus, E., Glorieux, I. & Van Rossem, R. (1984). Tijdsbesteding en maatschappelijke integratie van werklozen. Centrum voor Sociologie, Vrije Universiteit Brussel, Onderzoeksgroep TOR (598 pp).

Elchardus, M., & Glorieux, I. (1987). De tijd als zingever. *Tijdschrift voor* Sociologie, 8(4), 53–87.

Elchardus, M., & Glorieux, I. (1989). The generalized meanings of time use: replication and progress report. In International Association for Time Use Research (eds.), Time use studies world wide (pp. 209–229). Sofia: Socio Consult.

Elchardus, M., & Glorieux, I. (1999). What does your time mean? Some arguments for including indicators on the meaning of time use in time budget research. In The 1999 IATUR conference: 'the state of time use research at the end of the century', 6- 8 October. Colchester, UK.

Eurostat. (2018). *European statistics code of practice: for the national statistical authorities and Eurostat (EU statistical authority)*. Luxembourg: Publications Office of the European Union.

Eurostat. (2020). *Harmonised European Time Use Surveys (HETUS) – 2018 guidelines – Re-edition*. Luxembourg: Publications Office of the European Union.

Fisher, K., Gershuny, J., Gauthier, A. H., & Victorino, C. (2000). *Exploring new ground for using the Multinational Time Use Study*. ISER Working Paper Series, No. 2000-28, Retrieved from https://www.econstor.eu/handle/10419/92133 on 9 June 2023.

Frazis, H., & Stewart, J. (2010). Why do BLS hours series tell different stories about trends in hours worked? In *Labor in the New Economy* (pp. 343-372): University of Chicago Press.

Gershuny, J., & Sullivan, O. (1998). The sociological uses of time-use diary analysis. *European sociological review, 14*(1), 69-85.

Gershuny, J. (2003). *Changing times: Work and leisure in postindustrial society*. Oxford: Oxford University Press.

Gershuny, J. (2012). Too many zeros: A method for estimating long-term time-use from short diaries. *Annals of Economics and Statistics/ANNALES D'ÉCONOMIE ET DE STATISTIQUE*, 247-270.

Glorieux, I. (1995). *Arbeid als zingever: Een onderzoek naar de betekenis van arbeid in het leven van mannen en vrouwen.* Brussel: VUBPress.

Glorieux, I., Koelet, S., Mestdag, I., Moens, M., Minnen, J. & Vandeweyer, J. (2006). *De 24 uur van Vlaanderen. Het dagelijkse leven van minuut tot minuut.* Tielt: LannooCampus.

Glorieux, I., & Minnen, J. (2009). How many days? A comparison of the quality of time-use data from 2-day and 7-day diaries. *Electronic International Journal of Time Use Research, 6*(2), 314-327.

Glorieux, I., Minnen, J., van Tienoven, T.P., Daniels, S., Weenas, D., Deyaert, J., Mészáros, S., & Van den Bogaert, S. (2015). Technical Report TOR13. Modular Online Time Use Survey (MOTUS): Fieldwork and response analyses. Vrije Universiteit Brussel, Onderzoeksgroep TOR (32 pp.)

Harvey, A. S. (1993). Guidelines for time use data collection. *Social Indicators Research, 30*, 197-228.

Honoré, C. (2005). *In praise of slowness: Challenging the cult of speed*: HarperCollins Publishers.

Houle, P., Benes, E., & Vaca Trigo, I. (2022). Minimum Harmonized Instrument for the Production of Time-Use Statistics. Accessed 8 June 2023 [https://unstats.un.org/unsd/statcom/53rd-session/documents/BG-3h-TimeUseStats-rev2-E.pdf].

Huysmans, F., Lammers, J., & Wester, F. (1997). Radioluistertijd: Dagboekmeting, yesterday-meting en directe schattingen vergeleken. *Tijdschrift voor Communicatiewetenschap, 25*(3), 253-276.

Juster, F. T. (1986). Response errors in the measurement of time use. *Journal of the American Statistical Association, 81*(394), 390-402.

Juster, F. T., & Stafford, F. P. (1991). The allocation of time: Empirical findings, behavioral models, and problems of measurement. *Journal of Economic literature, 29*(2), 471-522.

Kamphuis, C., van den Dool, R., van den Broek, A., Stoop, I., Adelaar, P. & de Haan, J. (2009). *TBO/eu en TBO/nl: een vergelijking van twee methoden van tijdsbestedingsonderzoek.* Den Haag: Sociaal en Cultureel Planbureau.

Kuonen, D., & Loison, B. (2019). Production processes of official statistics and analytics processes augmented by trusted smart statistics: Friends or foes? *Statistical Journal of the IAOS, 35*(4), 615-622.

Le Play, F. (1877). *Les ouvriers européen*. Tours: Alfred Mame et fils.

Minnen, J., & Glorieux, I. (2011). Two days a week? A comparison of the quality of time-use data from 2-day, 7-day diaries and a weekly work grid. In J. Carrasco, S. Jara-Díaz, & M. Munizaga (Eds.), *Time use observatory* (pp. 105-118). Santiago de Chile: Grafica LOM.

Minnen, J., Rymenants, S., Glorieux, I., & van Tienoven, T. P. (2023). Answering current challenges of and changes in producing official time-use statistics using the data collection platform MOTUS. *Journal of Official Statistics*, Online First.

Pronovost, G. (1989). The sociology of time. *Sociologie Contemporaine (La), 37*(3), 1-124.

Reeves, M. S. R., & Reeves, M. P. (1913). *Round about a Pound a Week*: G. Bell and sons, Limited.

Rinderknecht, R. G., Doan, L., & Sayer, L. C. (2022). MyTimeUse: An Online Implementation of the Day-Reconstruction Method. *Journal of Time Use Research, 1*.

Robinson, J. P., & Converse, P. (1972). Social change as reflected in the use of time. In A. Campbell & P. Converse (Eds.), *The human meaning of social change* (pp. 17-86). New York: Russell Sage Foundation.

Robinson, J. P., & Godbey, G. (1997). *Time for life: The surprising ways Americans use their time*. University Park, PA: Penn State Press.

Salgado, D., Esteban, M. E., Novás, M., Saldaña, S., & Sanguiao, L. (2018). Data organisation and process design based on functional modularity for a standard production process. *Journal of Official Statistics, 34*(4), 811-833.

Scheuch, E. (1972). The time budget interview. In A. Szalai (Ed.), *The use of time* (pp. 69-87). The Hague: Mouton.

Schöps, M. (1980). *Zeit und Gesellschaft.* Stuttgart: Ferdinand Enke Verlag.

Sonck, N., & Fernee, H. (2014). *Using smartphones in survey research: a multifunctional tool. Implementation of a time use app; a feasibility study.* The Hague: Netherlands Institute for Social Research.

Sorokin, P. A., & Berger, C. Q. (1939). *Time-budgets of human behavior* (Vol. 2): Harvard University Press.

Sorokin, P. A., & Merton, R. K. (1937). Social time: A methodological and functional analysis. *American Journal of sociology, 42*(5), 615-629.

Stinson, L. L. (1999). Measuring how people spend their time: a time-use survey design. *Monthly Lab. Rev., 122*, 12.

Statistics Canada (https://www.statcan.gc.ca/en/survey/household/4503). Accessed 8 June 2023.

Statistics Finland (https://www.stat.fi/en/surveys/aja). Accessed 8 June 2023.

Stodden, V. (2014). The reproducible research movement in statistics. *Statistical Journal of the IAOS, 30*(2), 91-93.

Sullivan, O., Gershuny, J., Sevilla, A., Walthery, P., & Vega-Rapun, M. (2020). Time use diary design for our times-an overview, presenting a Click-and-Drag Diary Instrument (CaDDI) for online application. *Journal of Time Use Research*.

Szalai, A. (1972). *The use of time: Daily activities of urban and suburban populations in twelve countries*. The Hague: Mouton.

Te Braak, P., Van Droogenbroeck, F., Minnen, J., van Tienoven, T. P., & Glorieux, I. (2022). Teachers' working time from time-use data: Consequences of the invalidity of survey questions for teachers, researchers, and policy. *Teaching and Teacher Education, 109*, 103536.

Wong, S., Harrison, L. J., Gibson, M. L., Press, F., Bittman, M., Crisp, K., & Ryan, S. (2022). Measuring early childhood educators' time at work using an electronic random time-sampling approach. *International Journal of Research & Method in Education*, 1-16.

Zeni, M., Bison, I., Reis, F., Gauckler, B., & Giunchiglia, F. (2020). Improving time use measurement with personal big data collection–the experience of the European Big Data Hackathon 2019. *Journal of Official Statistics, 37*(2), 341-365.

Zerubavel, E. (1982a). *Hidden rhythms: Schedules and calendars in social life*. Chicago: The University of Chicago Press.

Zerubavel, E. (1982b). *Hidden rhythms. Schedules and calendars in social life*. Chicago: The University of Chicago Press.

Zuzanek, J. (1980). The Work-Leisure Relationship in Soviet Sociological Discussion. *Canadian Slavonic Papers, 22*(1), 122-128.

This chapter is based on Minnen, J. & I. Glorieux (2011). Two days a week? A comparison of the quality of time-use data from 2-day, 7-day diaries and a weekly work grid. In: Carrasco Juan Antonio, Jara-Diaz Sergio & Munizaga Marcela (Eds.), Time Use Observatory (pp.105-118). Santiago de Chile: Grafica LOM.

CHAPTER 2

Two days a week? A comparison of the quality of time-use data from 2-day, 7-day diaries and a weekly work grid

Time-use survey in a comparative context

The first and to this day most important milestone in comparative time-use research is the Multinational Time Use Study directed by Alexander Szalai. The results of this cross-national time-use survey was reported in the bible of time-use research 'The Use of Time' (Szalai 1972). This book also was the first to outline a number of conventions with regard to the methodology of time budget research. After more than 40 years these methodological guidelines still are the main reference in time-use research and therefore its influence can hardly be overestimated. Given that chances to ever replicate a big scale international study like this are very small, two alternative scenarios for international co-operation in time-use research and comparative analysis exist: (1) merging existing national data sets into one common data base and (2) the co-ordination of the design and conduct of future national studies to afterwards facilitate merging them into a common data set (Harvey 1993). The first scenario is the one Jonathan Gershuny followed when he started the 'Multinational Longitudinal Time Budget Archive' (Gershuny et al. 2000). EUROSTAT took up the challenge for the second option. Under the impulse of the International Association for Time-Use Research (IATUR) it established a taskforce and finally developed 'Guidelines on Harmonized European Time-Use Surveys (HETUS)' (European Commission 2004; 2009). Since the turn of the century many EU-member states and non-member states conducted time-use surveys that followed the HETUS-guidelines. This resulted in dozens of new more or less comparable data sets. The HETUS-guidelines imply amongst others, the sampling procedure, the number and procedure of selecting diary days, the diary format, the field work period and the

minimal background information asked for in the individual and household questionnaires.

In this contribution we discuss the recommendation concerning the number of diary days. In the HETUS-guidelines it is recommended "…to use two diary days, i.e. one weekday (Monday-Friday) and one weekend-day (Saturday and Sunday). The use of only one diary day will also be acceptable, but with only one diary day it is impossible to get any idea of the intra-personal variation. The general rule from this point of view is that the more diary days the better. Considering also the problem of increasing non-response with increasing respondent burden a reasonable choice is two or three diary days." (European Commission 2004; 2009). We will argue that instead of recommending two diary days, it might have been better to opt for a 7-day diary.

Arguments for and against seven days

Activity patterns are structured in terms of socially relevant cycles of which the day, the week, the year and the life cycle seem to be the most important ones in modern Western cultures (Zerubavel 1979). The day has a certain structure and the timing of activities in the daily cycle is socially relevant. Most people sleep at night, get up in the morning, eat at noon, work between 9 a.m. and 5 p.m., spend the evening in leisure, … So, if we want to get a picture of daily life, we literally need to have a view on the whole 24-hours or an entire day. But given the differences between days, especially the week-weekend contrast in Western societies, it is recommended in the EUROSTAT-guidelines to have at least one weekday and one weekend day.

However, with only two diary days, part of the variation in daily behaviour remains invisible. Activities like visiting family, doing sports, shopping, cleaning the house or other household tasks or odd jobs, going to the pub, going to a club, watching football, … are often done on specific days of the week (Zerubavel 1985) and as such, the study of an entire week cycle seems to be more appropriate. Many researchers acknowledge the advantages of increasing the number of diary-days, since "… [it] reduces the important dimensions of measurement error, costs and the usefulness of the data for the analysis of subgroups …" (Harvey 1993). Harvey refers to Gershuny's argument that "… due to intra-person variance longer diaries […] give significantly more accurate time estimates than shorter diaries do"

(Harvey 1993). After some statistical tests Gershuny (in Harvey 1993) concluded that for some activities and some particular social groups the 7-day data give much more precise estimates.

The kind of activities and the variability of time-use activities are also relevant in reference to the specific time-use parameters. Aggregated analyses on large enough samples of respondents who filled in one or two day-diaries covering all the seven days of the week, generally yield good estimates concerning the duration per respondent (i.e. average duration of activities for all respondents, irrespectively whether or not they did this activity during the period of registration). Hedges (1986) and Gershuny and Robinson (1988) found no real differences in the durations per respondent calculated on basis of a one-day and a seven-day data set.

This is totally different for estimates of the participation rate (proportion of doers) and the duration per participant (i.e. average duration of activities for the doers of this activity). Participation rates (and thus the related estimate for the duration per participant) are very dependent on the window of observation. Activities mainly following a daily rhythm are captured well by a one-day diary and reflect the weekly participation rate fairly good, but the participation rates of activities following a weekly rhythm are much lower when captured only on the basis of a one-day diary compared to a multi-day diary or seven-day data set. So, the participation rates for visiting friends, doing sports, going to the movies, … will be much lower in a sample of respondents who filled out a one-day diary as compared to a seven-day diary sample.

In general, we can conclude that almost all researchers definitely see the advantages of a longer period of observation and the seven-day diary. Critics even argue that one- or two-day diaries are not very valuable. Scheuch (1972), and Pas and Sundar (1995) argue that the high demands of scientific research cannot be accomplished unless multi-day cycles are captured. Evidence for this is found in a number of studies (see Arentze et al. 1997; Glorieux et al. 2008). Longer periods of observation offer better prospects for analyses, especially for the study of rhythms and activity patterns which typically follow cycles of multi-day duration and which are part of daily life (Gärling 1998).

If a seven-day diary has so many advantages, why did the EUROSTAT task force not recommend a seven-day diary? The main objections for enhancing the

number of observation days have to do with the validity of the data. More concretely, it is argued that a longer period of registration will negatively affect the response rate and the quality of diary-keeping.

In 1983-1984 Hedges (1986) performed an extensive methodological experiment where one-day and seven-day data were gathered in the same study. He did find a much higher response rate for the one-day survey. Gershuny and Robinson (1988) came to the same conclusion for different datasets in the UK, as well as Harvey for various international datasets (1993). Rydenstam (1995) as well as Bagatta (1995) reported a higher non-response in a Swedish and Italian pre-test for the Harmonized European Time-Use Survey as a result of the heavy burdens on the respondents when more than two days were recorded. The same conclusion was found in a pre-test in Korea (Shon 1999) and in Australian research (Australian Bureau of Statistics 1988). So, generally it is found that extending the window of observation lowers the response rates.

A second element of importance in the discussion on the number of diary-days is the quality of diary-keeping. Generally it is believed that the longer respondents have to keep a diary, the poorer the quality of these data. One indicator for this is the number of registered activities. Niemi (1983) found in Finish time-use data that the same amount of primary activities were reported on the first two registration days but from the third day on it dropped sharply. Väisänen (2009) used the data of the participating countries in the HETUS-project and found a decline between the first and second registration day.

Some point out that longer periods of observation cause fatigue or diminished motivation (Szalai 1972; Axhausen et al. 2002; Backor et al. 2007). So the increase of the number of diary days will lead to more inaccuracies. Golob and Meurs (1986) among others show evidence of a reduced quality after the second registration day. Arentze et al. (1997) on the other hand advocate that time-use literature is still not conclusive on this. Specialized transportation surveys show that respondents even report more trips once they are familiarized with the diary recording (Ampt and Richardson, 1994). Gershuny et al. (1986) and Harvey (1993) found no real change in more general studies, indicating that there is no strict evidence to conclude that the data quality reduces along the diary days.

Using time-use data of 1999 and 2004 from Flanders (Belgium) in which respondents filled out a diary during 7 consecutive days, we will examine some of

the advantages of a 7-day diary in comparison to a 2-diary as recommended in the EUROSTAT-guidelines. We will also investigate whether a longer registration period is harmful for the quality of the data. Although the EUROSTAT-guidelines recommend collecting 2 diary days, they also recommend registering working times for a 7-day period in a work grid. We will evaluate this instrument using the Belgian time-use surveys of 1999 and 2005 that more or are less were designed according to the EUROSTAT-guidelines.

Data

The data referred to as TOR9904 were gathered in Flanders (Belgium) in 1999 (n=1,474) and 2004 (n=1,780) both between April 15th and October 31st with a summer break from July 15th till August 31st. Respondents between 18 and 75 years old were asked to report their time-use activities in a diary using a pre-coded activity list. Each activity is specified with an exact beginning and ending time and context information related to the place, the means of transportation and the social context (Glorieux, Minnen and Vandeweyer 2005). The dataset was weighted (post-stratification) for sex, age and educational level.

The data referred to as TBO9905 were gathered in 1999 and 2005 from January, the 1st till December, the 31st among the Belgian population of 12 years or older. Since these time-use surveys followed the EUROSTAT-guidelines, respondents were asked to fill in a 2-day diary (one weekday and one weekend day). In 1999 8,382 individuals from 4,275 households participated in the survey. In 2005 this study was repeated among 6,400 individuals living in 3,474 households (Glorieux, Mestdag and Minnen 2008). In both surveys, the working population also filled in a work grid consisting of all seven days of the week and including the two diary days. The diary methodology of TBO9905 is at various points different from the TOR9904 survey (sampling procedure, diary format, number of diary days, registration period …). In the TBO9905 survey, for every ten minute episode respondents wrote down their activities in their own wordings. As in TOR9904 the context of an activity is reported by the respondents. The TBO9905-dataset was weighted simultaneously for individual and household characteristics.

Multi-day diaries, better estimates?

We use the TOR9904-data to test the differences between a 2-day and a 7-day registration. We selected 2 days, one weekday and one weekend day, out of the seven registered days to compare with the initial 7-day dataset. This way all other sample related differences are the same for both the 2-day (selected) dataset and the 7-day dataset. The selection of the two days was done with the EUROSTAT-guidelines in mind. The selection of the weekday (Monday till Friday) was not random. If the first day of registration was a weekday, we took this day as the weekday in the dataset. By doing this we created the same conditions for all respondents, i.e. they all have had the same difficulties (i.e. learning) at the start of the registration. During the field work, the first registration day was allocated by a controlled random procedure, so the starting days were spread more or less evenly along the entire week (Monday till Sunday). This means that about 2/7th of the respondents started their diary during a weekend day. For them we randomly selected a weekday. The weekend day was randomly selected for all respondents.

Table 1. Duration per respondent (hh:mm) and standard deviation per week – 2-day versus 7-day registration (TOR9904 - 18 to 75 year; n=3,096).

	Time/resp. per week (2-day registration) (1)	Time/resp. per week (7-day registration) (2)	Diff. a (2)-(1)	S.D. per week (2-day registration) (3)	S.D. per week (7-day registration) (4)	Diff. b (4)-(3)
Paid work	2:59	2:58	-0:01	3:19	2:56	-0:23*
Housework	2:46	2:44	-0:02	2:13	1:50	-0:23*
Childcare	0:21	0:21	0:00	0:51	0:45	-0:06*
Personal care	2:12	2:13	+0:01	0:53	0:43	-0:10*
Sleep & rest	8:42	8:44	+0:02	1:32	1:15	-0:17*
Education	0:22	0:22	0:00	1:17	1:11	-0:06
Social participation	1:23	1:23	0:00	1:30	1:07	-0:23*
Leisure	3:51	3:52	+0:01	2:16	1:54	-0:22*
Waiting	0:01	0:01	0:00	0:07	0:05	-0:02
Travel	1:02	1:01	-0:01	1:01	0:45	-0:16*
Other	0:16	0:15	-0:01	0:37	0:23	-0:14*

** significant at p<0.05*

In Table 1 we compare the duration of activities for a 2-day and a continuous 7-day registration. The time-use estimates of the 2-day registration were extrapolated to a synthetic week. The weekday was multiplied by 5 and the weekend day by 2 to receive weekly estimates, as recommended by the EUROSTAT-guidelines.

None of the differences (Diff. a) between the average durations per day are statistically significant. This clearly illustrates that the number of diary days does not affect the duration per respondent for these activity clusters on an aggregated level. The standard deviation however is significantly smaller for almost all the estimates based on a 7-day registration (only for 'education' and 'waiting' the difference (Diff. b) is not statistically significant), which points to a lower level of measurement error for these calculations.

In Table 2 the participation rates for weekdays (Monday till Friday), Saturdays and Sundays are compared. The participation rates for weekdays are shown for (1) only 1 day out of 5 (only one day per respondent is taken into account), as (2) an average per day over 5 weekdays (weighted average of each participation mean per day) and as (3) a participation rate based on the entire 5-weekday period.

Table 2. Participation rate (%) and standard deviation – 1 weekday, average weekday, along 5 weekdays, Saturday and Sunday (TOR9904 – 18 to 75 years old; n=3,096)

	Weekday (Mon-Fri)					Sat	Sun
	1 day (1)	Ave day (2)	Diff. a (2)-(1)	5 days (3)	Diff. b (3)-(1)	Diff. c	Diff. d
Paid work	50,8	50,2	-0,6	62,7	+11,9*	+0,2	-0,2
Housework	83,3	82,5	-0,8	95,3	+12,0*	-0,9	+1,3
Childcare	21,0	21,0	0,0	33,1	+12,1*	-0,6	-0,2
Personal care	99,3	99,5	+0,2	100	+0,7*	+0,4	+0,6
Sleep & rest	99,9	99,9	0,0	100	+0,1	+0,2	+0,2
Education	11,0	10,4	-0,6	22,4	+11,4*	+0,1	-0,6
Social participation	53,5	53,5	0,0	86,7	+13,2*	+0,1	-1,2
Leisure	93,6	93,1	-0,5	99,7	+6,1*	-0,6	+0,2
Waiting	5,1	5,8	+0,7	16,4	+11,3*	+0,1	-0,4
Travel	72,5	72,8	+0,3	89,2	+16,7*	+2,0	-1,7
Other	34,1	31,0	-3,1*	64,8	+30,7*	-2,9	-1,8

** significant at p<0.05*

The number of registration days does not really affect the participation rates for Saturdays (Diff. c) and Sundays (Diff. d) in the TOR9904-study. The only difference between both measures is that the estimates in the 7-day dataset contain both weekend days and as such the number of observations for both weekend days is double of that of the 2-day dataset. Also for weekdays only a small difference (Diff. a) is found between the participation rate of only one diary day (1 day) and the average daily participation rate over 5 days (Ave day). So, generally one day gives a fairly good estimation of the average participation rate per day over a longer period of time.

The participation rates for 1 weekday as compared to the entire period of 5 weekdays (5 days) show large differences (Diff. b). The more days, the higher the participation rate. These figures illustrate the presence of intra-personal variability in time-use. For some activities the increase of the participation rate is very moderate, as such it does not matter very much whether the participation rate is based on a 1-day or a 5-day observation. This is clearly so for 'sleeping and rest', since this is an activity almost everybody does every day. For 'social participation', on the other hand, we observe a clear increase alongside the extension of the period of observation, from 53.5% to 86.7%. For the activity cluster 'leisure', the difference in the participation rate for a 1-day registration and a 5-day registration is relatively small. Almost everybody has some leisure on a daily basis. This does not apply to more specific leisure activities being part of this activity cluster. Sports are a good example. Most respondents do not sport every day, but only once or a few times a week. On an average day only 6.6% of the respondents does sports. In a 5-days period this percentage increases to 18.8%. The same is true for other leisure activities such as shopping (+40.2%), recreation (+26.1%), cultural participation (+9.8%) and even TV-watching (+21.4%).

Our figures clearly point to the advantage of having estimates based on multiple-day diaries. The longer the observation, the lower the level of measurement error and the more stable the estimates, which is most important for more detailed analyses on specific activities for specific social categories. But what about the quality of the data? Although the evidence on that is less conclusive, a lot of time-use researchers fear that a longer registration period lowers the quality of the registration. In the next paragraph we examine three indicators of quality based on the TOR9904-survey.

Is less better?

The main objections for enhancing the number of observation days are related to the quality rather than to the reliability or usefulness of the data. One commonly agreed consequence of a longer observation period is the higher level of non-response. Other arguments focus on the quality of diary-keeping. In general it is believed that a higher number of activities in a diary points to a more accurate registration and as such it is expected that the longer the respondents have to report their activities the number of activities declines. Other indicators for the quality of time-use data are the amount of unregistered time and the reporting of activities starting and ending on exactly the hour or half hour (Geurts and de Ree, 1993).

Table 3 shows the results for three quality-indicators from the 7-day diary survey of TOR9904. Each column gives for each indicator the average score for the 1st till the 7th day of registration. Although the differences in the number of reported activities between the first day and day 3, 4 and 5 are statistically significant ($p < 0.05$), the differences from the 1st to the 6th day remain very small. Only on the 7th day the average number of activities is substantially lower. The differences between the number of activities on day 7 and all the other days, except day 4, are statistically significant ($p < 0.05$). However, the lower number of reported activities on the last day can be attributed to instructions that were unclear to some respondents. All the respondents in the Flemish time-use survey were asked to start their diaries on 8 p.m. on the evening before the first day of registration. The first 4 hours were considered as a sort of learning period and were not included in the data set. Since the instruction was to register activities for 7 days, a part of the respondents believed they had to stop at 8 p.m. of the 7th day, while in fact it was expected to keep the diaries till midnight of this last day (and report the ending time after midnight of the activity that started on the last day). For them, the 7th day only contains 20 hours and thus fewer activities. Apart from this, we see no substantial decline in the number of reported activities in the 7-day time-use data.

Table 3. Quality tests from day 1 to day 7 (TOR9904 – 18 to 75 years old; n=3,254)

Day of registration	Number of reported activities	Unspecified time in minutes	% activities starting and ending at hh:00 or hh:30
1st	19.5	24	20.8
2nd	19.3	13	20.8
3rd	19.1	11	21.0
4th	19.0	11	21.3
5th	19.1	12	21.3
6th	19.2	16	20.9
7th	18.7	15	20.2

Although the amount of unspecified time is generally interpreted as an indicator of inaccuracy, it can also be a result of the refusal to report some activities. In Table 3, we clearly see a higher amount of unregistered time on the first day of registration. The amount of unspecified time is significantly higher ($p < 0.05$) on day 1 as compared to all the other days, which is a clear argument for multi-day diaries. On the other hand, there is also a tendency of increased unspecified time on the 6th and the 7th day (the amount of unregistered time is significantly higher ($p < 0.05$) on day 6 and 7 as compared to both day 3 and 4). For the last day of registration, the amount of unspecified time is overestimated in the Flemish time-use data due to the already mentioned indefinite instruction about ending the registration.

The Flemish time-use surveys use open interval diaries. This means that respondents report the starting and ending time of the activities themselves. Although part of the daily activities are strictly scheduled to start at the beginning of a new hour (hh:00) or at half an hour (hh:30), most activities do not start at exactly round hours. Rounding time in the registration of activities can be interpreted as an indicator of lower quality. In Table 3 we find the proportion of activities of which the starting and/or ending time is exactly the round hour or half hour. We see no indication for a decline of the quality of the registrations as the number of diary days increases. There are no statistically significant differences ($p < 0.05$) between the diary days for the proportions of activities starting and/or ending at exactly the round or half hour.

Our analyses do not provide many indications that extending the period of registration leads to a deterioration of the quality of the data. To be able to capture the socially relevant week cycle, we therefore would recommend 7-day diaries. There is only one quality argument left not to follow this recommendation, i.e. the

increase of non-response rates. With our data, it is not possible to investigate the effect of longer registration periods on non-response rates. Therefore, we think it would be good to examine the effects of multi-day diaries on non-response further and to test procedures and formats to restrict non-response rates to make longer periods of observation feasible.

In a sense EUROSTAT subscribed the importance of weekly rhythms in daily time use, especially for the study of working times. Since, today's weekly work rhythm of employees is intertwined with days off, vacation days, sick days, less hours a day, free hours, overwork, flexibility and so on, one workday often does not give a representative picture of the different working days in a week (Glorieux, Mestdag and Minnen 2008). To be able to capture weekly working time schedules, without the drawbacks of a 7-day diary (mainly the heavy burden for respondents and the lower response rate) EUROSTAT created a new tool: the work grid (European Commission 2009). In the second part of this contribution we have a closer look at this instrument to register working times.

Results, differences and problems of the comparison between a 2-day diary and a 7-day work grid

The Belgian time use surveys of 1999 and 2005 largely followed the EUROSTAT-guidelines, and as such only contain time-use data for two days per respondent. Additional to the diaries however, respondents had to fill in, for an entire week, all work activities in a work grid. Contrary to the diary format, in which respondents report their activities in their own wordings, paid work in the work grid is defined by a predetermined definition: "At what time, and for how long did you work each day of the week? Include part-time and one-off jobs. Self-Employment and time spent working for a family business should also be included. Include second jobs and any work brought home from a paid job and done at home. Do not include unpaid breaks such as lunch breaks, or time spent travelling to and from work."

The two diary days were recorded during the 7-day period of the work grid. This way the working time is collected by two different time-use formats in the same period by the same respondents. This makes it possible to compare the extrapolated weekly working time of a 2-day diary with the 7-day estimate of the work grid. On the other hand we can run a quality test comparing the input of

working activities in the work grid with every episode during the 2 diary days. For the comparison between the two time-use formats, the definition of paid work in the diary was adjusted to the definition of paid work in the work grid. Format differences which are not to overcome and which hamper the comparison between both methodologies are (a) the grain of precision, and (b) the start and ending time of the 24-hour cycle. In the 2-day diary respondents register their activities with a precision of 10 minutes (a) and the start reporting at 4 a.m. till 4 a.m. the next day (b), whereas in the work grid uses 15 minutes slots (a) and the 24-hour cycle runs from midnight to midnight (b). These format issues however do not have a large impact on the registration and analysis of working times.

On basis of the extrapolated 2-day diary the average weekly working time per respondent (18 to 64 years old) is 19h35, whereas the estimated work time based on the work grid is 20h08. International comparisons of working time estimates found out that the working time reported in a diary is generally lower than in a work grid, which in turn is lower compared to a stylized question (Robinson, Chenu and Alvarez 2002). Nevertheless, we can conclude that a 2-day diary is more or less comparable to a 7-day work grid, since the average difference per day (33 minutes/7) is less than 5 minutes. This finding is comparable with the conclusion we made in previous section where we found on basis of the TOR9904-dataset that the aggregated weekly durations per respondent based on a 2-day and a 7-day diary registration are very much the same.

If we shift our focus to more qualitative requirements, hidden issues and differences come to the surface. In Figure 2 the weekly working time based on the 2-day diary registration and the 7-day work grid are compared (for those who registered paid work in the work grid). The difference between the extrapolated 2-day diary and the work grid (0-line) is presented on the vertical axis. The working time as reported in the work grid is shown in 10 five hourly categories on the horizontal axis. The difference between the weekly time resulting from the 2-day diary and the work grid is presented as a total and for males and females separately.

Figure 2. Difference in working time: extrapolated 2-day diary compared with 7-day work grid (TBO9905 - 18 to 64 years old; n=5,583)

There seems to be a clear downward linear trend in Figure 2. For those working less than 20 hours a week the weekly working time based on 2-diary days is overestimated as compared to the weekly working time measured by the work grid (more for males than for females). The point where there is no difference between both estimates is found between 20 and 25 hours. From that point on the extrapolated working time of the 2-day diary is less than that of the working grid. For those working more than 40 hours on a weekly basis the estimates based on the 2-day diaries underreport more than 5 hours of work as compared to the 7-day work grid (females more than for males). The longer the working time, the more it is underestimated in 2-day diaries. A possible reason for these differences could be the difference in the way the working time is recorded by the diary versus the work grid. In the diary the paid work activities are embedded into a sequence of different activities which is not the case in the work grid.

The extraordinary situation that workers kept a work grid the same week they reported their daily time-use in a 2-day diary makes it possible to check directly whether or not the worker indicated a work activity at the same time in both formats. Analyses showed that a substantial proportion of paid work reported in the work grid was not reported as paid work in the diary. This means that some respondents do not read or understand the definition of paid work (see

at the beginning of this section) well enough to fill in the work grid properly. For almost 1/4th of the total time a work activity was indicated in the work grid but not in the diary, the specified in the diary was 'travel or commuting'. According to the definition of paid work commuting should not be included. The same is true for 'eating and drinking' (about 1/5th). Other non-working activities in the diary which have been indicated as paid work in the work grid are 'time at work without working (or applying for a job)', 'pc use, telephone, or other communicating for private reasons', 'reading for private reasons' (and 'school or education for private reasons' (together about 22% of the total time). A substantial part (about 17%) of 'work' in the work grid was reported as 'domestic work and family care' in the diary.

Conclusion

In this contribution we examined and discussed the EUROSTAT-recommendation concerning the number of diary days. In the first part we confirmed the advantages of week-long diaries using the Flemish dataset TOR9904. Longer periods of observation clearly lead to better data and to more accurate estimates. It has been shown that multi-day data are better suited for the study of rhythms and activity patterns of activities that do not follow a daily rhythm. We also did not found many indicators that extending the period of registration led to a deterioration of the quality of the data as described or suggested in literature. The amount of unspecified time might be somewhat higher on the 6th and 7th day of registration, but this is equally true for the 1st day of registration. We also did not found a decrease of registered activities as the period of registration continues, or a decrease in the accuracy of the registration of the beginning and ending time of the reported activities. In general, we see more arguments for extending the registration period than to keep it to one or two diary days. To be able to capture the socially relevant week cycle, we would recommend 7-day diaries. The quality loss throughout a lower response rate for 7-day diaries as compared to 1- or 2-day diaries stays open for further research. Therefore, we would recommend diary formats which are less subjected to non-response but on the other hand capture multi-day cycles better than single-day diaries.

The work grid as recommended by the EUROSTAT-guidelines could be such an alternative to the more demanding 7-day diaries. Since in the TBO9905-study

the 2 diary days were recorded during the period of the 7-day work grid, we were able to compare both time-use formats and evaluate the quality of the work grid data. The comparison of the duration of paid work per respondent showed fairly comparable results between diary and work grid registration estimates. The aggregated results however mask some underlying quality issues. Comparing the time episodes in the diary and the work grid for work and non-work activities showed that a substantial proportion of the paid work is reported in the work grid was in fact not indicated as paid work in the diary. In most cases these activities are work-related activities which indicates that the predefined definition of paid work in the work grid was not understood or read properly. Apart from that the work grid seems to be quite an accurate instrument to capture working times and weekly work schedules, but of course it never can be an alternative for full diaries in which all activities and their context are registered in much more detail.

References

Ampt, E. and A.J. Richardson (1994). The validity of self-completed surveys for collecting travel behavior data. *Proceedings of the 22nd European Transportation Conference*, 2, 77-88.

Arentze, T., H. Timmermans, F. Hofman and N. Kalfs (1997). Data Needs, Data Collection, and Data Quality Requirements of Activity-Based Transport Demand Models. *International Conference on Transport Survey Quality and Innovation*, 24-30 May, Grainau, Germany.

Australian Bureau of Statistics (1988). *Time use pilot survey*. Information paper No. 95, New South Wales Office, Sydney.

Axhausen, K. W., A. Zimmermann, S. Schönfelder, G. Rindsfüser and T. Haupt (2002). Observing the rhythms of daily life: A six-week travel diary. *Transportation*, 29: 95-124.

Backor, K., S. Golde and N. Norman (2007). *Estimating Survey Fatigue in Time Use Study*. The Stanford Institute for Quantitative Study of Society (SIQSS), Department of Sociology, Stanford University, Stanford.

Bagatta, G. (1995). *European Time-Use Survey Pretest Italy*. Report ISTAT.

European Commission (2004). *Guidelines on harmonized European Time Use Surveys*. September 2000, Adapted for CIRCA January 2001, European Commission, EUROSTAT, Luxembourg.

European Commission (2009). *Harmonized European time use surveys. 2008 guidelines*. European Commission, EUROSTAT, Luxembourg.

Gärling, T. (1998). Behavioural assumptions overlooked in travel choice modelling. In De Ortuzar, J., D. Hensher and S. Jara-Diaz (eds.), *Travel Behaviour Research: Updating the State of Play* (pp. 554). Oxford: Elsevier.

Gershuny, J. I. Miles, S. Jones, C. Mullings, G. Thomas & S. Wyatt (1986). Time budgets: preliminary analyses of a national survey. *The Quarterly Journal of Social Affairs*, 2, 13-39.

Gershuny, J. and J.P. Robinson (1988). Historical Changes in the Household Division of Labor. *Demography*, 25(4), 537-552.

Gershuny, J., K. Fisher, A. Gauthier, S. Jones and P. Baert (2000). Appendix 2: A Longitudinal, Multinational Collection of Time-Use Data – the MTUS. In: Gershuny, J. (ed.), *Changing Times: Work and Leisure in Postindustrial Society* (pp. 304). Oxford: Oxford University Press.

Geurts, J. and J. de Ree (1993). Influence of Research Design on Time Use Estimates. *Social Indicators Research*, 30, 245-284.

Glorieux, I., J. Minnen and J. Vandeweyer (2005). *Technisch verslag van de tijdsbudgetenquête TOR'04'*. Onderzoeksgroep TOR, Vakgroep Sociologie, Vrije Universiteit Brussel, Brussel.

Glorieux, I., I. Mestdag and J. Minnen (2008). The Coming of the 24-hour Economy? Changing work schedules in Belgium between 1966 and 1999. *Time & Society*, 17(1), 63-83.

Glorieux, I., I. Mestdag and J. Minnen (2008). *Technisch verslag Time&Budget*. Onderzoeksgroep TOR, Vakgroep Sociologie, Vrije Universiteit Brussel, Brussel.

Golob, T.F. and H. Meurs (1986). Biases in response over time in a seven-day travel diary. *Transportation*, 13, 163-181.

Harvey, A.S. (1993) Guidelines for time use data collection. *Social Indicators Research*, 30, 197-228.

Hill, M. (1984). Investments of time in houses and durables. In Juster, F.T. and F.P. Stafford (eds), *Time, Goods, and Well-Being* (pp. 542). Ann Arbor: Institute for Social Research, University of Michigan.

Hedges, B. (1986). *National Time Budget Study: Methodological Report*. Economic and Social Research, London.

Niemi, I. (1983). *The 1979 Time Use Study Method*. Central Statistical Office of Finland, Helsinki.

Pas, E. I. and S. Sundar (1995). Intrapersonal variability in daily urban travel behavior: Some additional evidence. *Transportation*, 22, 135-150.

Robinson, J., A. Chenu and A.S. Alvarez (2002). Measuring the complexity of hours at work: the weekly work grid. *Monthly Labor Review*, April, 44-54.

Rydenstam, K. (1995). *The Harmonised European Time-Use Surveys*. Statistics Sweden, Sweden.

Scheuch, E.K. (1972). The Time-Budget Interview. In Szalai, A. (ed.), *The Use of Time. Daily Activities of Urban and Suburban Populations* (pp. 868). The Hague: Mouton.

Shon, A. (1999). Methodological and Operational Dimensions on Time Use Survey in the Republic of Korea. *Proceedings of the Seminar on Time use Survey*, 7-10 December.

Szalai, A. (1972). *The Use of Time. Daily Activities of Urban and Suburban Populations*. The Hague" Mouton.

Väisänen, P. (2009). Number of episodes as a measure for unobserved item nonresponse of diaries. *Paper presented at the ESRA-Conference*, 29 June – 3 July, Warsaw, Poland.

Zerubavel, E. (1979). *Patterns of Time in Hospital Life*. Chicago: The University of Chicago Press.

Zerubavel, E. (1985). *The Seven Day Circle. The History and Meaning of the Week*. New York: The Free Press.

This chapter is based on Minnen, J., T.P. van Tienoven, I. Glorieux, & S. Daniels (2012). Samen doen of samen zijn? Over arbeids- en gezinsverantwoordelijkheden en de tijd die partners samen doorbrengen. Tijdschrift voor Sociologie, 33, 3-4: 381-403.

For the convenience of the non-Dutch reader, that chapter is based on the English version of this paper, namely Glorieux, I., J. Minnen, T.P. van Tienoven (2010): Spouse "Together Time": Quality Time Within the Household. Social Indicators Research, 101, 2: 281-287.

CHAPTER 3

Spouse "Together Time": Quality Time Within the Household

Introduction

More time-use data are being gathered at the household level, meaning that different members of the same household register their time-use during the same period instead of as single individuals. Time-use information at the household level provides far more insight for research that has been largely dominated by diary information gathered at the individual level (Schwartz et al. 2002). Since different members of the household influence each other's behavior (Daly 1996), a "household [therefore] is more than a convenient aggregation unit to summarize the behavior of its members" (Van Wissen 1991: 3).

One emerging research field involves the study of quality of life, based on the (quality) time partners within a household spend together. This in turn is often linked to associating the amount of time spent together and relationship satisfaction (for an overview see Guldner and Swensen 1995). The amount of face-to-face spousal interaction is considered to be critical for marital quality (Berger and Kellner 1964). Kingston and Nock (1987), for instance, showed that dual-earner couples spent less time together in domestic life than other couples, and they linked this to a decrease of marital quality; likewise, Spitze and South (1985) argued that longer working hours of women could increase the risk of divorce, because of the decrease in marital interaction time it caused (see also Presser 2000).

The time couples spend together has been measured by retrospective survey questions (e.g. Gager and Sanchez 2003), by men and women separately (e.g. Kalmijn and Bernasco 2001), or by the simultaneity of time in a time diary—that is the time both partners are doing the same activity together (e.g. Kingston and Nock 1987). This last method is clearly the most detailed.

The aim of this article is to identify: (1) which activities couples do together (Table 4), (2) when they spend more time together (Figure 3), and (3) what household characteristics predict couples' together time (Table 5).

We expect the couples' employment situation to affect the amount of social quality time in the sense that dual-earner couples have less time together due to the off-scheduling of their paid work hours (see above). Moreover, we also expect that the time they spend together will be influenced by: (1) the presence of (young) children (because of their unpredictability), (2) whether the couple cohabitates or is married [since cohabiting people tend to spend more of their time on separate activities (Kalmijn and Bernasco 2001)], (3) the number of years of marriage [since the longer people are married the less time they tend to spend together (Kingston and Nock 1987)], (4) the partners' ages (if they are in the busiest 25–44 year age range, with both career opportunities and peak family demands) and (5) their educational level [because higher educated people tend to work less in non-standard hours (Hamermesh 2002) and will have a more egalitarian gender-ideology concerning the division of housework (Calasanti and Bailey 1991)].

Although Kingston and Nock (1987) only found spouse employment, work hours and off-scheduling to have a significant effect on time spent together, it is useful to re-investigate these other factors, since their survey is now almost 30 years old and only for a non-representative US subsample. Whether couples with more together time perceive a higher quality of life and the causal directions involved must be left to other studies (Gager and Sanchez 2003; Guldner and Swensen 1995; Kalmijn and Bernasco 2001; Kingston and Nock 1987).

Data and method

The data used here come from pooled (non-panel) time-diary data from two Belgian national surveys, one conducted in 1999 (TUS'99) and the other in 2005 (TUS'05). This pooled data set includes 14,782 individuals aged 12 years and above, living in 7,749 households and having completed time diaries for 1 weekday and 1 weekend day. Our analysis centers on households with two adult partners, with or without children, which reduces our sample to 4,043 households. Both partners filled in the diaries on the same days. The data have been weighted to give an equal spread of household characteristics and weekdays versus weekend days (Glorieux et al. 2008a).

Table 4. Average time (in hours) spent together and individually by Belgian couples and accumulated couple time (pooled TUS'99 and TUS'05—n = 4,043 households)

Activity cluster	Time spent together		Time spent individually				Accumulated couple time	
			Male		*Female*			
	Hrs	%	Hrs	%	Hrs	%	Hrs	%
Paid work and education	0.1	0.8	21.6	64.0	11.9**	35.2	33.8	100.0
Domestic work	5.0	20.1	12.6	25.7	26.7**	54.2	49.3	100.0
Household work	2.4	15.3	5.5	17.7	20.6**	67.0	30.8	100.0
Chores	0.5	11.8	5.2	68.5	1.5**	19.7	7.6	100.0
Shopping and services	1.1	35.4	1.6	26.8	2.3**	37.8	6.0	100.0
Child care and raising	0.3	11.3	1.1	23.3	3.1**	65.4	4.7	100.0
Personal care	62.0	78.3	15.9	10.1	18.5**	11.7	158.3	100.0
Eating and drinking	6.2	58.4	4.4	20.8	4.4	20.9	21.3	100.0
Other personal care	0.6	9.6	4.9	42.8	5.5**	47.7	11.5	100.0
Sleeping and resting	52.2	83.6	9.3	7.4	11.3**	9.0	125.5	100.0
Recreation	18.6	50.9	21.7	28.8	16.5**	21.9	75.4	100.0
Participatory activities	0.2	22.4	1.1	51.2	0.6**	26.4	2.1	100.0
Social life and going out	4.5	42.7	5.8	27.8	6.2**	29.5	20.9	100.0
Leisure outdoor and indoor	1.8	22.1	7.4	45.7	5.2**	32.2	16.2	100.0
Hobbies and games	0.1	18.2	0.9	61.6	0.3**	21.6	1.5	100.0
TV and video	10.0	57.7	8.5	24.9	6.2**	16.2	34.5	100.0
Travel	3.3	34.8	7.1	37.3	5.3**	27.9	19.0	100.0
Total	89.0	53.0	79.0	23.5	79.0	23.5	336.0	100.0

Differences between men and women are significant for (*) p < .05 and (**) p < .01

Results

Activities done together

Table 4 shows the average time both partners spend together and individually on 14 clusters of activities together for a "synthetic" week. Since we analyze both the individual time of the wife and husband spent on each activity as well as the time they spend together on each activity (which is logically the same for both spouses), that "synthetic" week sums up to 336 h (168 for wives + 168 for husbands). The first column in Table 4 presents the average time spent together as a couple on the specified activities. The next two columns present the time spent individually, that is, with no spousal interaction. The last column contains the total time both partners spend on each activity, and it is derived by multiplying the time spent together by two and adding the results to the time spent individually

by both partners. The numbers in parentheses refer to the proportions of these couples' combined weekly total of 336 h.

Overall, couples spend over half of their total time (53%) together. Not surprisingly, Table 4 shows sleeping & resting, eating & drinking and watching TV & video as the three activities that couples do jointly more often than individually. Couples average 52.2 h a week of sleep together, which is almost 84 percent of all the time both partners spend on sleep and rest. For eating & drinking and for watching TV & video, this proportion is about 60 percent. Also the proportion of time spent together on shopping & services, social life & going out, leisure (both outdoor and indoor), and travelling is relatively high. However, these activities have a higher rate of being done individually. Men, for example, tend to spend almost four times as much time on outdoor and indoor leisure (7.4 h) than they do together (1.8 h) with their wives. Women, on the other hand, tend to spend almost twice as much time shopping individually (2.3 h) as they do together with their husbands (1.1 h).

Very few couples do paid work together—less than one percent of the time couples work. Domestic work (household work, chores and child care & raising) is the most gendered activity within the household. Not only is there a substantial difference in the amount of time spent by both partners individually, but also in the proportional division of the total time. Women do over 60 percent of the total time both partners spent on household upkeep, and the same holds for childcare. On the other hand, men alone take up two-thirds of the total time spent on chores. Nevertheless, the difference in time spent on domestic work between men and women remains considerable.

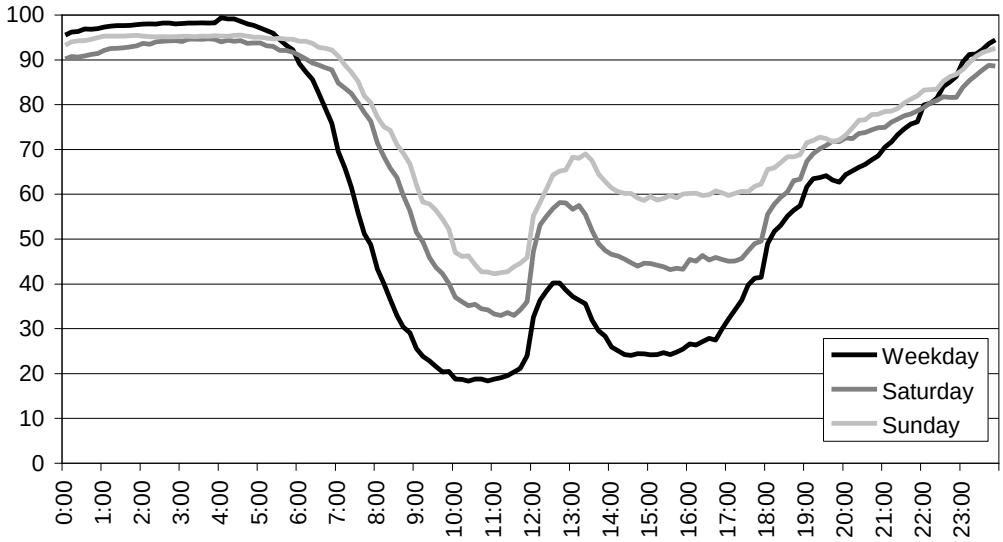
Times when together

Our data make clear that the household is an important spatial scene for socially simultaneous activity. These findings concur with what Huysmans (1996) terms the 'time culture' that characterizes the intra-household interaction and influences of the allocation of time of both partners. Therefore, we might use the time partners spend together (regardless of the type of activity) as an indicator of social quality time and combine it with other subjective indicators, for example with indicators of satisfaction or time-pressure. Figure 3 shows that most of the

time couples spend together occurs during meal times and during the evening and at night.

Moreover, we see that the 'time culture' is more dynamic on weekend days than weekdays. On Saturdays (and even more on Sundays), couples spend more time together during the period they usually work on weekdays (i.e., between 7 a.m. and 6 p.m.). On weekdays about 35 percent of the couples are together around noon, but on Saturdays this rises to almost 55 percent and on Sundays to over 60 percent. Together time in the evening and at night is not much affected by working times, and as such we do not see much difference between weekdays and weekend days in time spend together after 6 p.m. For Saturday and Sunday work Belgium is ranked at the bottom compared with other European Countries and is ranked in the middle for evening and night work. Belgium clearly cannot be seen as a 24/7 society (Evans et al. 2001; Glorieux et al. 2008b).

Figure 3. Total time together of couples (with interaction and at the same place) for a weekday, Saturday and Sunday (in percentage of couples) (pooled TUS'99 and TUS'05—n = 4,043 households)



Predictors of together time

In order to identify the household factors that positively influence a couple's time together, we found, firstly and not surprisingly, that non-earner couples have more time together (over 65 percent of the total accumulated couple time). Single-earner couples spend only about 54 percent together and dual-earner couples

some 3 percentage points less. It turns out that the proportion of time together strongly depends on the time spent on paid work (which also concurs with Figure 3), and that the differences between single-earner and dual-earner couples are relatively small, because as soon as one of the partners is out to work, it becomes difficult to do things together. Given the high impact of paid work on time together, we left non-earner couples out of our model when incorporating more household characteristics in this analysis.

Table 5. MCA of the percentage of Belgian couples' weekly time together (pooled TUS'99 and TUS'05—n = 2,950 households)

Covariates	Unadj.	Adj.
Accumulated couple time spent on paid work in hours (**) (°°)	−.220	−.168
Accumulated off-scheduled couple time spent on paid work in hours (**) (°°)	−1.892	−1.455
Predictors	**Unadj.**	**Adj.**
(1) Earning situation (**)		
Single-earner couple	54.4	52.4
Dual-earner couple	51.7	52.6
(2) Living situation		
Married	52.4	52.5
Cohabiting	53.2	52.7
(3) Young child(ren) under the age of 7 years (**)		
Absent	53.2	52.7
Present	51.0	52.5
(4) Number of children (**) (°°)		
No children	54.4	53.8
Only one child	51.4	52.0
Two children	51.7	51.9
Two or more children	50.3	50.9
(5) At least one spouse aged 25–45 years (**)		
No	54.3	51.6
Yes	52.0	52.8
(6) At least one spouse higher education or university		
No	52.3	52.2
Yes	52.7	52.8
Adjusted R 2		0.353

Unadjusted effects are significant for (*) p < .05 and (**) p < .01
Adjusted effects are significant for (°) p < .05 and (°°) p < .01

Table 5 shows a Multiple Classification Analysis (MCA) presenting both unadjusted (bivariate) and adjusted (controlled for the other variables in the model) predictors of the proportion of spousal time together. The covariates related to working hours by far have the strongest influence on the proportion of time together, especially the number of off-scheduled working hours. These findings highlight the importance of paid work in directing the daily rhythm of

individual time and time together of single- and dual-earner couples (see also Glorieux et al. 2008b).

The bivariate (unadjusted) analysis shows that living as a single-earner couple, having fewer children (or children older than 7 years) and not being middle-aged positively affects the time together. After controlling for the other variables in the model however, only the effect of having children persists besides the covariates. We expand the previous analyses of Kingston and Nock (1987) by incorporating the effect of having children. It is clear from our analysis that the lack of time together is due mainly to the combination of long working hours (often as a dual earner couple) and the presence of (younger) children. All the other differences in Table 5 are relatively small.

Conclusion

In examining the temporal and spatial dimensions of spouse together time, we have found that some clusters of activities (apart from sleeping, mainly meals, watching TV and going out) are done more together with one's spouse than others (mainly paid work, household work and child care). Using the amount of time together as an indicator of quality time, we assume that it is important for couples to make time to eat together, to spend time together in the evening (even in front of the TV set), and to go out together from time to time. This seems essentially important for those aged 25–44, since their longer work hours in combination with having (young) children, negatively affect the time they spend together.

As found by Nock and Kingston, working times in general seem the most decisive factor influencing the amount of together time. Non-working couples have much more opportunities to do things together and for other couples, working long hours and/or having off-scheduled working hours and non-overlapping working schedules negatively affect the time couples spend together. The increased labor market participation of women, on the other hand, seems not to be so much a threat for the time a couple spends together. The differences in spouse together time between single-earner and dual-earner couples are relatively small—once one spouse is at work, it becomes difficult to do things together. Our findings are thus largely compatible with those of Kingston and Nock (1987), but with a more recent and representative sample.

References

Berger, P., & Kellner, H. (1964). Marriage and the construction of reality. An exercise in the microsociology of knowledge. *Diogenes*, 12(46), 1–23.

Calasanti, T. M., & Bailey, C. A. (1991). Gender inequality and the division of household labor in the United States and Sweden: A socialist-feminist approach. *Social Problems*, 38(1), 34–51.

Daly, K. (1996). *Families & time. Keeping pace in a hurried culture*. Thousand Oaks: Sage.

Evans, J. M., Lippoldt, D. C., & Marianna, P. (2001). Trends in working hours in OECD countries. *OECD labour market and social policy occasional papers*, No. 45. Paris: OECD.

Gager, C. T., & Sanchez, L. (2003). Two as one? Couples' perceptions of time spent together, marital quality, and the risk of divorce. *Journal of Family Issues*, 24(1), 21–50.

Glorieux, I., Mestdag, I., & Minnen, J. (2008a). Technisch verslag Time&Budget (Technical report Time&Budget), Brussels: Vrije Universiteit Brussel, Department of Sociology, Research Group TOR.

Glorieux, I., Mestdag, I., & Minnen, J. (2008b). The coming of the 24-hour society? Changing work schedules in Belgium between 1966 and 1999. *Time & Society*, 17(1), 63–83.

Guldner, G. T., & Swensen, C. H. (1995). Time spent together and relationship quality: Long-distance relationships as a test case. *Journal of Social and Personal Relationships*, 12(2), 313–320.

Hamermesh, D. S. (2002). Timing, togetherness and time windfalls. *Journal of Population Economics*, 5(4), 601–623.

Huysmans, F. (1996). Social time and media use. Communications, *The European Journal of Communication Research*, 21(4), 405–419.

Kalmijn, M., & Bernasco, W. (2001). Joint and separated lifestyles in couple relationships. *Journal of Marriage and Family*, 63(3), 639–654.

Kingston, P. W., & Nock, S. L. (1987). Time together among dual-earner couples. *American Sociological Review*, 52(3), 391–400.

Presser, H. B. (2000). Nonstandard work schedules and marital instability. *Journal of Marriage and the Family*, 62, 93–110.

Schwartz, L.K., Herz, D., & Frazis, H. (2002). Measuring intrahousehold allocation of time: Response to Anne E. Winkler, *Monthly Labor Review*, 125, February, 53–59.

Spitze, G., & South, S. J. (1985). Women's employment, time expenditure, and divorce. *Journal of Family Issues*, 6, 307–329.

Van Wissen, L. J. (1991). A model of household interactions in activity patterns, Working Paper, No. 15, The University of California at Berkeley, The University of California Transportation Center.

This chapter is based on Minnen, J., Glorieux, I., & Pieter van Tienoven, T. (2016). Who works when? Towards a typology of weekly work patterns in Belgium. Time & Society, 25(3), 652-675.

CHAPTER 4

Who works when? Towards a typology of weekly work patterns in Belgium

Introduction

The main reason for most people for performing paid work is its remuneration. However, as an extension of this 'manifest function', employment as a social institution also has 'latent functions': it is a source of social contacts, it enhances participation in collective or individual transcending purposes, it offers an acceptable status and social identity, and contributes to regular activity (Jahoda, 1982). Simply because these experiences are unintended though inevitable consequences of the presence of paid work, it is mainly by becoming unemployed that one becomes aware of these latent functions of work. 'While the unemployed are left to their own devices to find experiences within these categories if they can and suffer if they cannot, the employed take them for granted' (Jahoda, 1982: 39).

Although this is taken for granted and unintended, the way of experiencing time and the regularity-creating characteristic of paid work plays an enormous role in the organization of daily life that forgoes the simple question of how much (how many hours) we work. Work schedules form the basis of our daily and weekly time-use patterns even for those who do not work. This highlights the importance of studying

> *the instantaneous use of time, that is, studying the use of time at the episodic or activity level by its four characteristics (timing, tempo, sequence and duration), as opposed to time use integrated over days, weeks, years or a working life. (Hamermesh, 1999)*

In other words, studying the structuring mechanism of paid work means addressing the question when people work and not (only) the question how much they work. However, somehow the former question is often reduced to the latter in a sense that it is answered by identifying who works how much time in (non-

)standard working hours or in part-time working hours (i.e., the integrated approach). However, within these non-standard or part-time working times, a variety of non-standard and part-time arrangements exist, and it is precisely through studying the episodic use of time that we will be able to grasp this variation (i.e., instantaneous approach).

Non-standard work can be either the result of high time sovereignty of self-employed or employees in the public sector or the result of high time flexibility of blue-collar workers facing rigid working schedules and shift work. Besides addressing the question when people work, it is of equal importance to address the question who or what people work on non- standard hours. Especially because non-standard work is amongst other things, related to poorer health outcomes of employers (e.g. Jamal, 2004) or their family (e.g. Fenwick and Tausig, 2001), which motivates the need for a thorough approach of the subject. Likewise, part-time work can either be a deliberate choice (often in high-income families) (e.g. Booth and Van Ours, 2013) or an unavoidable consequence (often in low-income families, or inability to find a full-time job) to combine work and family responsibilities (e.g. Blank, 1989). Additionally, part-time work is typically a women's 'choice'. By grasping the additional variation in work patterns by the episodic (or instantaneous) approach using a more sophisticated analytical method (see further), we readdress some of these findings.

The aim of this contribution is, thus, to truly grasp the timing of weekly work (i.e., question 1: when do people work and how much?) and (re-)evaluate how different patterns of weekly work are socio-economically dispersed over society (i.e., question 2: who works when?). We use Belgian data from a weekly work grid (WWG) and an accompanying individual questionnaire (n=6330) to answer both questions. Firstly, we will use the combination of two dimensions of weekly paid work to construct a typology of weekly work patterns, which is the innovatory part of this contribution. The first dimension is how much people work, varying from different amounts of part-time work to overwork. The second dimension is how these hours are dispersed not only over the days of the week but also over various (non-)standard working periods, i.e., daytime, evening and night-time work. Secondly, we will investigate who works by which schedule and – although we cannot test causality – elucidate on the implications of occupying a certain social position for the (possible) working time arrangement someone faces.

In what follows, we will first provide some background on delineating non-standard and part-time working arrangements and on who is assumed to work by such arrangements and argue where and how variation in these arrangements can be found. Secondly, we will introduce the data and explain the methodology and analytical strategy that allows us to make this variation visible. Thirdly, we present the different work patterns in terms of their arrangement over the week, working hour characteristics and socio-demographic background. Finally, we conclude with a discussion.

Background

As mentioned in the introduction, this contribution aims to both identify how (non-)standard and part-time work is patterned over the week (Q1) and who works by these patterns (Q2). In this section, we give a brief background on how the timing of work has been studied already in the past, how current literature explains the relation between social position and employment in non-standard and part-time work arrangements and how this contribution extends these attempts and findings.

Timing of (non-)standard and part-time work

The most frequently used indicator of time spent on paid work on standard or non-standard hours, or on full-time or part-time work comes from the Labour Force Survey (LFS) in Europe or Current Population Study (CPS) in the U.S. In the LFS, non-standard work is divided in evening work (7p.m.–11p.m.), night work (11p.m.–5a.m.) and work on Saturday and Sunday. Addressing the question of timing of work, then, is reduced to the question 'How often have you worked on each of these periods/days' with a four-category answering scale (Presser, 2005). Likewise, part-time employment is only questioned by expressing the extent of part-time work as a percentage of full-time employment.

Both questions are exemplary of how the true timing of work is missed. Consider the latter question and suppose someone answers 75%. How do we know whether this is the result of working 6h on all five weekdays or of working 8h on Monday to Thursday only? To truly grasp the timing of non-standard and part-time work, we need exact hours and minutes when the paid work was

performed and for this reason scholars rely on time-use surveys (see, e.g. Hamermesh, 1998). Time-use surveys include diaries in which respondents denote for every activity – including paid work – the beginning and ending time. Time-use studies thus do provide information on the timing of paid work and a statistical technique called optimal matching analysis (OMA; see Data and method section) has been introduced to time-use research to identify time-use schedules or patterns in time-use data. This led to studies in Europe, in which Lesnard (2008), Glorieux et al. (2008) and Lesnard and De Saint Pol (2009) identified five different generic workday schedules, being typified as regular 'standard', 'long', 'shift work' and 'part-time' workdays and the irregular 'fragmented' workday.

However, time-use surveys are often limited to one day (e.g., yesterday recall method in the U.S.) or two days (e.g., the European HETUS guidelines suggest one weekday and one weekend day). So although these studies provided a relevant first insight in the scheduling of paid work, the data still included at most only one weekday and one weekend day per respondent and thus forced these scholars to treat days separately or, as far as we know, left weekend days out of the analyse. The days are being torn loose from the more encompassing week rhythm and the same problem as with the LFS questions remains present: suppose someone only registers one weekday and this weekday turns out to be a standard workday, we still do not have sufficient information about this person's workweek or whether or not this person works full time or part time.

Social dispersion of (non-)standard and part-time work

Non-standard working hours.

The issue of non-standard working hours is often approached from the remunerative or economic characteristics of work only, as if it were a problem of 'the matching of workers with heterogeneous tastes for work times with firms that have different costs of offering work at various times of the day' (Hamermesh, 1999: 38). Albeit workers will consider the non-monetary amenities of a job (e.g., non-standard working hours), their earning ability plays an important role, such that workers with low earning abilities will accept unpleasant jobs that compensate for this unpleasantness by offering higher wages. As a result, a relative increase in earnings will increase the possibility to avoid working at unpleasant times, giving non-standard working hours its inferior characteristic

(Hamermesh, 1999). This inferior characteristic is also substantiated by the evidence that an overall relative increase in earnings over time is associated with an overall decrease in evening and night-work and an increase of work at the peak times of a 'normal' workday (Hamermesh, 1998, 2002).

Previous studies found that individuals of different socio-economic and demographic characteristics have a different tendency to work on (non-) standard hours. Presser (2005) thus found for the U.S. that age, education and race significantly relate to changes in working non-standard and weekend days. This relation for age is negative and equal for men and women, that is, the older one is, the lower the odds of working at unpleasant hours. The effect of education seems to be U-shaped: higher odds of having a non-standard time of work were found for both lower education (explained by shift work of blue-collar workers) and higher education (explained by, e.g. being on call of high-skilled workers like medical specialists). Lastly, women with an ethnicity other than Hispanic or non-Hispanic white or black women have one of the highest odds of having non-standard working schedules.

However, the reasons for men and women to work on non-standard hours or on weekend days are not merely economical. In the U.S., for example, a quarter of men and almost 35% of women mention personal and familial reasons, of which better childcare arrangements, most frequently. Here, Presser (2005) finds that children depress the odds for working non-standard hours for mothers but that the reverse holds for fathers, with an exception for dual-earner families. Mothers in dual-earner families also face a 'positive' effect of children on the odds of working on non-standard hours. In fact, over one-third of dual-earner couples with children under the age of 5 include at least one spouse who works on non-standard hours, and almost half of these couples include at least one spouse who works on weekend days. This leads Presser to conclude that 'non-standard work schedules are no longer that nonstandard' (2005: 214).

Part-time work.

Working at non-standard hours can be the result of individual (e.g. low educated and therefore possibly less employable in good daytime jobs) or job characteristics (e.g. content of the job like 'emergency services' or assembly line work). In any case, the consequences for family life almost speak for themselves.

Working at non-standard hours negatively affects the quality and stability of marriage, and this negative effect grows stronger once young children are present. As a result, according to Hamermesh (2002), couples try to arrange their working schedules in a way that they can spend some leisure time together. Additionally, working at non-standard hours complicates childcare arrangements (Presser, 2005). Whereas, for example, the United Sates leaves childcare largely to the market or to informal care, and whereas, for example, Scandinavian countries highly subsidize childcare facilities, in other countries, solutions arise in terms of working time arrangements like part-time work. The Netherlands is such a country that is highly characterised by female labour market participation through part-time employment (Bosch et al., 2010). In 2013, in the Netherlands, 77% of the female employed is working part time, whereas in Sweden, for example, this percentage is much lower (37.7%). Belgium falls somewhere in between with 42.5% of the female workforce working part time in 2013 (figures from the Policy Research Centre Work and Social Economy, www.steunpuntwse.be).

The Netherlands, thus, lends itself well to study (the mechanisms of) part-time work. Bosch et al. (2010) report stability in average working hours of women over cohorts from 1925 to 1987 in the Netherlands despite the increase in women's educational attainment. They conclude that even though many studies emphasize the negative aspects of part-time work (see, e.g. Connolly and Gregory, 2008), this stability at least may be part of individual or household strategies (see, e.g. Hägerstrand, 1975). In fact, the presence of children and a full-time working male spouse increases the probability for the female spouse to work part time, and this 'state of affairs' results in a higher life satisfaction for both men and women (Booth and Van Ours, 2009, 2013). The same holds for satisfaction with working hours. Booth and Van Ours (2013) calculated the equilibrium weekly working hours to be 21 for women and 32 for men. However, the authors also found that for job satisfaction, no such relationship existed, hinting that 'occupational downgrading' of women is a serious issue. Connolly and Gregory (2008) report one-quarter of women who switch to part-time work to work at lower qualification than their previous job.

Nonetheless, women's choice for part-time work might be a deliberate one to solve the puzzle of daily and weekly planning of activities that often happen in function of the working schedule. With good reason, Hochschild (1990) names

work the 'first shift' of the day around which the 'second shift' of domestic work needs to be scheduled. Both shifts are in a constant struggle for daytime planning for two reasons: firstly, both paid work and domestic work contain activities that cannot be postponed (i.e., we have to go to work and we have to eat) and, secondly, both shifts repeat themselves every day (in the case of paid work at least on all contracted workdays). Despite the gender inequality in the division of work, but because of the positive relation to life satisfaction, the Dutch government took several measures in favour of part-time work in the Netherlands. Part-time workers now have the legal right on equal treatment (wages, overtime, bonuses, etc.), the legal right to request a reduction or increase in working hours and face a tax system that makes part-time work more attractive as compared to non-employment in relation to spouse's full-time employment (Bosch et al., 2010). The authors thus conclude that part-time work is 'here to stay' in the Netherlands as a solution for families to face the daytime struggle of combining both 'shifts' themselves and take into account the 'shifts' of their spouse (see also Glorieux et al., 2010b).

It goes beyond the scope of this contribution to discuss whether the tendency of women working part time is a desired situation or not. What concerns us here is that from the above, we derive that non-standard working hours are becoming more 'standard' and that part-time working solutions might not only result from job characteristics but from a various number of family characteristics as well. So studying the main patterns of paid work within a society means studying the way the temporal organization of society takes place and vice versa (Dumazedier, 1962; Gershuny, 2000; Robinson and Godbey, 1999). In other words, unravelling different work schedules gives an insight in how the struggles of the daily 'shifts' gets solved. An example is the rise of part-time work schedules that can be understood from the increased female labour force trying to solve the time-puzzle that emerges from their simultaneous roles as an employee and caring mother. As a consequence, it will be highly likely that there exist different non-standard and different part-time work patterns. Furthermore, a pressing additional question includes what the 'pattern of reference' – the standard working pattern that is becoming less standard at least according to Presser (2005) – looks like? At this point, we side with (Hamermesh, 1998; 1999; 2002) that we should be concerned with the *timing* of work and not only with calculating equilibriums of the number of working hours.

Weekly work patterns

As we mentioned, to analyse the scheduling of paid work profoundly, studies that only investigate average work time durations provide insufficient information. Likewise, time-diaries that inquire only one weekday and/or one weekend day do provide an insight in daily scheduling of work, but extrapolating these findings to a weekly work pattern still might result in false assumptions. One way to solve this problem is to use data from the so-called WWG, which contains information of the timing of work for seven consecutive days.

Lesnard and Kan (2011) were the first to use the WWG to identify weekly work patterns, by, firstly, identifying workdays (standard, long, shift, part-time, short workdays) like previously done by Lesnard (2008) and Glorieux et al. (2008) and, secondly, analysing the sequence of these workday typologies within each individual week (standard, long, shift, alternate, part-time I and II, short workweeks). The reason they give for the two-stage approach is that investigating workweek patterns involves two nested periodicities, namely, hours within days and days within weeks. Therefore, 'it will be more appropriate to take account of these two nested periodicities in the analysis as workers are likely to schedule their work time at two stages in real life' (Lesnard and Kan, 2011: 345).

We argue that there is not necessarily a need to depart from two nested periodicities of paid work. The reason here for is twofold and concerns the worker's increased freedom or sovereignty to schedule their working hours every single day of the week (cf. the first nested periodicity of workweek patterns). Firstly, the temporal structure of daily work is relatively rigid because its social character reflects and builds on the work hour preferences of the employers (Golden, 2001; Lesnard, 2008). A temporal structure of daily work in which every employee works according their preferences is very unlikely to happen (at the least because of coordination problems) and, secondly, even if this would be possible, the social or collective rhythm of society would, in the end, lead to relatively rigid temporal structures of daily work, no matter what (Hägerstrand, 1975; Lewis and Weigert, 1981). Individuals living together are in need of coordination and time functions as a structuring mechanism to make this coordination possible. Time, at this point, becomes a social and normative construct that guides the temporal arrangements of our lives, which, if we follow these guidelines, in turn, reinforce them (Durkheim, 1965 [1912]). So, it comes at

no surprise that most of us sleep at night, have breakfast in the morning, lunch at noon, leisure in the evening and work during daytime. So, in alliance with collective rhythm of a society, most of the employees work between 8 a.m. and 6 p.m., and most part-time workers either take-off one whole day or every afternoon. Based hereupon, we argue that this rigidity of the temporal structure of daily work legitimates (or maybe even requires) the study of the scheduling of paid work immediately within the periodicity of the week cycle.

Therefore, and as far as we know, we will for the first time apply the optimal matching directly to the WWG data. Although the main goal of this contribution is to answer the question *who works when?*, it also allows us to compare our results with those of Lesnard and Kan to see if this direct optimal matching yields different results than their two-stage approach.

Data and method

Data

We will use the WWG, more specifically a pooled file of the 1999 and 2005 data (WWG9905), that comes along with the Belgian time-use surveys of 1999 (TUS99) and 2005 (TUS05). Both surveys are conducted by Statistics Belgium and are a random sample of the Belgian population (n = 14782). Whereas the TUS only asks respondents to fill in diaries for one weekday and one weekend day, the WWG requests employed respondents to indicate their seven-day work episodes by drawing a line from the starting time to the ending time of each work episode. In order to do so, for every day of the week, the WWG provides a grid of 96 15-min time slots and the instructions hold that respondents exclude (meal) breaks and travelling time.

We withheld only those respondents (18 to 75 years) who have reported to be employed in the questionnaire and who reported at least one work episode in the WWG. This brings the sample size to 6330 respondents.

Measures

As mentioned in the introduction, we use two dimensions of paid work to typify weekly work patterns. The first dimension is the number of hours worked, which indicates the continuum of part-time through full-time work (i.e., 40

h/week) to overwork (i.e., extended workweek). The second dimension is the percentage of work performed on non-standard periods, which we define as weekend work (i.e., work performed on weekend days from 6 a.m. till 7 p.m.), evening work (i.e., work performed all days from 7 p.m. till 10 p.m.) and night work (i.e., work performed on all days from 10 p.m. till 6 a.m. the next day). The 'standard workweek pattern' has to meet the standard of both dimensions, that is, contain about 40 h of paid work and the least percentage of work performed on non-standard working periods.

We will analyse the identified weekly work patterns in terms of gender, age (18–39 years, 40–54 years, 55–75 years), education (max. lower secondary, higher secondary, higher or university), earning situation (single earner, single-earner family, dual-earner family), age of youngest child (no child or child over the age of 25, child under the age of 7, child between 7 and 25 years old) and sector of employment (private sector, public sector, self- employed). No valid and reliable measure of income is available in the Belgian time-use studies of 1999 and 2005.

Frequency distributions of these sample characteristics are shown in Table 6.

Analytical strategy

Optimal matching analysis (OMA).

OMA has been introduced in social sciences by Andrew Abbott and colleagues (Abbott, 1983, 1984, 1995b; Abbott and Forrest, 1986; Abbott and Hrycak, 1990). The main purpose of OMA is to discover patterns in individual sequences of events by comparing each individual sequence with all other sequences in terms of the number of 'operations' needed to equalize two sequences. These operations consist of 'inserting' an event, 'deleting' an event or 'substituting' an event, and different operations concerning different events are assigned different 'costs'. The cost-setting of these operations is, although often based on theoretical grounds, largely arbitrary (for a theoretical discussion on cost-setting, see Abbott, 2000; Abbott and Tsay, 2000; Lesnard, 2014; Levine, 2000; Wu, 2000) (for a technical outline of cost-setting, see Abbott, 1995a; Dijkstra and Taris, 1995; Elzinga, 2003; Hamming, 1950; Lesnard, 2010; Levenshtein, 1966). Nevertheless, in the end, this makes OMA an optimization problem, namely, computing the minimal ('optimal') costs needed to 'match' an individual sequence

with all other sequences. The result of OMA, then, is a matrix containing the costs or 'distances' between all sequences, which, in turn, can be reduced by a clustering method in order to aggregate sequences for which mutual distances are low and for which distances from the other sequences are high.

Table 6. Sample characteristics (column percentages)

	Men	Women	Total
Age			
18-39 years	7.2	8.0	7.6
40-54 years	41.0	46.7	43.5
55-75 years	51.8	45.3	49.0
Education			
Lower secondary	34.1	25.6	30.3
Higher secondary	36.9	37.1	37.0
Higher or university	29.1	37.3	32.7
Earning situation			
Single earner	21.6	30.8	25.7
Single-earner family	25.7	6.8	17.3
Dual-earner family	52.6	62.5	57.0
Age of youngest child			
No children or ≥ 25 years	39.5	40.1	39.8
Youngest child < 7 years	21.5	19.7	20.7
Youngest child ≥ 7 and < 25 years	39.0	40.2	39.5
Occupation			
Private sector	60.7	59.1	60.0
Public sector	30.1	34.6	32.1
Self-employed	9.2	6.3	8.0

Source: WWG9905 and TUS9905; n 1⁄4 6330; 18–75 years old, employed, cases are weighted by post-stratification weight including gender, age and education.

OMA has been introduced to time-use research by Lesnard (2004) and, hereafter, applied to study the sequences of different time-use activities, such as paid work time (Glorieux et al., 2008; Lesnard, 2008; Lesnard and De Saint Pol, 2009), active and passive leisure time (Glorieux et al., 2010a) or temporal regimes of contracted, committed and personal time (Kragelj, 2009).

One of the reasons OMA is being more and more applied to time-use data is because time-use series are a specific type of sequences and time-sequences are easily divisible in equally large or small time slots (e.g., 24 h, 96 quarters of an hour, 144 10-min intervals, etc.). However, the continuous, linear character of time implies that applying 'insertions' of 'deletions' to match time-sequences would imply 'time warping' and thus make not much sense. The reason for this is the so-called embeddedness of time-use (Lewis and Weigert, 1981), meaning that many

activities get their meaning from 'occupying' a certain timeslot during the day and from the preceding or succeeding activity. For example, 1 h of work during daytime has a different meaning or connotation than 1h of work during night-time (cfr. Hamermesh, 1999). The meanings and connotations we attach to time-use makes that time both has a natural and social course during the 24 h that make up the day or 168h that make up the week, and, as a result, 'warping' time-use activities (e.g., deleting lunch at noon and inserting it at midnight) violates the collective and social structure of time-use activities (Van Tienoven et al., 2011).

Because of the equal length and structure of time-sequences and because of the 'substitution' of time-use activities as the only legitimate operation to match different time-sequences (since it recognizes the contemporaneity of time-sequences), OMA is a relatively powerful analysis tool to identify different time-use patterns that aggregate from individual time-use schedules like paid work, as we will demonstrate in this contribution.

Analytical approach

Since the WWG9905 consists of 96 episodes a day or 672 episodes a week starting on Monday at midnight and with the registration of only two states (i.e., work or no work), we are able to use the OM algorithm to compare the 672 episodes of each individual sequence with the homologous episodes of all other sequences. To match these sequences, we use 'Dynamic Hamming Matching', which allows only substitutions as a valid operation (Lesnard, 2004). Moreover, cost-setting for the operation is based on transition frequencies, which basically means that costs vary relative to the timing of sequences, that is, costs are made inversely proportional to transition frequencies between pairs of states at a given time as observed in the sample (Lesnard and Kan, 2011). The less two sequences resemble each other; the more operations (i.e., substitutions) are needed to make them both 'match'. Summing these substitutions will provide a measure for the distance between those two sequences and OM will generate a matrix containing all mutual distances of all sequences. Hereafter, we used 'Ward Hierarchical Clustering' to reduce this matrix of distances to typify the most common workweeks. Both analyses are performed with the statistical program 'R'.

After having presented the identified workweeks, we merge the WWG9905 to the individual questionnaire of the TUS9905, and we use a binomial logistic

regression model to analyse the relationship of the socio-economic measures and the workweek patterns. Analyses are performed separately for men and women to compare differences in effects of the socio-economic measures.

Results

Weekly work patterns

In total, we have identified 10 weekly work patterns. For completeness, we mention that there was an 11th pattern which was highly fragmented and consisted of a low number of respondents (6.7% of the selected sample) probably as a result of days called in sick, days off or any other reasons that made the registered workweek 'highly unstructured'. We will leave this pattern out of further analyses, which reduces the sample size to 5908 respondents.

To create a typology of weekly work patterns, we relate them to a standard workweek. As we mentioned in the previous section, the standard workweek itself will be marked off on the basis of two criteria of what is generally assumed to be 'standard': (a) work is performed on Monday till Friday both in the morning and afternoon (i.e., full time for about 40 h) and (b) it is the pattern containing the least work performed on non-standard work hours (i.e., work after 7p.m. or in the weekend). This weekly work pattern is typified as the 'standard 42 h' workweek and serves as a reference to which all other patterns are reflected. We note that the number of work hours lies above the contractual work hours (38 to 40 h) of a typical fulltime workweek in Belgium. The reason for this is that respondents to a limited extent include unpaid lunchtime and/or travel from and to work in the WWG (Robinson et al., 2002). This leads to a minor overestimation of working hours (see also 'Discussion' section).

Figure 4. Tempograms of workweek patterns representing the percentage of people at work on different weekdays.

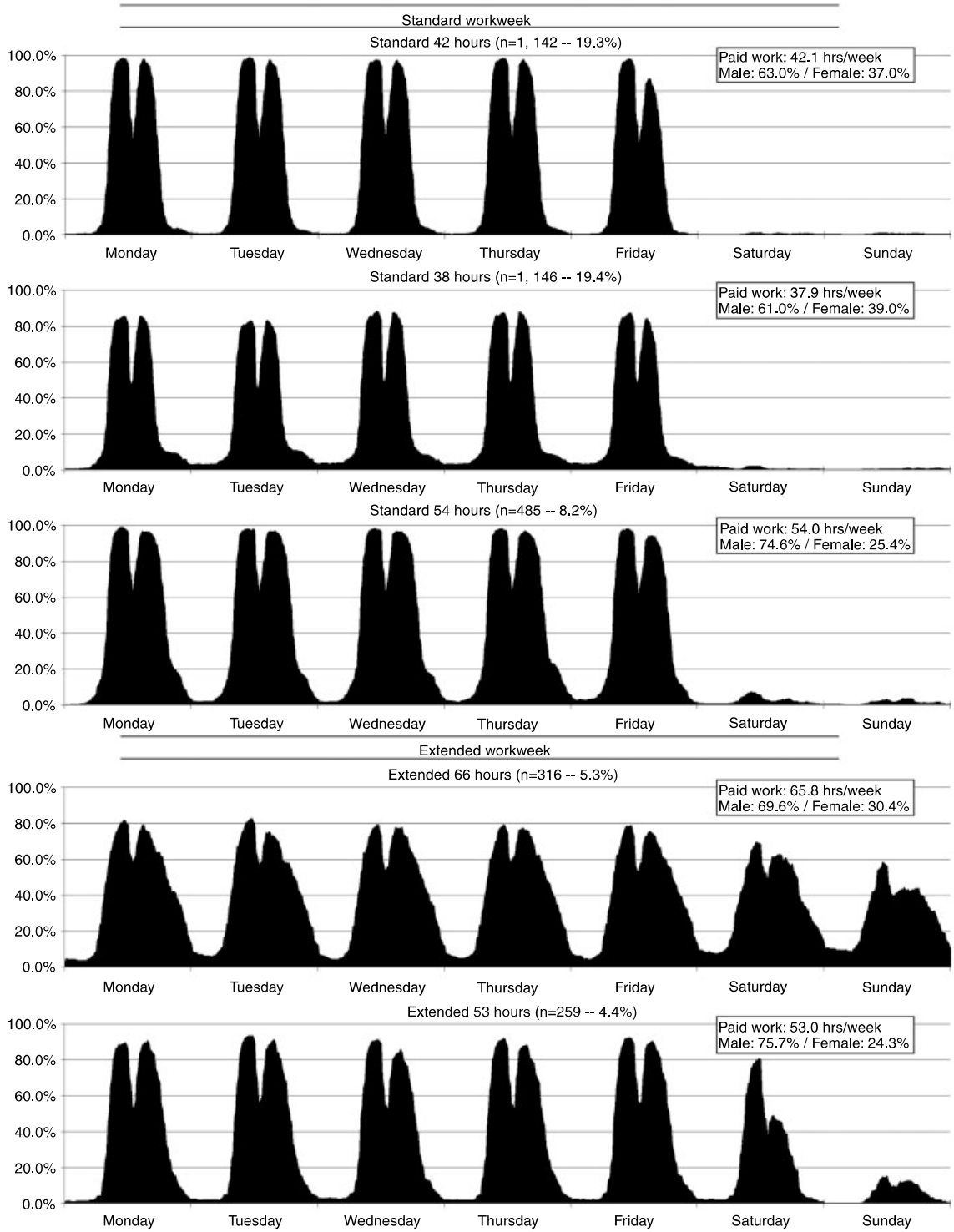


Figure 4. *Continued.*

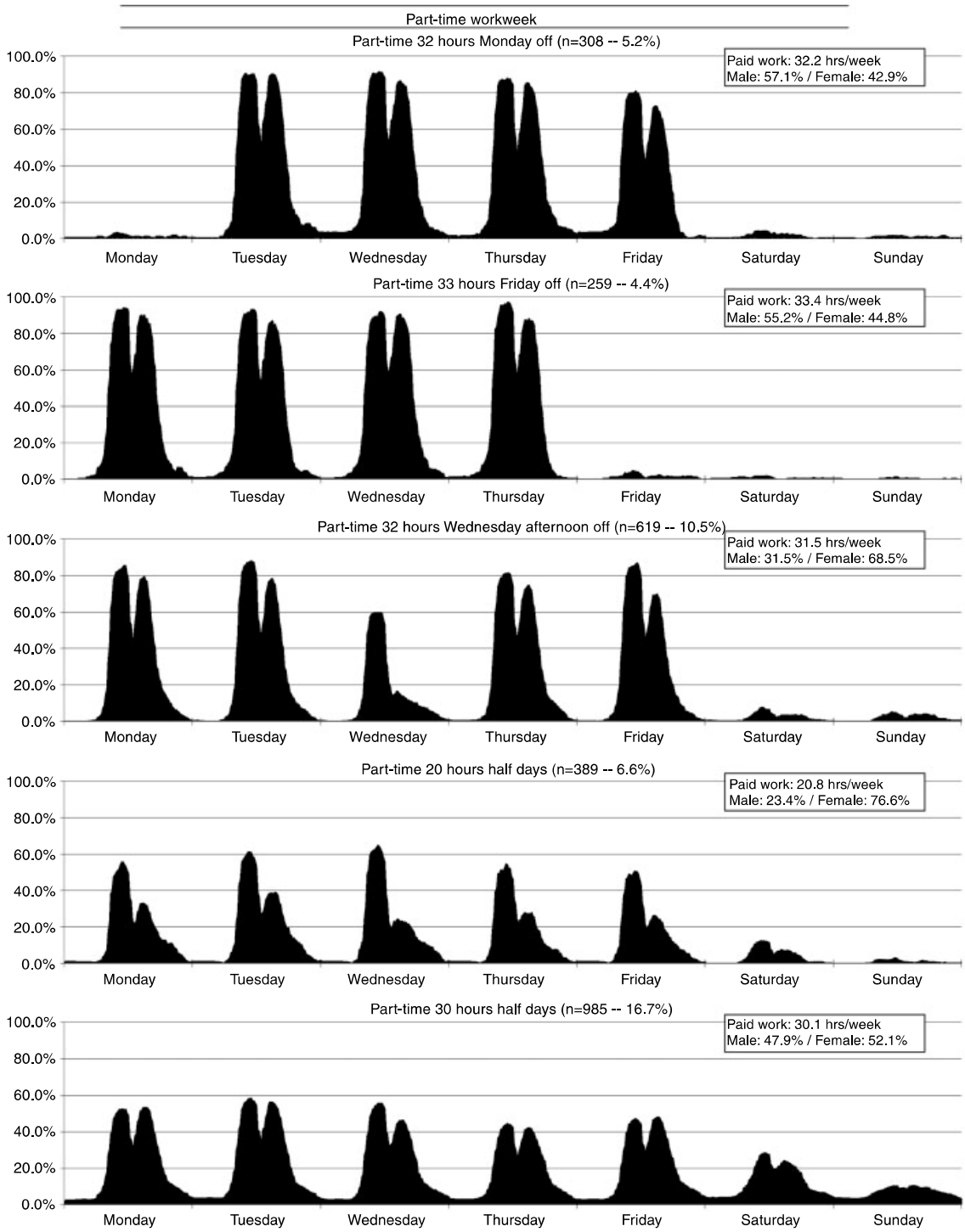
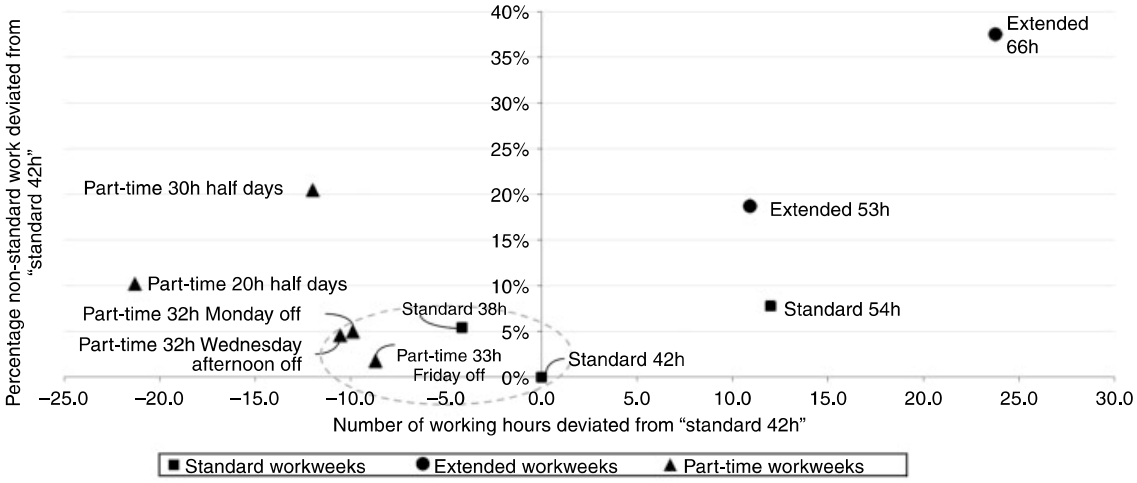


Table 7. Non-standard work in identified weekly work patterns

	Type of workweek									
	Standard			Extended		Part-time				
	42h	38h	54h	66h	53h	32h Monday off	33h Friday off	32h Wednesday afternoon off	20h half days	30h half days
Total (n)	1142	1146	486	316	259	308	259	619	389	985
% of total (row %)	19.3	19.4	8.2	5.3	4.4	5.2	4.4	10.5	6.6	16.7
Non-standard work [%]										
Evening work	0.5	3.8	2.5	8.6	2.4	3.0	1.3	0.7	1.9	6.1
Night work	1.3	3.3	6.3	12.4	6.1	2.7	2.1	3.5	5.8	5.9
Subtotal extended work	*1.8*	*7.1*	*8.8*	*21.0*	*8.5*	*5.7*	*3.4*	*4.2*	*7.7*	*12.0*
Work on Saturday	0.1	0.2	0.7	10.3	10.3	1.0	0.3	1.3	3.9	7.2
Work on Sunday	0.1	0.1	0.4	8.3	2.0	0.4	0.1	1.1	0.7	3.3
Subtotal weekend work	*0.2*	*0.3*	*1.1*	*18.6*	*12.3*	*1.4*	*0.4*	*2.4*	*4.6*	*10.5*
Total non-standard work [h]	2.0	7.4	9.9	39.6	20.8	7.1	3.8	6.6	12.3	22.6

Source: WWG9905, n=5908; 18–75 years old, employed.

Figure 5. Positioning of weekly work patterns based on total weekly hours worked and percentage of non-standard work.



We summarized all information in Figure 4 and Figure 5 and Table 7. Figure 4 shows the tempograms or collective rhythm of work time for each weekly work pattern. The black colour in the figure represents the average percentage of people within each pattern that is working at every 15-min time slot, starting at Monday at 0h and continuing till midnight at Sunday. Our workweek of reference is the first tempogram depicted in the figure. Based hereon, we were able to categorize all weekly work patterns in three generic types of workweeks, namely, the standard workweek (i.e., working full time only on weekdays), the extended workweek (i.e., working full time on weekdays and on non-standard hours and weekend days) and the part-time workweek (i.e., working part time by not working all five weekdays or working half days). We also have included the average numbers of hours worked and the proportional division of men and women in each pattern.

Table 7 takes a closer look at the distribution of non-standard work. It distinguishes between extended work, that is, evening work and night work on all seven days of the week, and weekend work, that is, work during Saturday and Sunday on standard hours (6 a.m. till 7 p.m.).

Figure 5 positions all weekly work patterns relative to each other in terms of total weekly work hours and the weekly percentage of non- standard work. At the origin of the graph, we positioned the 'standard 42h' workweek. Both axes represent the deviation of each pattern from this reference workweek in the number of weekly work hours (horizontally) and the percentage points of non-standard work (vertically). This means that the farther a weekly work pattern is situated relative to the origin both in width and height, the less it follows a standard weekly work pattern.

Standard workweeks.

Three variations of the standard workweek exist, and 56.7% of the sample falls within this category. Almost 40% of the total sample has a workweek that runs from Monday to Friday and lasts 42 or 38 h on average. The distinction between both patterns has been made on the 7.1% of evening and night work in the 'standard 38 h' pattern. Another 8.2% works more hours (54 h/week) due to more evening and night work (10% of total work time), but still only work on

weekdays. As a result, these patterns lie close to the origin of the graph in Figure 5. This confirms that it is still reasonable to speak of standard workweeks.

Extended workweeks.

The extended workweeks are named after the fact that work is continued during the weekend and also in the evening and night, as becomes clear from Figure 4. Especially the 'extended 66 h' weekly work pattern suggests long non-standard working hours. More than 20% of the reported work hours are performed during the evening or the night and another, almost, 20% on Saturday and Sunday (see Table 7). Equally, the 'extended 53 h' workweek has also over 20% of the working hours being performed on non-standard times. Although the total number of working hours almost equals the 'standard 54 h' workweek, twice as much paid work is performed on non-standard working periods. Based on the positions of the extended weekly work patterns in Figure 5, we may conclude that these are the least regular work-time schedules. Nonetheless, less than 10% of the selected sample has an extended workweek.

Part-time workweek

Around 40% of the sample works by a weekly part-time work schedule, and we identified five variations of part-time work (see Figure 4). Firstly, there are three weekly work patterns of around 32 working hours (almost 20% of the total sample) which consist of having a Monday off (5.2%), a Friday off (4.4%) or a Wednesday afternoon off in combination with early work ending times in the afternoon on all other weekdays (10.5%). The latter workweek pattern is a typical female pattern (68.5% within this pattern is female). Secondly, there are two workweek patterns that are part time only in terms of the number of hours worked (20 and 30 h/week, respectively). However, these patterns are characterised by a high percentage of non-standard work (12.3% and 22.6%, respectively, see Table 7). The 'part time 20 h' pattern is also a typical female workweek pattern (76.6% within this pattern is female). The 'part time 30 h' pattern is the most irregular part-time workweek (see Figure 5).

Table 8. Binomial logistic regression analyses for three generic types of workweek by gender

	Standard workweek		Extended workweek		Part-time workweek	
	Men Exp(B)	Women Exp(B)	Men Exp(B)	Women Exp(B)	Men Exp(B)	Women Exp(B)
Constant	.767	.710	.144***	.036***	.633	.734
Education						
Lower secondary (ref.)						
Higher secondary	1.232	1.331*	.739	1.437	.961	.883
Higher or university	1.205	1.457**	.668*	1.314	1.020	.873
Age						
18–39 years (ref.)						
40–54 years	1.569	1.228	.980	1.189	.576	.857
55–75 years	1.571	1.017	.979	1.552	.574	.916
Earning situation						
Single earner (ref.)						
Single-earner family	1.182	.750	1.055	.286*	.869	1.640**
Dual-earner family	1.048	.741**	.929	.922	.995	1.369***
Youngest child						
No (ref.)						
<7 years	1.024	.534***	.642*	.606	1.160	1.620***
>=7 years and <25 years	.986	.553***	.928	.563*	1.055	1.679***
Sector						
Private (ref.)						
Public	.521***	.636***	.906	1.158	1.987***	1.358***
Self-employed	.345***	.590**	9.475***	5.889***	.645**	.734
Omnibus test of model coefficients (Chi2)	115.512***	129.953***	267.906***	68.656***	95.526***	97.078***
Nagelkerke R2	.050	.066	.164	.075	.044	.048

*Source: WWG9905 and TUS9905; n=5908; 18–75 years old, employed. Levels of significance: ***p≤0.001, **p≤0.01, *p≤0.05.*

Type of workweek and social position

Table 8 presents the results of the binomial logistic regression for the three generic types of workweeks and for men and women separately.

The most striking finding is that men's chance of working either a standard workweek or a part-time workweek is not affected by socio-demographic characteristics and only by job characteristics, in this case the sector of

employment. Men working in the public sector have a lower chance of having a standard workweek (OR=0.521, p<0.001) and a higher change of having a part-time workweek (OR=1.987, p<0.001). For women, we find the same significant chances for the sector of employment, but more important, earning and family characteristics seem to have a significant impact. Women who live with a working partner are less likely to work by a standard workweek (OR=0.741, p=0.003) and more likely to work by a part-time pattern (OR=1.369, p=0.001). Even women who live with a non-working partner are much more likely to work by a part-time pattern (OR=1.640, p=0.006) than by a standard workweek pattern although the latter is not significant. Additionally, if there are children present, regardless whether they are younger than 7 years old or not, women have a lower chance of being employed in a standard workweek (respectively OR=0.534 and 0.553, p<0.001) and a higher chance of being employed in a part-time workweek pattern (respectively OR=1.620 and 1.679, p<0.001). Education does matter for women; higher educated women are more likely to have a standard workweek pattern (OR=1.457, p=0.005). Finally, having an extended workweek pattern is almost only associated with being self-employed, as observed with the high-odds ratios (9.95 for men; 5.89 for women).

Discussion

Timing, social position and (non-)standard and part-time work

In this contribution, we posed two questions: when do we work and who works when? Firstly, these questions were methodologically motivated. Studies of non-standard work or part-time work hardly ever grasps the true variation hereof. Largely, this is due to the use of an unsuitable question that reduce the timing of non-standard and part-time work to the duration hereof (like in the LFS) or due to the limitations of the data since most time-use surveys only investigate one weekday or one weekend day. On the contrary, the WWG provides information of the timing of work for a whole week, and thus we used WWG to identify by what weekly work patterns we work. This truly improved previous work on weekly and daily timing of work (Glorieux et al., 2008; Lesnard, 2004; Lesnard and De Saint Pol, 2009; Lesnard and Kan, 2011) since it allowed, for example, identifying different types of a part-time workweek.

Secondly, from this methodological improvement, the social relevance stands clear. In line with Presser's (2005) statement that the 'standard workweek' is not so standard anymore, we do find that only 40% of the employees in Belgium have a true standard full-time workweek (i.e., work on weekdays only, hardly any non-standard work and a total of 38 up to 42 h/week). However, this does not mean that the 24-h economy flourishes exuberantly. Most patterns only show up to 6% of night work, with an exception for the 'extended 66h' workweek (12.4% of night work). Nonetheless, large part of the Belgium workforce is likely to face non-standard working times or social inequality in working times (i.e. non- standard work of blue-collar shift workers or part-time work of women).

Next to the standard workweek patterns, we also identified two extended workweeks and five variations of part-time work. These variations are the result of the number of hours worked and the percentage of work per-formed on non-standard working times. Unlike Presser (2005), who was able to differentiate between extended workdays and weekend work only, our extended workweeks were characterised by evening and night work and work on weekend days. The longest workweek lasted on average 66 h and contained 40% of work on non-standard working times. It involves a large share of men and, a very large proportion of self-employed, feeding the idea that extended workweeks in our case are not so much the result of the inferiority of non-standard working hours, as Hamermesh (1999) suggests, but the result of deliberate labour market choices. As we mentioned, part- time workweeks present themselves in different forms, either by (part of the) days off or by a high percentage of non-standard work.

When answering the second question of who works when, the binomial regression analyses showed very different results for men and women. Men's likelihood of working by one of the standard or part-time workweek patterns is to a great part solely motivated by job characteristics. For women, however, family characteristics play a much more important role. Having a working partner and/or a child almost halves the chances of women working by a standard full-time workweek pattern. We do not have any information on the motivation for part-time work, so we cannot judge whether or not this is an equally deliberate choice, as it seems in the Netherlands (Booth and Van Ours, 2009). Nonetheless, regardless the motivation, it remain women who adjust their work to family demands and

we demonstrated by revealing different patterns of part-time work that multiple strategies exist.

The weekly work grid

We demonstrated that the WWG is very valuable when studying the arrangements of working hours. It reveals more insights in the temporal organisation of paid work compared to working hour estimates that are 'integrated' over days (cfr. Hamermesh, 1999). Therefore, we argue that surveys that provide these estimates – of which the obligatory LFS is the most well known – come with a WWG, such that the 'instantaneous' use of time can be analysed as well. We mentioned, however, that the WWG to a limited extent overestimates the number of working hours because respondents tend to include some work-related activities like unpaid lunch breaks and/or travel to and from work (Minnen & Glorieux, 2011). Ideally, the WWG (and LFS) also come with a time-diary, since time-diaries have proven to provide less biased estimates of the time spent on different activities. A study from Robinson et al. (2002) revealed that, when comparing weekly work hours of the time-diary, work grid and survey estimate, 'the largest average was from the estimate [...], the lowest for the diary [...], with the work grid in between [... providing] independent evidence that simple workweek estimate questions provide overestimates' (2002: 48). A combined dataset including all three methods for the same respondents would settle the discussion on work time arrangements even better.

Optimal matching and time-use data

To conclude, a final word on OMA. We applied OMA – a relative new technique in time-use research – to data coming from the WWG. This leads us to positively evaluate both the usefulness of the WWG as a seven-day registration method for paid work additional to classic diary research as well as optimal matching as an effective method to identify time-use patterns (in this case patterns of paid work) without detaching these activities from their sequential occurrence in time as Lesnard and Kan (2011) do in their UK study. We also argued that we saw no reason to first identify different workdays and second identify different workweeks based on the combination of these different workdays. Although we

need to be very cautious about comparing workweeks in the UK and Belgium because of different working conditions and social systems, we do see some general similarities. Both in the UK and Belgium, almost half of the employed work according to standard workweek pat- terns and in both countries the 'standard workweek' includes 42h and only a small portion of non-standard and weekend work. Both methods are also able to distinguish between part-time work patterns of around 32 to 34 h and of around 21 h for an equal share of the sample. However, there are some differences that we might assign to a difference in approach. This concerns the nuances in the standard and part-time work patterns. Our approach yields a distinction in 'long' workweeks that are long because of evening and night work on the one hand and because of weekend work on the other. The same holds for part-time work, where we identified patterns that have a Monday off, a Friday off or Wednesday afternoon off. Our results underline the notion of Lesnard and Kan (2011) that 'the overall proportion of atypical or non-standard workweeks will be underestimated if the figures are generalized from the analysis of workdays alone' (2011: 364) when following their approach. Even though our more nuanced findings of non-standard or part-time work pattern might still be the result of different working arrangements in the UK and Belgium, they prove that the statement that results of analysing both workdays and workweeks using two-stage optimal matching 'gives some confidence to researchers who only have day long time use data' and that 'analysing how work is organized at the level of the day is likely to give good insight into how work is scheduled over a longer weekend' (2011: 364) should be taken with care. The week as a social time-cycle adds to the scheduling of working hours and, for example, even though the worked days and hours are equal, a working pattern with Monday off is different than a working pattern with Friday off.

References

Abbott A (1983). Sequences of social events: Concepts and methods for the analysis of order in social processes. *Historical Methods*, 16, 129–147.

Abbott A (1984). Event sequence and event duration: Colligation and measurement. *Historical Methods*, 17, 192–204.

Abbott A (1995a). A comment on ''Measuring the agreement between sequences''. *Sociological Methods & Research*, 24, 232–243.

Abbott A (1995b). Sequence analysis: New methods for old ideas. *Annual Review of Sociology*, 21, 93–113.

Abbott A (2000). Reply to Levine and Wu. *Sociological Methods & Research*, 29, 65–76.

Abbott A and Forrest J (1986). Optimal matching methods for historical sequences. *Journal of Interdisciplinary History*, 16, 471–494.

Abbott A and Hrycak A (1990). Measuring resemblance in sequence data: An optimal matching analysis of musician's careers. *American Journal of Sociology*, 96, 144–185.

Abbott A and Tsay A (2000). Sequence analysis and optimal matching methods in sociology: Review and prospect. *Sociological Methods & Research*, 29, 3–33.

Blank RM (1989). The role of part-time work in women's labor market choices over time. *American Economic Review*, 79, 295–299.

Booth AL and Van Ours JC (2009). Hours of work and gender identity: Does part-time work make the family happier. *Economica*, 76, 176–196.

Booth AL and Van Ours JC (2013). Part-time jobs: What women want? *Journal of Population Economics*, 26, 263–283.

Bosch N, Deelen A and Euwals R (2010). Is part-time employment here to stay? Working hours of Dutch women over successive generations. *Labour*, 24, 35–54.

Connolly S and Gregory M (2008). Moving down: Women's part-time work and occupational change in Britain 1991– 2001. *The Economic Journal*, 118, F52–F76.

Dijkstra W and Taris T (1995). Measuring the agreement between sequences. *Sociological Methods & Research*, 24, 214–231.

Dumazedier J (1962). *Vers une Civilisation du Loisir*. Paris: Seuil.

Durkheim E (1965 [1912]). *The Elementary Forms of the Religious Life*. New York: The Free Press.

Elzinga C (2003). Sequence similarity: A nonaligning technique. *Sociological Methods & Research*, 23, 3–29.

Fenwick R and Tausig M (2001). Scheduling stress. Family health outcomes of shift work and schedule control. *American Behavioral Scientist*, 44, 1179–1198.

Gershuny J (2000). *Changing Times: Work and Leisure in Postindustrial Society*. Oxford: Oxford University Press.

Glorieux I, Laurijssen I, Minnen J, et al. (2010a). In search of the harried leisure class in contemporary society: Time-use surveys and patterns of leisure time. *Journal of Consumer Policy*, 33, 163–181.

Glorieux I, Mestdag I and Minnen J (2008). The coming of the 24-hour economy? Changing work schedules in Belgium between 1966 and 1999. *Time & Society*, 17, 63–83.

Glorieux I, Minnen J and Van Tienoven TP (2010b). Spouse ''together time'': Quality time withing the household. *Social Indicators Research*, 101, 281–287.

Golden J (2001). Flexible work schedules: Which workers get them? *American Behavioral Scientist*, 44, 1157–1178.

Hagerstrand T (1975). Space, time and human conditions. In: Karlquist A, Lundquist L and Snickars F (Eds). *Dynamic Allocation of Urban Space* (pp. 3-13). Farnborough: Saxon Houses.

Hamermesh D (1998). When we work. *American Economic Review*, 88, 321–325.

Hamermesh D (1999). The timing of work over time. *The Economic Journal*, 109, 37–66.

Hamermesh D (2002). Timing, togetherness and time windfalls. *Journal of Population Economics*, 15, 601–623.

Hamming RW (1950). Error detecting and error correcting codes. *The Bell System Technical Journal*, 29, 146–160.

Hochschild AR (1990). *The Second Shift. Working Parents and the Revolution at Home*. New York: Avon Books.

Jahoda M (1982). *Employment and Unemployment. A Social-Psychological Analysis.* Cambridge: Cambridge University Press.

Jamal M (2004). Burnout, stress and health of employees on non-standard work schedules: A study of Canadian workers. *Stress & Health*, 20, 113–119.

Kragelj B (2009). *Social consequences of information and communication technology – A time use perspective*. Dissertation, University of Ljubljana, Ljubljana.

Lesnard L (2004). Schedules as sequences: A new method to analyze the use of time based on collective rhythm with an application to the work arrangements of French dual-earner couples. *Electronic International Journal of Time Use Research*, 1, 63–88.

Lesnard L (2008). Off-scheduling within dual-earner couples: An unequal and negative externality for family time. *American Journal of Sociology*, 114, 447–490.

Lesnard L (2010). Setting cost in optimal matching to uncover contemporaneous socio-temporal patterns. *Sociological Methods & Research*, 38, 389–419.

Lesnard L (2014). *Using Optimal Matching Analysis in Sociology: Cost Setting and Sociology of Time*. Notes & Documents, 2014-01. Paris: OSC, SciencesPo/ CNRS.

Lesnard L and De Saint Pol T (2009). Patterns of workweek schedules in France. *Social Indicators Research*, 93, 171–176.

Lesnard L and Kan MY (2011). Investigating scheduling of work: A two-stage optimal matching analysis of workdays and workweeks. *Journal of the Royal Statistical Society*, 174, 349–368.

Levenshtein VI (1966). Binary codes capable of correcting deletions, insertions, and reversals. *Soviet Physics Doklady*, 10, 707–710.

Levine JH (2000). But what have you done for us lately? Commentary on Abbott and Tsay. *Sociological Methods & Research*, 29, 34–40.

Lewis JD and Weigert AJ (1981). The structures and meanings of social time. *Social Forces*, 60, 423–462.

Minnen J and Glorieux I (2011). Two days a week? A comparison of the quality of time-use data from 2-day, 7-day diaries and a weekly work grid. In: Carrasco JA, Jara-Díaz S and Munizaga M (Eds). *Time Use Observatory* (pp. 105-118). Santiago de Chile: Impreso en Gráfica.

Presser H (2005). *Working in a 24/7 Economy: Challenges for American Families*. New York: Russell Sage Foundation.

Robinson JP, Chenu A and Alvarez AS (2002). Measuring the complexity of hours at work: The weekly work grid. *Monthly Labor Review*, 125, 44–54.

Robinson JP and Godbey G (1999). *Time for Life. The Surprising Ways Americans Use Their Time*. Pennsylvania: The Pennsylvania State University Press.

Van Tienoven TP, Glorieux I, Laurijssen I, et al. (2011). The social structure of time: Optimal matching for time-use data. In: Carrasco JA, Jara-Díaz S and Munizaga M (Eds). *Time Use Observatory* (pp. 141-157). Santiago de Chile: Impreso en Gráfica.

Wu LL (2000). Some comments on ''Sequence analysis and optimal matching methods in sociology: Review and prospect''. *Sociological Methods & Research*, 29, 41–64.

This chapter is based on Minnen, J., Glorieux, I., van Tienoven, T. P., Daniels, S., Weenas, D., Deyaert, J., ... & Rymenants, S. (2014). Modular Online Time Use Survey (MOTUS)-Translating an existing method in the 21st century. *Electronic International Journal of Time Use Research*, 11(1), 73-93.

CHAPTER 5

Modular Online Time Use Survey (MOTUS) – Translating an existing method in the 21st century

Introduction

What is time-use research? Answering this question means being aware of the concept of time and its meaning for social life as quoted for example by Szalai in 1972 (p.1): "Many interesting patterns of social life are associated with the temporal distribution of human activities, with the regularities in their timing, duration, frequency, and sequential order". These elements, i.e., timing, duration, tempo and sequence are often referred to as the parameters of time (Zerubavel 1982) and all data collection techniques that gather information about at least one of these four parameters are referred to as time-use studies.

In general there are three methodological methods to capture daily human behaviour: direct observation, survey research and diary research. The former has been acknowledged to be most accurate method to register 'real-time' human activities, albeit not the most functional and reliable one since the registered and observed behaviour is most likely to be influenced by the observer(s). The most frequently used methodology to study human behaviour is the survey method, either by self-report or through an interview. In surveys measuring human practices respondents are retrospectively asked what they have done during a certain period of time (i.e. participation), how often their activities took place (i.e. frequency) and/or how long there activities lasted (i.e. duration). The advantages are a reasonable response in addition to a fairly low field-cost, even for population studies, and the absence of a diary component, which leaves more space for inquiring in depth background questions, albeit the probability of having biased results is higher due to, for example, memory recall-effects and social desirability.

In terms of the four parameters of time, survey methodology can only grasp the tempo and/or duration of activities.

Apart from direct observations and survey methodology, time-diary methodology (often referred to as time-use surveys) is capable of capturing all four parameters of time at once and, is therefore, believed to be one of the most profound and valuable ways to capture human behaviour. Time-use surveys draw a picture of how individuals use their time by utilizing a log or a time-diary during at least twenty-four consecutive hours (Pronovost 1989, pp. 76). Through self-observation respondents chronologically report their activities and specify for each new activity the beginning and ending time as well as some contextual information like the place of occurrence and the possible presence of others. The temporal and the behavioural embeddedness of each specific activity makes that the design of the diary is a useful tool for the respondent to report the natural flow of consecutive acts, so that "the time-diary, then, is a microbehavioral technique for collecting self-reports of an individual's daily behaviour in an open-ended fashion on a activity-to-activity basis" (Robinson 1999, pp. 83). This self-reporting is done either through telephone interview, the so-called yesterday-method as applied in the American Time Use Surveys (ATUS) with between 9,000 and 10,000 interviews/diary days per year since 2003, or by completing a paper time diary, the so-called paper-and-pencil method applied in the Harmonised European Time Use Surveys (HETUS). In either way, it is this activity-to-activity structure that empowers both the quality and the usefulness of the data. Time-diary methodology largely overcomes the (un)intended biases of survey methodology because respondents reconstruct their daily behaviour by denoting activities that are always embedded in other activities and are restricted to the maximum length of the day, which will benefit the quality. Besides, time-diary methodology serves multiple research topics because it is not a priori focussed on a specific topic of interest (in contrast to, for example, the European Social Survey - ESS).

Nevertheless, besides these benefits time-diary methodology has also its pitfalls. Firstly, it is bookmarked as a technique with a high demand of cooperation resulting in generally low response rates but which do not have necessarily a selective impact on results (Gershuny 2004). Secondly, it is highly expensive because of the wide fieldwork period (mostly the survey takes an entire year), the labour intensive execution, and the time intensive data-preparation (punching and

cleaning) in order to start valorising the data. However, a large range of comparative studies show the superiority of time-budget surveys over survey research when it comes to analysing daily human behaviour, especially because the time-diary methodology is capable of taking into account all four parameters of time at once (see for example Michelson 2005).

Background of time-use surveys

The Odyssey of the Harmonised European Time Use Surveys (HETUS)

From the outset of time-use surveys[2] the focus laid on socio-economic issues. The earliest (small scaled) time-use surveys were motivated by the concern that the legal restriction of working hours would result in a working class with much free time to spend but without any ideas what to do (Bevans 1913) and by the occurrence of poverty and child mortality in the poorest families in London (Pember-Reeves 1914). Subsequent (large scaled) surveys kept the same focus, for example, economic and social planning in the communist Soviet-Union (Strumulin 1921-1923) and mapping female agricultural work in America between 1925 and 1931 (Zuzanek 1980; Stinson 1999, pp. 12-14). The international breakthrough of time-use surveys, however, came with the UNESCO-funded 'Multinational Comparative Time-Budget Research Project', coordinated by Alexander Szalai (Szalai 1972). Between 1964 and 1966 respondents in twelve countries reported their activities using the same time-diary methodology. The conventions of this methodology are still of crucial importance for today's time-use surveys (Minnen and Glorieux 2011).

From that point on, time-use surveys were never to lose their socio-economic angle of incidence and under impulse of the United Nations the application of time-use surveys for quantifying socio-economic development expanded even more during the 80s, for example, by making visible (the timing of) unpaid work (Juster and Stafford 1991, pp. 472; United Nations 2004). This growing use of time-use data preluded two important global developments in the 90s. Firstly, more and more academics started taking up time-diary methodology to analyse a wide variety of social and economical issues and, secondly, more and more national

[2] Note that from this point on by 'time-use survey' we explicitly mean surveys using the time-diary methodology as briefly outlined in the first section in combination with questionnaires before and after completing the time-diary.

statistical offices started conducting time-use surveys. The former led to the congregation of scholars in the International Association for Time Use Research (IATUR), the latter to a plea for more international comparative data (Harvey 1993) either by post-harmonising existing databases or by pre- harmonising the time-diary methodology. The post-harmonisation has largely been realized by the Oxford Centre for Time Use Research (CTUR) and resulted in an open-access database of Multinational Time Use Survey (MTUS), containing both EU- and American data. The process of pre-harmonisation, which logically was not at issue for the American Time Use Surveys but of major importance for the European Time Use Surveys, was not taken lightly and under the leadership of EUROSTAT resulted in a decade of debates and decision making that ultimately culminated in the guidelines on Harmonized European Time-Use Surveys (HETUS) (European Commission 2008). At the same time EUROSTAT promoted time-use surveys in its member states and associated countries, which resulted in comparable datasets of 20 countries.

The future of the Harmonised European Time Use Surveys (HETUS)

The HETUS-guidelines have resulted in highly comparable and highly valuable international data employed for a wide range of study domains (paid work, unpaid work, gender equality, leisure, ...). Nonetheless, these benefits come at a high cost that directly relate to conducting time-use surveys, including an intensive preparation phase (comprising the different elements like instructions for respondents, questionnaire and the diary, the construction of the sample selection, and the training of interviewers), a yearlong fieldwork period (face-to-face interviews, explanation of the diary procedure, collecting completed diaries), and extensive punching and cleaning of the paper-and-pencil diaries to a digital database. As mentioned, one of the pitfalls of time-use surveys is their relatively low response rate, which means that there often is over-sampling, which increases the costs even more. To give an example, the average cost per respondent of the Flemish 2004 7-day time-use survey was about 265 Euros (about 360 US Dollars). Note that mainly for this reasons the American Bureau of Labor Statistics (BLS) opted for the telephone-aided yesterday-method for the American Time Use Survey (ATUS). Although this makes ATUS more cost-efficient, it does have its downside because respondents could only be asked to recall their previous day.

Re-assembling a longer period significantly effects the quality of the reports (Juster, Ono and Stafford 2003), because of recall-effects. Nonetheless, the length of the observation window is an important element when studying activities not bounded by the daily cycle (e.g. paid work).

The combination of high processing costs and on-going cuts in research funding endangers (at least) the EUROSTAT-minded time-use surveys, and this (for the minimum) in two ways. Firstly, it hinders the continuity of conducting time-use surveys and of studying the changes of human behaviour for the wide range of study domains mentioned above. Secondly, and related to the former, it forces researchers to come up with cheaper methods that produce more or less equivalent estimates or to experiment with cheaper alternatives like online time-diaries. The former jeopardizes the comparability, validity and reliability of the socio-economic estimates, though the latter is undoubtedly welcomed because of its low costs. We estimated the marginal costs for a respondent based for an online 7-day time-use survey to be only 60 to 80 Euros and with the continuous growth of Internet access in the European population (Seybert 2011) online time-diary methodology offers a very good prospect. Several countries (Denmark, Belgium, The Netherlands, United Kingdom, Sweden, Australia, ...) have already been experimenting with time-diary registration through a website (see in Bonke and Fallessen 2010) or a native app (Fernee and Sonck 2013; Sonck and Fernee 2013). Nonetheless, we should not rejoice too quickly, because there is a tremendous downside of all this experimenting: if not done so already, it will put the time-diary methodology right back in the pre-harmonization era!

Assuming that an online time-diary methodology holds the future, the challenge, thus, is to come up with a system that on the one hand can be ultimately agreed on as the new standardized system of time-use surveys and on the other hand produces data that are as comparable as possible to the paper-and-pencil data to continue studying trends. This is the goal we have set ourselves when we received funding for the project called Modular Online Time Use Survey or abbreviated as MOTUS.

In this contribution we outline how we have translated all these features of the paper-and-pencil into a digital time-diary, the insuperabilities we have faced, how we have dealt with them, and the additional features we have included to make this new way of online time-use collecting more practical and easy to use.

Next we provide some preliminary results on the status, quality and response of our pilot study and discuss the additional experiments we have planned for the near future, the analyses we will perform to evaluate the online time-diary methodology, and what we expect from MOTUS in the near and distant future. An English demonstration version of MOTUS can be found at http://www.motusdemo.com.

Modular Online Time Use Survey

The classical procedure of paper-and-pencil time-use surveys is costly, time-consuming, and involves many personnel for conducting the fieldwork and cleaning and inputting the data. The online procedure of MOTUS has low marginal costs, is less time consuming, and involves many automated systems that replace much of the personnel. This does not, however, mean that the one methodology is a perfect substitute for the other. Reasoning from the latter, there are many elements that the online methodology can do better or more compared to the paper-and-pencil surveys, but there are also aspects that this new methodology cannot. In this paragraph we will elucidate how we translated all crucial elements of paper-and-pencil time-use surveys into the online methodology of MOTUS, what additional features MOTUS comprises that eases conducting time-use surveys, and what 'features' or advantages the paper-and-pencil methodology holds over an online system.

Translating paper-and-pencil to MOTUS

The standard process of a paper-and-pencil time-diary survey starts with sending out invitation letters (spread over the survey period) to potential respondents (preferably a random sample) notifying them that an interviewer will pass by. This interviewer has the important task of convincing the respondent to participate and, if so, to take the first (pre-)questionnaire in a face-to- face manner (using CAPI), explain the procedure of the time-diary, and leave behind a drop-off (post)-questionnaire. After the ending date of the time-diary, the same interviewer returns to the respondent and makes a quick check of the time-diary and post-questionnaire to adjust possible major flaws in the registration. Hereafter, all paperwork is converted into digital data, often through a double

punching procedure, and those responsible for this punching procedure try to undo most of the respondent errors (e.g. unspecified time slots, ambiguous activities, ...) by interpreting the context of activities. This is often seen as a weak link in processing time-use data (see Chenu and Lesnard 2006).

Generally, the mode of paper-and-pencil time-dairies varies along two elements: the registration of time, that is open-ended or fixed intervals, and the registration of activities, that is pre-coded or verbatim. In the open-ended registration respondents denote the exact beginning and ending time of the activities, whereas in the fixed interval registration respondents denote their activities with a 10-minute grain precision. Bluntly stated, the advantage of the open-ended mode is a more exact registration compared to the fixed interval mode wherein respondents are asked to retain the 'most important' activity that occurred in that interval[3]. On the contrary, the advantage of the fixed interval mode is that it is less likely to result in unspecified time periods. With regard to the other element, the pre-coded mode of denoting activities (i.e., respondents look up the activity in a list of activities and write down the accompanying code) eases the punching procedure and lets the respondents decide how to interpret the activity. However, this might also be seen as a disadvantage, because such an activity list will never be exhaustive and thus might frustrate the respondent when not being able to 'code' the activity, hence the existence of a verbatim mode.

A final word of importance has to be said concerning the length of observation window. The EUROSTAT-guided (and less burdensome) length is one randomised weekday and one randomised weekend day though many scholars prefer a length of seven consecutive days. The two-day length builds on the idea that the 'daily round' is comparable on all weekdays (and the same for weekend days), whereas the seven-day length builds on the idea that a week is made up of seven different 'daily rounds' (Weigert 1981; Zerubavel 1985).

The procedure of the 2013 Modular Online Time Use Survey (MOTUS) also starts with sending out invitation letters[4] (spread over the survey year) but now

[3] Suppose for a certain 10-minute interval that a respondent sleeps 9 minutes and starts breakfast on the 10th minute of this interval. If the respondent decides to register 'breakfast' as the most important activity of this 10-minute interval, we would, in essence, mistakenly conclude this respondent to have had breakfast for 10 minutes.

[4] Respondents of the pilot project of MOTUS were randomly drawn from the population register. The sample contained information on the names and the contact addresses of the respondents (street, number, postal code and city/municipality).

include a username and password with which respondents are invited to register themselves on the website. Once logged on, they are invited to change their password and voluntarily provide an e-mail address and/or a cell phone number in order to contact them. Hereafter they are invited to start the online pre-questionnaire that contains all features as any other online survey (different types of questions, routing based on previous answers, ...). After completion of the pre-questionnaire the respondents are guided through a communication page that tells them when to start logging their time-diary and provides several explanatory links (instruction page, instruction video, activity list, note page for mnemonic, ...). When finished the time-dairy for the given period, a new communication page asks the respondent to fill in the post-questionnaire to finally complete the survey. Hereafter a final communication page passes on the respondents 'lottery number' to win a money price and a web link that gives them an overview of their own time-use in com- parison to the population sample results, which both are the incentives of the 2013 online time-use survey.

With regard to time registration, we have taken a middle course: the default time slot that is suggested on the diary page is set at 10 minutes, albeit respondents are free to adjust the beginning time and ending time to the very precise minute. Concerning the activity registration, we offer respondents two pre-coded ways of registering an activity. The first is a selection method that let respondents stepwise choose from a 3-level tree structure their main category, the subcategory, and finally their detailed activity. The second is a search method that let respondents to type in a keyword (including the activity code) that generates a list to which this term is tagged and from which the most detailed activity can be selected. These activities are also sorted based on their occurrence in the registration procedure [5]. Additionally, at the level of the subcategories we provided an 'empty' category allowing respondents to write down their activity verbally if none of the pre-coded activities sufficed. Finally, the length of the time-diary is set at 7 consecutive days.

[5] For example, if a respondent types in 'baby' the first activity suggested list is 'taking care of baby: washing, bringing to bed, soothing' and the last activity suggested is 'taking baby to general practitioner'.

Benefits of MOTUS over paper-and-pencil

Methodologically, most of the benefits of MOTUS relate to controlling the quality of the time-diary registration. Firstly, to reduce the unspecified time, the ending time of the previous activity is suggested as the beginning time of the next activity. If respondents do leave open a period of time, this time slot will appear in red in the respondents' timeline overview and allows the respondent with one single click to still edit this time slot.

Secondly, like any online registration method, several algorithms can be run to perform real-time verifications. We distinguish hard warnings from soft warnings. While the former cannot be ignored the latter can. Examples of hard warnings include the impossibility to register activities in the future and the impossibility to leave certain fields open (e.g. whether one was alone or someone else was present during the registered activity). Examples of soft warnings include a notification if an activity endures longer than 20 hours (which is often the result of wrong date setting) or a notification of not having registered a displacement if the location of two sequential activities has changed. Besides those warnings, the system also communicates encouragements, for example, by complimenting respondents for every day they completed and by counting down the days to be filled in.

Administratively, MOTUS has some major beneficial features like Direct Data Storage (DDS), Respondent Management System (RMS), Respondent Tracking System (RTS), and Customized Survey System (CSS). The DDS facilitates the storage of all respondents' input to a direct available database, which makes the (time- and cost expensive) procedure of (double) punching unnecessary. The RMS on the one hand automates the mail handling, for example, with respect to randomly assigning respondents to different research modules (see further) and equally (and randomly) spreading respondents over the survey period, and on the other hand randomly assigns starting days for the time-diary [6]. The RTS allows sending out notifications or reminders via e-mail or text messages if respondents pass pre-defined 'states' of the survey. Such states might be 'not having registered any activity for the past 24 hours', or 'having completed the time-diary but not the

[6] In case of a seven-day registration length, the RMS randomly assigns the starting day and in case of a two-day length the RMS randomly assigns a starting weekday and, when completed, a starting weekend day (or vice versa) with a maximum of a 6-day difference (Monday-Sunday or Saturday-Friday).

post-questionnaire'. Additionally, the RTS stores the respondents' para data like logging times, browser type, time lapse of completing certain aspects of the time-use survey, and so on. The RTS thus allows real-time monitoring of respondents and intervention (through notifications) when needed and in a sense largely replaces the interviewer. Finally, the CSS allows creating several surveys at the same time or altering existing surveys period by deciding on all elements mentioned above: whether or not to include pre- or post-questionnaire, open-ended or fixed interval mode, pre-coded or verbatim mode, number of (levels of) activities, number of days, and so on. This adds a high degree of flexibility to (time-use) surveys compared to the paper-and-pencil method for which every alteration means reprinting and redistributing questionnaires and time-diaries.

Benefits of paper-and-pencil over MOTUS

Like any online survey one element is untranslatable and that is the human factor involved. When it comes to persuading people to participate in surveys, especially in the somewhat more burdensome time-use surveys, personal contact cannot be underestimated. Someone explaining the need/aim of the survey, guaranteeing anonymity, and immediately answering the most pressing questions might instil more confidence than a letter with an encrypted username and password. Especially in times where eavesdropping, NSA, and PRISM are daily news. Here the telephoned-aided American Time Use Surveys has an advantage over online time-use surveys because there is still human contact between interviewer and interviewee. We did try to overcome this feature by placing a special made short video on the importance of time-use surveys on the MOTUS homepage, by having a special phone number that invitees to the survey can call, by trying to respond to e-mails within one day, and by putting a privacy statement on the website. Though this will never replace face-to-face contact with an interviewer.

Modularity

The 'M' of MOTUS stands for modularity and part of this modularity has already been explained in the previous subsections: all elements of the survey itself and the administrative features are adjustable to one's wishes. There is,

however, a modularity that has been underexposed so far and that has to do with registering the context of activities. In all time-diaries respondents are asked to provide the context in which the activity took place, that is, respondents denote who else was present, with whom they talked, where the activity took place, and (in some cases) what motivated them to perform that activity (Glorieux 1990). From the perspective of different research domains, different contextual information might be of interest, though this idea has never been taken up by any time-use survey for several reasons. Firstly, paper diary layout simply lacks space to include more contextual information. Secondly, assigning different contextual questions to different parts of the survey requires a lot of administrative planning and coordination. Thirdly, most of this type of contextual information is activity-specific and thus need not to be completed for every activity.

An online time-use survey methodology might easily overcome these problems and that is what we have tried in the pilot study. We developed three 'modules' that should test questioning additional context information. The first module, the base module, only questions the 'typical' context information (what activity was done, where it took place or what transport mode was used, and with whom the activity was undertaken). The second module, the media module, questions for every activity whether any media (smartphone, tablet, laptop, written media, ...) has been used. The idea behind this module comes from the fact that the use of, for example, smartphones or tablets are so well established in daily life that their usage is hardly ever registered as an activity. This module is developed in consultation with the research group on Studies on Media, Information and Telecommunication (SMIT) of the Vrije Universiteit Brussel.

The third module, the transport module, questions contextual information only if the respondent registers a displacement and is developed in consultation with the research group on Business Technologies and Operation (BUTO) of the Vrije Universiteit Brussel who focusses amongst other things on logistics. This module demonstrates the feasibility to link a particular questionnaire to a particular activity. That is, if and only if respondents register a displacement, the system generates a small questionnaire asking, for example, the mode of transport or scaling the ease of transport. It is obvious that running activity-specific questions is not an option in paper-and-pencil diaries; you either print all possible contextual questions or ask none. Additionally, both modules allowed testing if

there is some sort of upper limit of the number of contextual questions that a respondent will answer. We did not, however, find any negative effects of these additional questions. Respondents in the transport module did not register less transportation activities compared to the base module in order to avoid these questions.

Both modules generate context questions based on answers that were given in the pre-questionnaire (what multimedia devices do you own?, how many cars do you own?, what type of car(s) do you have?, ...). The ease of modulating questions gathering this activity specific contextual information truly does justice to the 'M' of MOTUS.

Preliminary results

It is important to know that the Research Group TOR (TOR being the acronym of Tempus Omnia Revelat which translates to Time Reveals Everything) of the Vrije Universiteit Brussel has developed the methodology MOTUS and that TOR has an extensive expertise in conducting and analysing time-use surveys. It has conducted a small sample time-use survey in 1984, a time-use survey with emphasis on additional contextual information in 1988, two Flemish population time-use surveys in 1999 and 2004, and had an advisory role in the Belgian population time-use surveys in 1999, 2005, and 2013. All this expertise has been of crucial importance in determining the strategy of the development of MOTUS, which we will call a top-down approach: we aimed for MOTUS to be capable of conducting the most extensive, though reasonable, time-use survey we could think of. This implied having an elaborate pre-questionnaire, a 7-day time-diary with open-ended time registration and a list of over 225 activities, an elaborate post-questionnaire, and the implementation of three different research modules with respect to contextual information. Moreover, we decided the pilot study to be a population study, for at least two important reasons: firstly, to get an insight in the (selective) non-response and secondly, because we planned the survey period of MOTUS to run parallel with the survey period of the paper-and-pencil population time-use survey of 2013 as conducted by the National Institute of Statistics Belgium (NIS) following the HETUS-guidelines. The latter allows us to compare both methodologies and if needed to benchmark MOTUS with these paper-and-pencil-data and to see if we need to weight the online data in case

online effects come forward. Nonetheless, the choices for a top-down approach and a pilot population study off course have an important impact on measuring participation. In the following section we provide some preliminary insights on the participation of our surveys and the quality of our data.

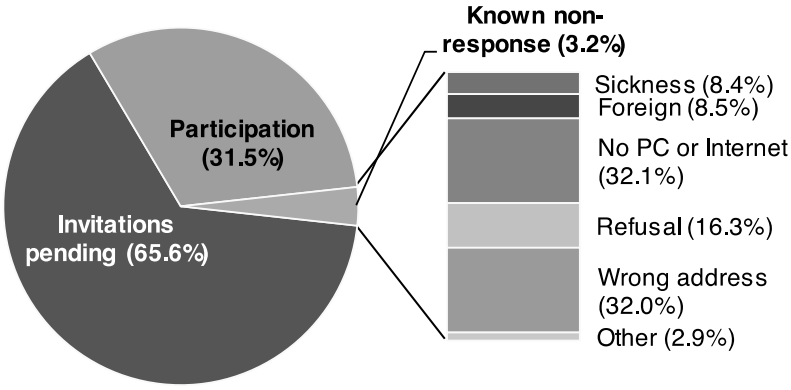
Participation

One of the main measures of participation used in any survey is the response rate. Nonetheless (and especially in time-use surveys), there (still) does not exist a clear consensus on how to define a response rate, even though Kviz started this discussion already in 1977 and the American Association for Public Opinion Research (2011) provides (and updates) standard definitions since 1998. For example, whether to calculate it using the raw sample size, or whether to first adjust the sample size for certain noise like inexistent addresses, deceased respondents, illiterate respondents, households with no Internet access, or even whether to count respondents that delivered unusable data because they simply do not fill in all days, not in a consecutive order, or do not meet certain standards (e.g. by registering only 2 activities per day). This implies that such measures are almost always incomparable and this is often worsened by not clearly specifying the conditions of the survey design, for example, whether the sample is drawn from an 'experienced' panel, whether the survey is linked to another survey, or whether the sample is randomly selected from the population register. In order to evaluate MOTUS in terms of (non-)participation, we, therefore, split up the whole procedure as outlined in the previous section in stages. Note that we do not distinguish between the different modules of MOTUS because, even though significant ($\chi 2=25.916$, $p=0.004$), pairwise comparisons show that this is only the result of a slightly higher percentage of respondents in the media module finishing the pre-questionnaire and a slightly lower percentage of respondents in the media module finishing the whole survey. All other differences in percentage of stages over these modules are negligible.

All figures concern the 39,756 persons between 18 and 75 years old that have received an invitation letter and at most two reminders in the period January 2013 until half of March 2014 and the progress of this time-use survey is downloaded from the MOTUS server at 14 April 2014. Of all invitations, over 65% are still pending (see Figure 6), though this percentage definitely will include a large part

of the non-response, if only because in Flanders almost a quarter to thirty per cent of the households still has no PC and/or internet connection at least not for 7 consecutive days and even 15% of the Belgian have said never to have used Internet before (Belga News Agency 2013; Statistics Belgium 2014). The latter is nicely reflected in the almost 3.2% of persons of which we are happy to know their non-response. Almost one third of the known non-response relates to this problem and another third relates to wrong or non-existent addresses. The other non-response relates to refusal of participation, sickness, non-natives, and a small miscellaneous category that includes amongst other things illiterate or deceased per- sons. In relation to the absence of a home computer or Internet connection the paper-and-pencil design has an advantage over online surveys. Additionally, having interviewers that can ask about the refusal to participate or can give their appreciation about the reason of non-participation (e.g. address not found, respondent has moved out, ...) will off course make the non-response more transparent.

Figure 6. Participation and know non-response



Almost a third of the invitations are answered and once logged to the system we make two important observations in relation to the participants. The first observation is rather ambiguous: over 90% of the respondents complete the pre-questionnaire, over 80% takes a preview of the time-diary, but only 52% of the respondents start using the time-diary (i.e. log at least 1 activity). At this point we thus somehow face a dropout of almost half of the respondents that logged on to our system. Probably, one main reason for this dropout is that although every respondent has immediately access to their time-diary, the randomly assigned

starting day not necessarily follows the day on which they complete the pre-questionnaire. The reason for this is that in following the HETUS guidelines of EUROSTAT, we let the system randomly assign starting days to keep track of the quota of dispersion of starting days over the week. Other reasons might be respondent fatigue or (technical) difficulties with logging activities. From respondents that contacted us on the telephone helpline and from the para data on the used Internet browsers during the study we learned that some used old computers with slow processors that badly performed when loading the time-diary pages and from the logging data that are stored automatically to the server, we learned that several respondents had out-dated Internet browsers that were unable to visualise the online diary properly[7].

Paper-and-pencil time-use surveys are known for their low response because of the intensive survey procedure. Apparently, the online version does not immediately alter this, although obviously we did not expect this from the first population pilot study in which we tested the most demanding fieldwork setup that lasted in total at least 10 consecutive days [8]. However, online time-use surveys like MOTUS do have the advantage of knowing more about the drop-out non-response compared to paper-and-pencil time-use surveys, simply because all data are immediately stored on the server. For any respondent starting the survey and dropping out the answers given already are kept in the database. This allows answering questions like 'at what question did respondents quit?' or 'what are the characteristics of respondents not continuing with their time-diary?'.

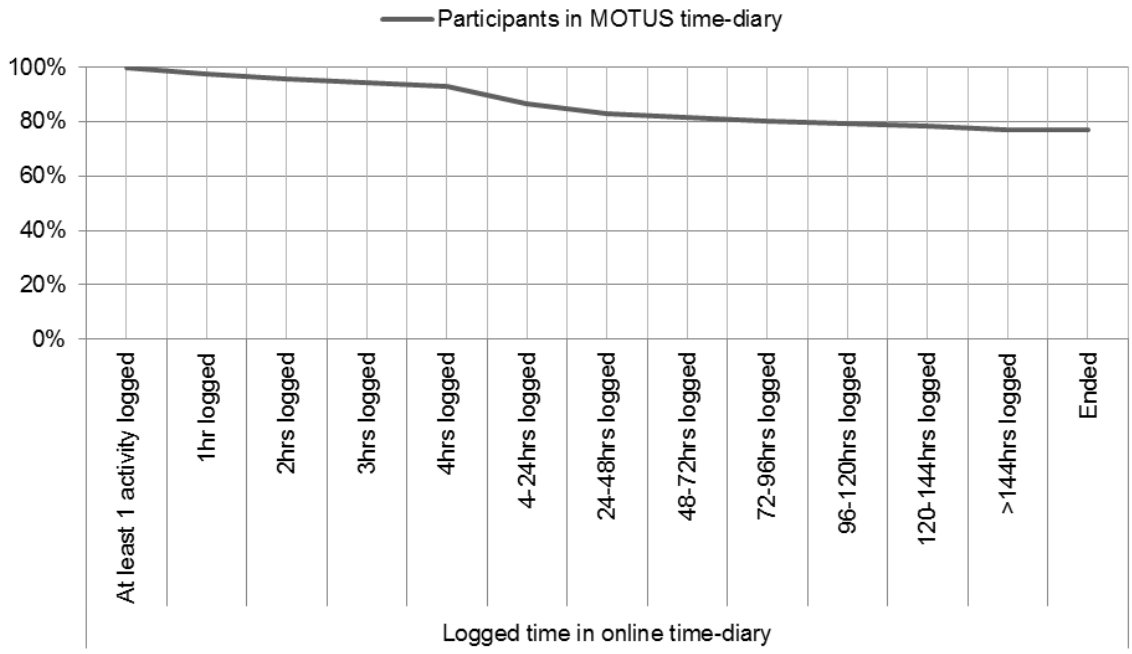
The second observation, though, is certainly positive: once respondents logged their activities in the time-diary for up to 24 hours, they are very likely to complete the whole survey which underlines the easy and intuitive registration flow of the MOTUS time diary design (see Figure 7). In other words, the crucial point of MOTUS apart from persuading more people to accept the invitation thus is to convince people to continue to the start phase of the time-diary and start experimenting with the log-procedure, because once familiar, it turns out not too

[7] Especially Internet Explorer 6 and lower caused some troubles with the visualization of the time diary.

[8] After the respondents completed the pre-questionnaire (day 1) the starting date of the diary registration was communicated. This diary could start the earliest the following day (day 2) and existed of a learning period from 19h till 24h. At midnight (day 3) the actual period of 7 days started and lasted until all days were completed (day 9) and the ending time of the last activity ran over midnight (day 10). After the diary registration was ended respondents also had to fill in a short post-questionnaire.

difficult to complete the time-diary. Note that this applies to people that have the possibility to participate in an online survey. If we want to include more people in a time-use survey in general, we might, for example, opt for a mixed mode (online and paper-and-pencil). To further elaborate on the above results we can have a look at Table 9.

Figure 7. Participants by logged time in MOTUS



Based on the presented results we might conclude that we were somewhat too overanxious with respect to the selectivity of our response. As it turns out females are only slightly overrepresented in our response compared to the population sample and the oldest age group (65-75) are some mere percentage points underrepresented. For the level of education of our population sample we use the information of the Flemish subsample of the Belgian Labour Force Survey (LFS) conducted by the Belgian National Institute of Statistics. The LFS sample can be regarded as being representative for our studied population in 2013 and based on the results we might carefully conclude that the lower and medium educated are slightly underrepresented in our response and the higher educated somewhat

overrepresented [9]. Even more striking is the finding that the distribution of these characteristics hardly changes after the dropout during the transition from pre-questionnaire to time-diary. Again this lets us provisionally conclude that our concern about participation rates should not be with selective response, but with convincing respondents to make the step from finishing the pre-questionnaire to starting the time-diary.

Nonetheless, we do have to conclude from the last column of Table 9 that over the whole process of completing MOTUS, we do lose males, those 65 and over, and lower educated respondents.

Table 9. Response by population characteristics (in %)

	Population sample	Respondents	Respondents starting time-diary	Respondents completed at least one diary day	Respondents completing MOTUS
Gender					
Male	50.1	52.8	48.8	44.1	43.9
Female	49.9	47.2	51.2	55.9	56.1
Age group					
18-24 years	10.9	13.2	13.9	13.7	13.3
25-39 years	25.2	26.1	26.7	26.2	24.7
40-54 years	30.2	31.3	30.3	31.6	32.0
55-64 years	18.3	18.8	18.1	19.5	20.1
65-75 years	15.3	10.7	11.0	9.0	9.8
Level of education[a]					
Low	29.5	22.3	25.5	15.3	14.7
Medium	39.3	35.7	36.9	34.6	34.0
High	31.2	42.0	37.5	50.1	51.3

a: Distribution of level of education in weighted population sample based on Belgian Labour Force Survey 2012 (Flanders only), Source: National Register 2012 (population sample gender and age), Belgian Labour Force Survey 2012 (population sample education), MOTUS 2013 (respondents), own calculations.

Quality of time-diary data

From the previous subsection we derive that the time-diary is the most burdensome element of MOTUS to complete. Nonetheless, once started, respondents do go through the whole process of completing 7 consecutive days. A next question to address concerns the quality of the completed time-diaries. We can judge this quality by three indicators (Juster 1986): (1) the average number of

[9] Levels of education: low=at most lower secondary education, medium=at most higher secondary education, and high=higher education or university degree.

activities registered per day, (2) the average number of minutes of unspecified time per day, and (3) the percentage of activities rounded to obvious time slots (e.g. to 1 hour or to 10 minutes). Table 10 gives an overview of these three indicators per registration day. We also contribute to the debate whether or not the registration quality declines as the number of diary days increases. Note that these days do not concur with the days of the week, since each respondent is randomly assigned a starting day. Further note that we again do not distinguish between the three different modules of MOTUS since none of scores on the indicators significantly differs between these modules [10]. This finding is an indication that counters the idea of 'negative respondent learning' resulting in respondents that avoid registering activities that generate extra questions (and thus require more time). For the former two indicators Table 10 also provides the figures by gender, age group, and level of education.

Firstly, the average number of activities registered per day is 18 and varies between 17.1 on day 1 and 18.3 on day 7. Although this figure is slightly lower than the median of 21 (primary) activities achieved by HETUS-based paper-and-pencil time-use surveys (Rydenstam and Wadeskog 1998), the difference is negligible when comparing to the average number of 18 registered activities per day in previous 7-day paper-and-pencil time diaries of the Flemish 1999 and 2004 time use surveys using an open time registration and pre-coded activity list . Apart from the average per day, it is more interesting to mention that regardless of the population characteristics, figures hardly vary over the day and variance is small, which all points in the direction of a 'learning curve': respondents provide more detail once familiar with the registration system (which is contrary to general belief). Note that difference between sexes, age groups, and levels of education do not say anything about the quality of the data. It is known that women, 25 to 54-year-olds, and the higher educated have a more fragmented time-use and thus register more activities (see for example Glorieux, Laurijssen, Minnen and Van Tienoven 2011).

[10] Combined difference between modules for average number of activities per day: F=0.554, p=0.574. Combined difference between modules for average number of minutes of unspecified time per day: F=0.118, p=0.889.

Table 10. Overview of three indicators of quality of time diary data

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Overall
				Number of registered activities				
General mean	17.1	17.3	17.5	17.5	17.7	17.9	18.3	17.6
Differences between days: F=5.586, p<0.001, η^2=0.002								
By gender								
Male	15.6	15.7	16.2	16.1	16.3	16.6	16.9	16.2
Female	18.3	18.6	18.6	18.7	18.9	18.9	19.4	18.8
Differences between sexes: F=410.406, p<0.001, η^2=0.019								
By age group								
18-24y	15.9	16.4	16.2	16.1	16.4	16.4	16.9	16.3
25-39y	17.6	17.6	18.1	17.8	17.9	18.4	18.8	18.0
40-54y	17.6	18.0	18.2	18.3	18.4	18.4	18.5	18.2
55-64y	16.7	16.8	16.9	17.2	17.7	17.8	18.7	17.4
65-75y	16.6	16.3	16.7	16.8	16.7	17.0	17.6	16.8
Differences between age groups: F=27.401, p<0.001, η^2=0.005								
By level of education								
Low	14.9	15.1	15.3	15.4	15.5	15.9	16.3	15.5
Medium	16.6	16.8	16.9	16.7	17.0	17.0	17.5	16.9
High	18.1	18.3	18.6	18.7	18.9	19.1	19.5	18.8
Differences between levels of education: F=173.158, p<0.001, η^2=0.017								
				Minutes of unspecified time				
General mean	19	2	1	1	0	0	2	3
Differences between days: F=88.646, p<0.001, η^2=0.025								
By gender								
Male	19	3	0	1	0	0	2	3
Female	18	2	1	1	0	0	2	3
Differences between sexes: F=0.012, p=0.913, η^2<0.001								
By age group								
18-24y	12	1	2	1	0	0	1	2
25-39y	8	1	1	0	0	0	3	2
40-54y	20	2	1	1	0	0	1	3
55-64y	27	4	0	1	0	0	1	5
65-75y	44	7	1	1	0	0	2	8
n/a								
By level of education								
Low	21	3	1	2	0	0	1	4
Medium	22	3	1	2	0	0	1	4
High	15	2	1	0	0	0	2	3
Differences between levels of education: F=3.547, p=0.029, η^2<0.001								
				Percentage of activities by rounded time slots				
Rounded to								
1 hr.	11.3	10.1	9.3	9.2	8.9	8.5	8.6	9.4
½ hr.	16.4	15.4	14.9	14.4	14.0	14.1	13.7	14.7
20 min.	13.9	14.2	14.7	14.9	14.8	15.3	15.3	14.7
10 min.	23.1	24.3	24.8	25.1	25.3	24.7	25.1	24.6
5 min.	33.0	33.8	34.0	34.2	34.7	35.0	35.0	34.2
<5 min.	2.4	2.2	2.3	2.3	2.3	2.3	2.4	2.3
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Percentage distribution differs between days: $\chi2$=586.738, p<0.001, η^2=0.002								

Secondly, the average number of minutes of unspecified time also underlines this short learning curve. The first day contains an average of 19 minutes of unspecified time (on a total of 1440 minutes per day), but this figure immediately drops to only 3 minutes on day two and gets negligible on the days thereafter. Again we conclude that once respondents start the time-diary and complete one day, there is no additional hurdle in completing the whole time-use survey. This holds for everyone, even for the oldest age groups and lowest levels of education. They only seem to have some more troubles with completing the first day but not with days thereafter.

Thirdly, the percentage of activities rounded to obvious time durations give an indication of whether respondents take the easy way out of the time-diary or not. Again these figures are optimistic. Over half of the activities are registered with duration of 10 to 5-minute time slots and this remains relatively stable over the days. Besides that, the percentage of activities rounded to 1 hour or half an hour slightly decreases over the days again indicating that respondents quickly adopt the entry procedure of the time-diary and register their activities in more detail.

Discussion

As we outlined above, the top-down approach of our pilot-study was rather ambitious. Conducting a large-scale population (18 to 75 years old) study without any help of an interviewer on a full time-use survey design that lasts at least 10 days since it includes extensive pre- and post-questionnaires, a 1-day time diary learning day, a 7-day time diary registration, and different modules to test the modularity of the contextual questions in the time-diary. With regard to the latter, we conclude that the different modules (read: different and additional contextual questions) do not result in different tendencies with regard to the participation in MOTUS. Apart from that, the pilot-study revealed some bottlenecks in the time-use survey design that require further investigation, modification, and evaluation. In this final section we briefly discuss current and future experiments that should increase the participation rate and even (more) higher the quality of registration (en surplus), we outline how we will continue to evaluate MOTUS, and we elucidate on what we expect from MOTUS in the future.

Small-scale experiments

The absence of an interviewer is an often-named flaw of the digitalization of surveys and although the confidence building contact with a real and reliable person might convince more people to take part in social surveys (especially in times with the NSA and PRISM as on-going headline news), we rather see its absence as merely insurmountable. Therefore, we aim at making meaningful adjustments in the survey design and methodology to see whether they positively affect people's willingness to participate and perseverance to continue. Note that this adjustability is one of the main advantages of online social surveys since it does not require any reprinting and redistribution of questionnaires and/or time-diaries.

Currently we set up an experiment that changes three elements of MOTUS in order to benefit the participation and continuation rates. Firstly, we invited 1,000 people to complete their time- diaries only for one randomized weekday and one randomized weekend day instead of 7 consecutive days (which is basically what EUROSTAT-HETUS prescribes). Secondly, we invited another 1,000 people that are proposed a fixed incentive of 10 euros for completing MOTUS. Currently, people are awarded a lottery number that will give them a 1 out of 4 chance of winning a money-price (ranging from several prices of 10 euros to one price of 500 euros). Thirdly, for another 1,000 invitees we change the three-level structure of activities to a two-level structure, which reduces the number of activities from which to select from 225 to 49 activities. Based on the results of this round we will make combinations of these adjustments and test these again, but we already see that reducing the registration days from 7 to 2 (one weekday and one weekend day) significantly highers the number of respondents starting and finishing the diary registration. This also shows that the automated communication to assign respondents to different days and remind them to start the second day (which is not necessarily the next day since, like in the HETUS-format, we question a weekday and a weekend day) works properly. Also, the two other tests have a merit towards the original setup.

Another experiment that is on the drawing table is to conduct MOTUS in a mixed mode setting, that is, letting people choose whether they want to participate via the online modus or via the classic paper-and-pencil modus, or to (re)introduce

the interviewer to convince respondents to participate and instruct people how to use the online diary registration. Both suggestions, undoubtedly, will increase the costs of conducting time-use surveys but this will still be less than a traditional paper-and-pencil design. Additionally, this gives the opportunity to include the 25 to 30% of households that do not have access to a PC with Internet connection.

Furthermore, we are redesigning the visible front-end of the time-diary. At this moment we use a sequence of input fields and display all entries in a timeline on the right-hand of the screen (Twitter view). However, we are interested in knowing whether an agenda-layout with the possibility to cut, copy, paste and drag activities might generate different results, since many people are already familiar with such designs (e.g. like Google calendar), or if a Life History view would be beneficial, which make it possible to develop an e-Work Grid as one of the research tools of HETUS. Additionally, we are trying to have the activity registration resemble the HETUS way of registering by allowing respondents to type in what they have done and use artificial intelligence to have the MOTUS-software analyse the inputted description and show to the respondent a number of related pre-coded activities. If the respondent chooses one of these suggestions the verbatim activity is already coded at no extra costs at a later stage.

Finally, we are currently working on developing an application for smartphone/tablets for all main operating systems (e.g. Android, iOS and Windows) that complements the online time-diary registration. This allows people to complete their time-diary entirely on a smartphone/tablet, or to make brief entries in their time-diary using the App, synchronise it on their computer via the website of MOTUS, or the other way around. Of particular importance is that respondents carry the smartphone/tablet with them almost all the time as if it were the 'paper-and-pencil booklet'. Pilot panel studies in the Netherlands have shown that people tend to use their smartphone to log an activity about 11 to 12 times per day. This is obviously more than can be expected from an online diary via a desktop or laptop.

Using the MOTUS database

As far as we know, MOTUS is the first online time-use survey ever conducted on a population scale so there exists no evidence on the reliability of time-use

estimates gathered through online time-use surveys. Therefore, we have deliberately chosen to conduct MOTUS parallel with the third wave of the 2-day Belgian time-use survey following the HETUS-guidelines (raw response rate of 19%). The latter, with a sample drawn from the same population, still uses the classical paper-and-pencil methodology, which enables us to analyse the reliability of the time-use estimates of MOTUS and compare both methodologies. Additionally, since we know that the response is selectively biased, this allows us to calibrate the MOTUS database with both the population and the Belgian time-use survey before using it for profound time-use analyses.

Furthermore, the MOTUS database contains a lot of data that are often referred to as para data. These data include type of browser used, times, dates and duration of respondents' logins, times, dates, and time-lapse of completing different fields of the questionnaires and time diary, loading times of submitting activities or retrieving questionnaires, and so on. Analysing these kinds of data will tell us a lot about the actual completion-behaviour of respondents, a view in term of quality measures that has never attempted by the traditional paper-and-pencil method.

Additionally, the 'stacked' design of MOTUS (pre-questionnaire, time-diary, post- questionnaire) in combination with the direct storage of any data inputted in the system, provides us with little up to a lot of information (based on their progress in the time-use survey) of the 'drop-out-response'. Compared to partially completed paper-and-pencil questionnaires or diaries that end up in the trash, we might use these interrupted data to touch upon some of the sore points of our time-use methodology.

The future of MOTUS

We are aware of the fact that MOTUS as a methodology for conducting online time-use surveys still has some important steps to take. Nonetheless the ambitious top-down approach for the development of MOTUS has one major advantage: almost every element of time diary research that one might think of is included in the software ready to be adjusted. Additionally, the MOTUS-software is future-proof in a sense that it allowed for optional plugins that might facilitate time-use registration (e.g. data gathered by GPS' or accelerometers on smartphones). Within MOTUS there is still a lot to explore, design, and test and

through this flexibility and modularity we hope to avert the scenario of ending up with multiple, freestanding, non-harmonized online time diary software. Therefore, we aim at setting up a broad international network of statisticians of National Bureaus of Statistics and international university research departments to jointly develop and fine-tune the future of online time-use research to arrive at a standard for conducting online time-use surveys; a sort of HETUS 2.0. The time-use community came a long way to harmonize the paper-and-pencil time-use methodology and make cross-national comparisons possible, especially in Europe, and we cannot imagine anyone willing to abandon this harmonisation. Nonetheless, the quest for cheaper time-use methodology does endanger this achievement. We already anticipated this by thoroughly designing the basics for an online time-use methodology but maintaining European or internationally harmonised guidelines cannot be done by us alone.

References

The American Association for Public Opinion Research (2011). Standard definitions – Final dispositions of case codes and outcome rates for surveys, 7th edition, AAPOR.

Belga News Agency (2013). "Vijftien procent van de Belgen gebruikt nooit internet" (Fifteen per cent of Belgians never uses internet.), 18 December 2013, downloaded at: http://www.deredactie.be/cm/vrtnieuws/binnenland/belga_20131218_Internet_15Procent.

Bevans, G. E. (1913). *How working men spend their spare time*. Columbia University Press, New York.

Bonke, J. and P. Fallessen (2010). The impact of incentives and interview methods on response quantity and quality in dairy- and booklet-based surveys. *Survey Research Methods*, 4(2), 91-101.

Chenu, A. and L. Lesnard (2006). Time use surveys – A review of their aims, methods, and results. *European Journal of Society*, 47(3), 335-359.

European Commission (2004). *Guidelines on harmonised European time use surveys*. Luxembourg: European Commission, EUROSTAT.

Fernee, H. and N. Sonck (2013). Is everyone able to use a smartphone in survey research?. *Survey Practice*, 6(4), 1-7.

Gershuny, J. (2004). Costs and benefits of time sampling methodologies. *Social Indicators Research*, 67(1-2), 247-252.

Glorieux, I. (1990). Social interaction and the social meanings of action – A time-budget approach. *Social Indicators Research*, 30(2), 149-73.

Glorieux, I., Laurijssen, I., Minnen J. and T. P. Van Tienoven (2011). In search of the Harried Leisure class in contemporary society – Time-use surveys and patterns of leisure time consumption. *Journal of Consumer Policy*, 33(2), 163-181.

Harvey, A. S. (1993). Guidelines for time use data collection. *Social Indicators Research*, 30(2-3), 197-228.

Juster, T. F. (1986). Response errors in the measurement of time use. *Journal of the American Statistical Association*, 81(394), 390-402.

Juster, T. F. and F. P. Stafford (1991). The allocation of time – Empirical findings, behavioral models and problems of measurement. *Journal of Economic Literature*, 29(2), 471-522.

Juster, T. F., Ono, H. and F. P. Stafford (2003). An assessment of alternative measures of time use. *Sociological Methodology*, 33(1), 19-54.

Kviz, F. (1977). Toward a standard definition of response rate. *Public Opinion Quarterly*, 41(2), 265-267.

Michelson, W. (2005). *Time use – Expanding explanation in the social sciences*. London: Paradigm Publishers.

Minnen, J. and I. Glorieux (2011). Two days a week? – A comparison of the quality of time-use data from 2-day, 7-day diaries and a weekly work grid. In: Carrasco, J. A., Jara-Diaz, S. and M. Munizaga (Eds.), *Time use observatory* (pp. 105-118), Grafica LOM, Santiago de Chile.

Pronovost, G. (1989). The sociology of time. *Current Sociology*, 37(3), 1-124.

Reeves, M. S. (1914). *Round about a pound a week*. New York: Garland Publishing.

Robinson, J. P. (1999). The time-diary method – Structure and uses. In: Pentland, W. E., Harvey, A. S., Lawton, M. P. and M. A. McColl (Eds.), *Time use research in the social sciences* (pp. 47-89). New York: Kluwer Academic/Plenum Publishers.

Rydenstam, K. and A. Wadeskog (1998). Evaluation of the European time use pilot studies. Eurostat DOC E2, TUS/5/98.

Seybert, H. (2011). Internet use in households and by individuals in 2011. In: EUROSTAT (Ed.), *Statistics in focus*, 66/2011.

Sonck, N. and H. Fernee (2013). *Using smartphones in survey research – A multifunctional tool*. The Hague: The Netherlands Institute for Social Research.

Statistics Belgium (2014). Survey on ICT use by households and individuals, http://statbel.fgov.be/en/statistics/surveys-methodology/surveys/ICT_household.

Stinson, L. L. (1999). Measuring how people spend their time – A time-use survey design. *Monthly Labor Review*, 122(8), 12-19.

Szalai, A. (1972). *The use of time – Daily activities of urban and suburban populations in twelve countries*. The Hague: Mouton.

United Nations (2004). *Guide to producing statistics on time use*. New York: Department of Economic and Social Affairs, Statistic Division, United Nations.

Weigert, A. J. (1981). *Sociology of everyday* life. New York & London: Longman.

Zerubavel, E. (1982). *Hidden rhythms – Schedules and calendars in social life*. Chicago & London: The University of Chicago Press.

Zerubavel, E. (1985). *The seven day circle – The history and meaning of the week*. Chicago & London: The University of Chicago Press.

Zuzanek, J. (1980). *Work and leisure in the Soviet Union – A time-budget analysis*. New York: Praeger.

This chapter is based on Minnen, J., Rymenants, S., Glorieux, I., & van Tienoven, T. P. (2023). Answering current challenges of and changes in producing official time use statistics using the data collection platform MOTUS. *Journal of Official Statistics*. Online First.

CHAPTER 6

Answering current challenges of and changes in producing official time use statistics using the data collection platform MOTUS

Introduction

Today, National Statistical Institutes (NSIs) face challenges and changes in the way they produce official statistics (Radermacher 2020). On the one hand, technological developments create the opportunity for paradigm shifts in methodology (Ashofteh and Bravo 2021). On the other hand, modern societal changes and challenges create new user demands for high-quality data and statistics (Cai and Zhu 2015). Taken together with the budgetary restrictions in place, this results in a large pressure to shift to online data collection and to connect data collection environments with other data sources that bring valuable information to specific statistical domains (Ricciato, Wirthmann, and Hahn 2020). This digital transformation rapidly changes the context and needs, and it also leads to growing privacy and data security concerns and suspicion towards official statistics (Keusch *et al.* 2019; Ricciato, Wirthmann, and Hahn 2020). Amidst these challenges and changes, modernisation initiatives should be supported by trustable, shareable, and scalable processes considering "smart" ways to collect data (Bruno, Inglese, and Ruocco 2021; Ricciato *et al.* 2019). These processes are assumed to lead to cost reductions for the statistical offices and to lower the respondent burden (Salemik, Dufour and Van der Steen 2020). In addition, these processes must remain standardized for reasons of comparability, yet flexible and agile enough to meet (country) specific needs and allow statistics to be disseminated quickly. At the same time, these processes must not compromise on the quality and reliability of the collected data (Salgado *et al.* 2018; Stodden 2014).

At the European level, the European Statistical System (ESS), which is a partnership between Eurostat and the NSIs of the EU and EFTA countries, aims at

enhancing the strengths (such as comparability) of harmonised statistical methods and to reverse the trend of a gradual disintegration of the data collection process stemming from NSIs facing declining participation rates and increasing difficulties in organising data collections (and thereby jeopardizing the quality and reliability of the statistics). At the same time, the ESS foresees to jump on the bandwagon of the process of digitalisation, growing smartphone usage (Keusch *et al.* 2019) and the availability of 4G and 5G networks (Gohar and Nencioni 2021). New technologies should improve respondent responsiveness by using new tools, integrating new data flows by connecting data sources, and help NSIs become more efficient by defining data collection platforms. The goal is to better capture and disseminate the perspective of households (Carletto *et al.* 2022).

The Time Use Survey (TUS) is one of the European surveys that are substantially affected by the challenges of and changes in the way NSIs produce statistics, but at the same time would substantially benefit from new technological developments. Against that backdrop, this contribution aims to answer whether the data collection platform Modular Online Time Use Survey (MOTUS) is able to tackle these challenges and align with these changes. Official TUSs face numerous challenges, such as the need to replace the expensive and laborious paper-and-pencil method by a digitalized method with smart ways to reduce respondent burden amid the absence of updated guidelines to harmonize digitalized TUS across NSIs. Many of these challenges relate to the principles of the European Statistics Code of Practice (Eurostat 2018). The central question this contribution addresses is *can MOTUS improve on respondent burden (principle 9), cost efficiency (principle 10) and quality such as accuracy and reliability (principle 12), and timeliness and punctuality (principle 13) in producing official TUS statistics?*

In answering this question, we consider respondent burden as a *perceived* burden, which results from low motivation, the complexity of the tasks at hand, and the challenging effort to complete the survey (Yan, Fricker and Tsai 2019). Furthermore, we consider the timeliness, the accuracy and reliability of the (intermediate statistics production steps as well as the final) time use statistics as quality indicators. We assume that the accuracy and reliability of statistics can be gained by reducing human data entry errors, by reducing the respondent recall error, and by supporting respondents with real-time prompts during the data collection process. In what follows, we evaluate MOTUS in terms of expected

improvements in costs, respondent burden, and quality compared to the current best practice of paper-and-pencil TUS for different phases of the Generic Statistical Business Process Model (GSBPM; Kuonen and Loison 2019).

Background

Time Use Surveys

A TUS collects data on daily life. They are a way to picture the "many interesting patterns of social life [that] are associated with the temporal distribution of human activities, with the regularities in their timing, duration, frequency, and sequential order" (Szalai 1972, p1). Respondents use a log or a time use diary of at least twenty-four consecutive hours to self-report their daily behaviour in a chronological and open-ended fashion on an activity-to-activity basis (Pronovost 1989; Robinson 1999). In the time use diary, respondents specify – for each new activity – the start and end time as well as some contextual information like the place of occurrence and the possible presence of others. This not only makes time use diaries capable of simultaneously collecting data on the duration, timing, tempo, and sequence of activities (Zerubavel 1982) but it also reduces respondent errors related to self-reporting of activities in daily life compared to other survey methods (Lavrakas 2008). Respondent errors related to understanding the concept (of the question asked) are reduced because respondents are not directly queried but use their own wording to describe their activities. However, insufficient detail in verbatim activity descriptions complicates posterior activity coding (Chenu 2004). Recall biases are reduced because respondents are asked to register their activities in close to real time, resulting in multiple registration moments per day. Other biases such as social desirability biases or confirmation biases are reduced because time diaries do not focus on a particular activity, activities chronologically follow each other (i.e., the ending time of one activity is the start time of the next activity), and activity durations are restricted to 24 hours a day (Te Braak, Van Tienoven *et al.* 2022).

A TUS is a valid source for policymakers to produce official statistics and to further enhance the understanding of daily life, initiatives have been taken around the world to harmonize the production of time use data (Robinson and Godbey 1997). One of the most extensive harmonization processes was carried out by

Eurostat and resulted in the guidelines on Harmonised European Time Use Surveys (HETUS) for these surveys conducted by NSIs (referred to as "the guidelines" below). The guidelines (which include sample design harmonization and standardization, mode and methodology design, activity coding, data coding, weights, and metadata) have been used by nearly 20 European NSIs in two HETUS rounds between 1998 and 2015.

The TUSs are not merely a European matter. Since 2003, the U.S. Bureau of Labor Statistics (BLS) collects yearly waves of the American Time Use Survey (ATUS) to support policy research related to household production, health and safety, and family and work-life balance. Similarly, and often with support of the International Labor Organization (ILO), numerous countries outside Europe use time use statistics to gain valuable insights on household production and gender (in)equality (United Nations 2016).

The major strength of TUSs is capturing detailed information of daily activities in a chronological and contextualised way. Yet this strength is also its weakness, both at the organisational "back office", as well as at the participation environment or "front office". From an organisational point of view, these surveys are costly, mainly due to postage, printing, and personnel costs resulting from multiple interviewer visits to the household and data entry from paper time use diaries. Regarding the latter, the large number of offline manual operations increase the risk of errors. Additionally, fieldwork periods typically run for 12 months to capture seasonal variations. From the respondent point of view, the burden to complete such a survey is relatively high, because household members complete multiple questionnaires and keep track of their daily time use in paper time use diaries.

A HETUS based TUS

To address the central question whether MOTUS can improve respondent burden, cost efficiency, accuracy and reliability, and timeliness and punctuality in producing official TUS statistics, we consider the guidelines to be the benchmark. As the HETUS is a household survey, sampling is carried out at the household level. The identified head of each participating household will complete a grid that records the relationships between all persons in the household (i.e., the household grid, see Eurostat 2020, p33) and a household questionnaire. Additionally, all

eligible household members (i.e., aged 10 and above) will complete an individual questionnaire. Currently, this is (most frequently) done via Computer Assistant Personal Interviews (CAPI), which implies an interviewer visit – at which the interviewer also leaves behind two paper time use diaries per eligible household member with the dates on which both time use diaries must be completed. One diary concerns a weekday, and one diary concerns a weekend day (the same two days for all household members). The interviewer might also leave behind a drop-off questionnaire, which is to be completed by all eligible household members after the time use diaries. At a prearranged date, the interviewer returns to check and collect the time use diaries and the drop-off questionnaire. At the NSIs, the paper time use diaries and drop-off questionnaires are entered into a database, often using parallel data entry to prevent input and coding errors.

Modular Online Time Use Survey

Introducing MOTUS

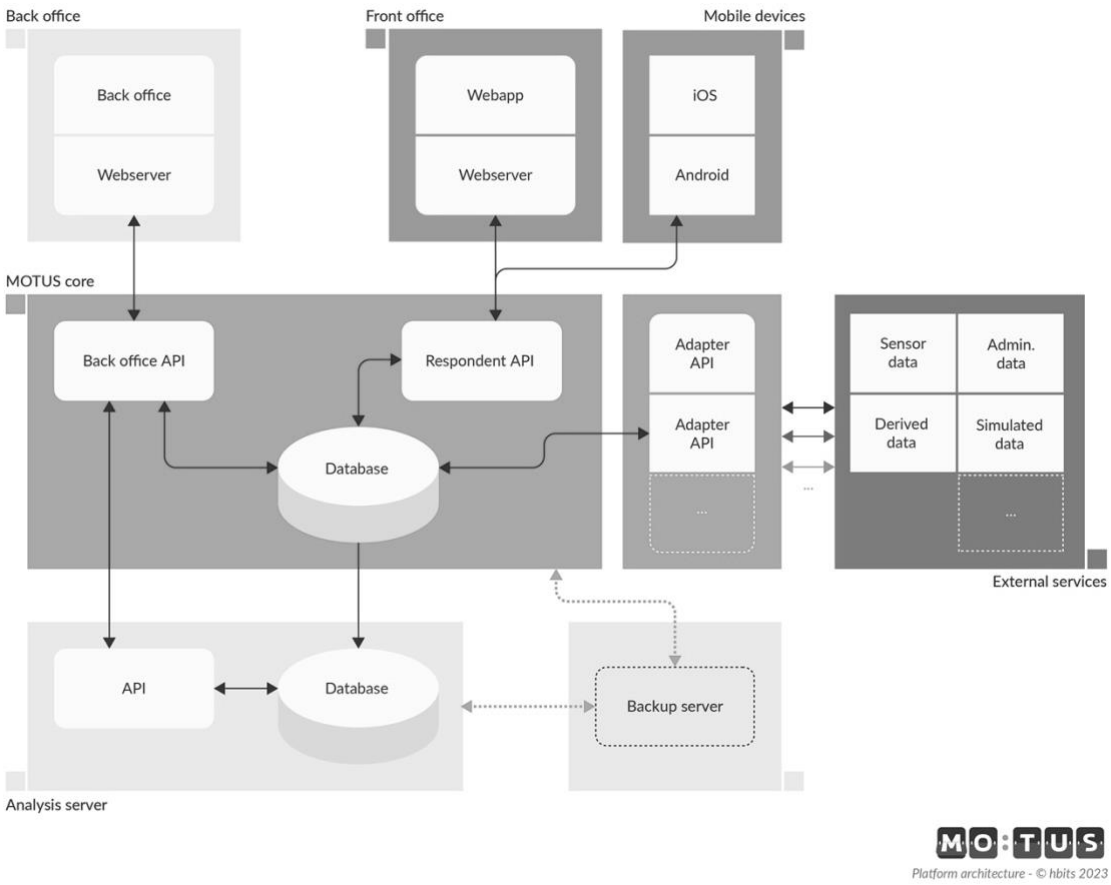
To counter the high costs of conducting TUSs and to lower the respondent burden, while maintaining reliable and quality output on daily life, scholars and NSIs started to experiment with conducting these surveys through web- and mobile applications (Bonke and Fallesen 2010; Fernee and Sonck 2013; Sonck and Fernee 2013; Sullivan *et al.* 2020), with the first applications coming into circulation around 2010. The first version of MOTUS was rolled out in 2012.

Figure 8 shows the platform architecture of MOTUS. The MOTUS data collection platform consists of a front office as well as a back office. The front office relates to the collection tool or application, with which the users can interact via a user interface (UI) and which delivers, through its functionalities, a user experience (UX). The MOTUS application is available as a web version for browsers (https://app.motusresearch.io) and in iOS and Android mobile versions for smartphones and tablets. The purpose of the application is to make it easier for the respondent to carry out all tasks of a (time use or other) survey.

The back office serves to build a study, to facilitate data collection and monitoring, and to process the data. To this end, the back office, which is accessible via a web environment, contains several *builders*. Both the front office and back office connect to the MOTUS core ("the core") through Application Programming

Interfaces (APIs). The core holds the database with all information required to build a study and collect data. A separate analysis server holds a replica of the database from the core and facilitates the processing of information in the back office. The back-up server is a replica of the core and analysis server. Adapter APIs serve to adapt external information so that it can be processed in the core, thereby allowing the ingestion of, for example, passive data gathered via integrated sensors or connected devices, administrative/secondary data available via external data sources, or other processed data. For reasons of optimization, data security and privacy, these data are handled and organised in an anonymized way in stand-alone microservices. All input provided by the user is sent encrypted via an https communication to the server and is immediately propagated to all devices of the user via the respondent API. As a result, the MOTUS web and mobile applications can be used interchangeably.

Figure 8. Overview of the MOTUS platform architecture



Building TUS with MOTUS

To enhance the comparability of official TUSs in Europe, the design hereof in MOTUS is largely informed by the guidelines, which are regularly updated (Eurostat 2020). In the current situation, these guidelines provide a good starting point to include online applications and data collection platforms, while considering an online first approach which still ensures comparability with paper diaries (Vassilev *et al.* 2020). At the same time, new applications and platforms and the options to implement smart solutions will produce possibilities that most likely impact the TUS design.

MOTUS supports building a HETUS guided TUS and currently features nine builders – eight of which are relevant for a TUS, while the ninth builder offers future possibilities. All builders contribute in varying degrees to the lowering of the respondent burden, the cost reduction, the improvement of the accuracy and reliability of the data, and the increased timeliness and punctuality. Table 11 provides an overview of the builders in relation to the GSBPM build phase and the improvements that they bring in relation to current TUS practices.

Collection instruments

The *survey builder* serves to create online questionnaires based on all common question types with all common functionalities (e.g., answer-based routing, piping). This builder allows sharing previous questionnaires over studies. For a TUS the survey builder would be used to construct a household questionnaire, two individual questionnaires (e.g., one before and one after the time use diaries) and context questionnaires. Context questionnaires are linked to activities that are registered in the time use diary and can gauge where the activity took place (or what mode of transport used in case of travel), with whom the activity was undertaken, and if any information or communication technology was used during the activity. Obviously, online questionnaires are timelier and more punctual as well as more cost efficient because they (can) eliminate interview and data entry processes (as data are already digitized, which also eliminates human data entry errors). They also contribute to accuracy and reliability because

conditions (e.g., mandatory questions) and restrictions (e.g., an answer cannot exceed a certain value) can be defined.

Table 11. Overview of the MOTUS builders in relation to the GSBPM build phase and improvements (by CoP principle) to TUS practices

Subphase	Supported phase	Builder	TUS elements	Improvement in CoP principles			
				Respondent burden	*Cost efficiency*	*Timeliness & Punctuality*	*Accuracy & Reliability*
3.1 Reuse or build collection instruments	4. Collect	Survey builder	- Household questionnaire - Individual questionnaires - Activity context questionnaires	–	●	●	○
		Diary builder	- Online Activity Classification List - Activity selection settings - Diary settings	●	●	●	●
		Grid builder	- Household members relationships - Eligibility criteria for participation	–	●	○	●
3.2 Reuse or build processing and analysis components	5. Process 6. Analyse	R builder	- Activation report (for reminders) - Finalisation report (for remuneration) - Quality and cleaning criteria - Dashboard progress report	–	●	●	●
3.3 Reuse or build dissemination components	7. Disseminate	R builder	- Data export	–	●	●	●
3.4 Configure workflow	4. Collect	Communication builder	- Communication content - Communication type	○	○	○	○
		Translation builder	- Set up multiple languages	○	–	–	○
		Invitation builder	- Manage respondent inflow	–	○	○	○
		Research builder	- Create workflow	○	●	●	●

Legend: ● Substantial improvement, ○ Reasonable improvement, – Limited to no improvement

The *diary builder* sets up the time use diary. At the core of the time use diary is the Online Activity Classification List (OACL) that respondents use to register their daily life. The OACL is derived from the Activity Classification List (ACL) as described in the guidelines. In MOTUS, an OACL is created as a tree structure with up to three levels and as many activities or activity categories in any given level as needed. In MOTUS, a (different) context questionnaire (as created in the survey builder) can be attached to each specified activity. The diary builder contains a repository with previous OACLs for reuse.

The use of OACLs presents a major improvement. Firstly, it is cost-efficient because there is no need to assign actual activity codes to written, verbatim activities. MOTUS can present the OACL to the respondents as a collapsible tree structure, and/or as a searchable list, and/or as a list of favourites. The searchable list is very similar to the traditional verbal description, with the difference that respondents are shown the activities that match their description and thus code their description themselves. Since respondents do this straight away, this also improves the accuracy and reliability as well as timeliness and punctuality. For the searchable list to work, an unlimited number of search tags can be assigned to each of the activities at the most granular level of the tree structure in the diary builder. For the favourite list to work, respondents need to star activities. The different options of selecting activities in the time use diary are also likely to lower the respondent burden and accuracy and reliability because relevant response alternatives are suggested. To handle the situation when an activity cannot be found, OACLs might contain the option to describe activities in the respondents' own words. The search terms used, and the finally selected activity are stored in the background to progressively improve the efficiency of the search algorithm during the course of the survey. Secondly, paper-and-pencil questionnaires are limited regarding the context questions and these questions cannot vary per activity in the ACL. This advantage of OACLs can lower respondent burden as (for instance) not all context questions need to be asked.

Next to the activity list, the diary builder also allows the survey manager to set a large array of time use diary parameters. These include the granularity of the time intervals (e.g., continuously or in whole minute intervals), the diary period and diary period calculation, the start and assignment of focus periods (i.e., the day or days for which the time use diary needs to be completed), and the (length

of the) learning period. For a HETUS based TUS, the focus days are a function of an algorithm that ensures an equal dispersion of starting days across the week and assigns one weekday and one weekend day to all eligible individuals of the household. The granularity would be set at 10-minute intervals. Controlling the time use diary parameters brings a substantial improvement to accuracy and reliability. The major disadvantage of drop-off paper time use diaries is the lack of control over and insight in what happens between dropping off the diaries and collecting them (te Braak, Van Droogenbroeck *et al.* 2022). The diary builder allows the survey manager to set, monitor, and adjust the time use diary during the fieldwork.

The *grid builder* is used when the unit of participation is not the individual but a group or, in our case, a household. In a TUS, the reference person of the household composes a household grid by adding household members, providing relevant information (e.g., at least date of birth), specifying relationships (e.g., mother-daughter, partners, siblings …), and answering questions about household members under 10 years old (e.g., about day care arrangements). Based on this information, household members are checked for their eligibility (according to the criteria set out in the grid builder) to take part in the survey. If the reference person provides group members' email addresses, all group members who are eligible to participate will receive an invitation via email with their initially assigned personal credentials. An online household grid has the same cost and time benefits as online survey questionnaires.

In a HETUS based TUS, participation needs to be coordinated, because of synchronous time use diary registration by all household members. In MOTUS, this is achieved by all group members enter a virtual waiting room. Once all eligible members have entered the waiting room, a subsequent, synchronized task can be assigned. In other words, only when all eligible household members completed their previous task(s), they can proceed to the time use diary task. Optionally, the reference person can manually request the next task if waiting for other group members is deemed to be futile. The cost reductions are obvious because of the elimination of the interviewer and the fully automated process of completing the household grid, checking on eligibility, and distributing individual questionnaires and time diaries. This also improves accuracy and reliability as well as timeliness and punctuality. However, as the household grid still needs to be

completed by the head of the household, the respondent burden is not decreased. Nevertheless, accuracy and reliability will improve if a waiting room is used because it allows the household members' time diaries to be truly synchronized; something which cannot be guaranteed (or even assessed) when the traditional method (dropping off paper-and-pencil time use diaries for pick-up at a later moment in time) is used.

Processing, analysis, and dissemination components

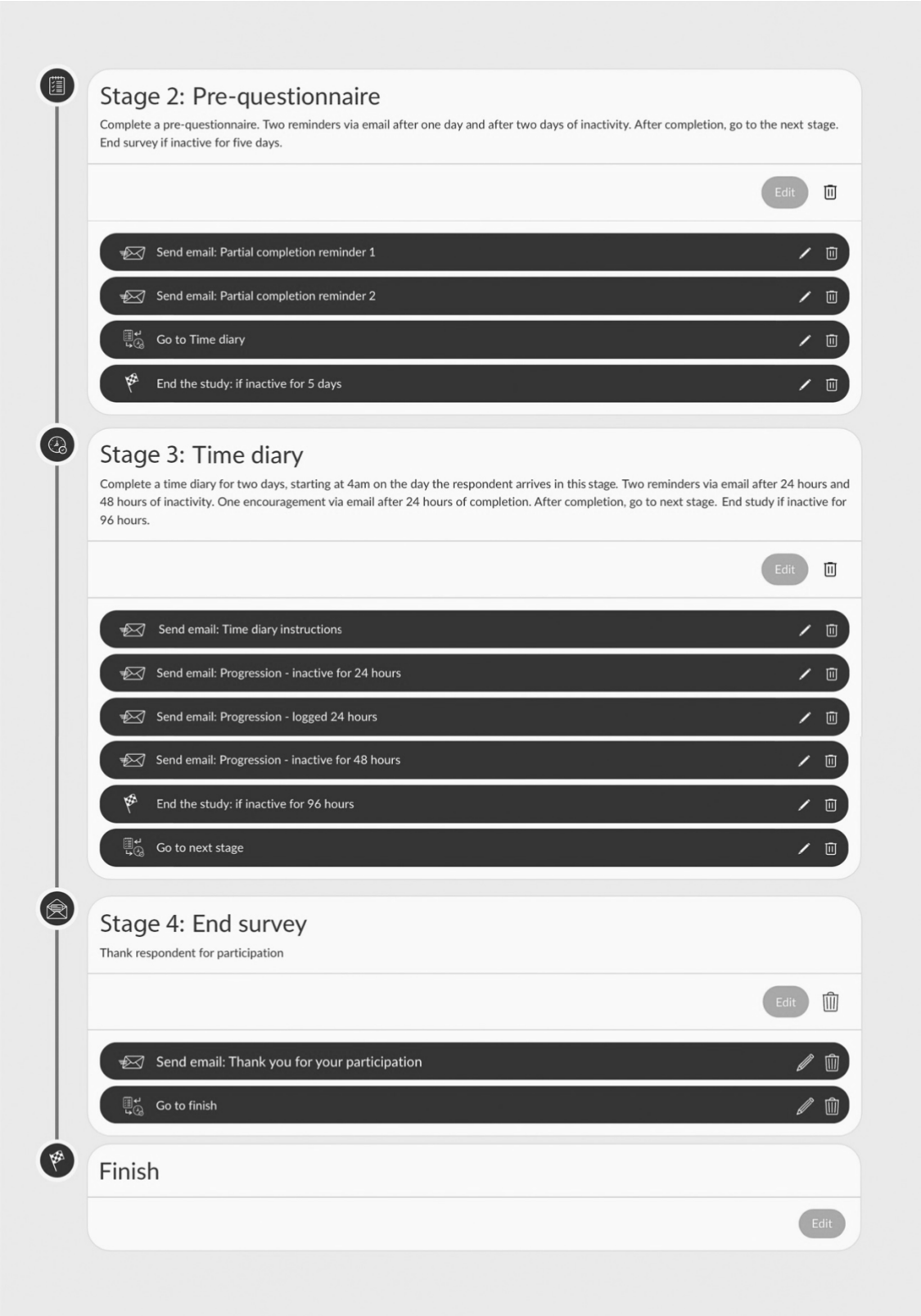
It is necessary to set up several processes (in addition to the collection instruments) that support the collection, the analysis, and the dissemination of the statistics. Many of the processing components are part of the MOTUS architecture, but some processes are built in the *R builder*.

Firstly, the R builder contains the `motusr` package which allows the creation of closing criteria settings or quality assessment of the time use diary. These thresholds or quality criteria relate to the amount of undefined time, the variance and number of different of activities logged, the prevalence of activities which start or end at the top of the hour, and the registration of certain activities, such as sleeping, eating, drinking, and travelling in case of changing locality (Juster 1986). Feedback on data quality can be presented to the respondent purely informatively via on-screen messages or lead to an explicit request to the respondent to adjust the registration in the diary as a requirement to proceed or end the time diary stage. The `motusr` package is currently under development and not yet listed on CRAN.

Secondly, the R builder periodically performs calculations on live data on the MOTUS server to check for changes and to update the outputs. These calculations feed into a dashboard that allows monitoring the progress. Finally, the R builder facilitates the construction, labelling, and filetype of databases for export (including para- and metadata and Universally Unique Identifier (UUID) keys to merge different databases).

All these automated processes not only make the fieldwork timelier and more cost efficient, but also improves the accuracy and reliability of the data.

Figure 9. Simplified workflow of a TUS on the MOTUS platform



Note. Stage 1 involves the activation of the MOTUS account (not pictured). The simplified workflow involves an individual pre-questionnaire (Stage 2) and a two-day time use diary (Stage 3)

Configure workflow

The collection instruments and processes need to be brought together to form a workflow and are linked through communication. All communication is defined in the *communication builder* and, in the absence of an interviewer and except for initial postal invitations when an email address is not yet available, there are four ways of communicating throughout the data collection process: email, push messages, and static pages. Push messages include real-time prompts that remind respondents of their survey tasks and support respondents registration process by, for example, suggesting relevant response alternatives. This improves the accuracy and reliability. Additionally, if studies need to be conducted in multiple languages, all elements (i.e., collection instruments and communication) can be translated in the *translation builder*. The translation builder supports the xliff format (an XML variant) which allows translations to be done externally and imported into MOTUS. Furthermore, the *invitation builder* manages how respondents enter the workflow. There are different invitation strategies, ranging from voluntarily registering on the MOTUS webpage (possibly following advertising through various channels), via receiving a letter with login details, to uploading a list of potential respondents in advance. For a TUS that follows the guidelines, NSIs typically draw their sample from a national population register wherein no email address information is available. In this case, the invitation builder generates usernames and temporary passwords which are printed in the invitation letters that are send to the sampled households. Invitation letters contain both a QR-code and a fully written web link directing respondents to the MOTUS website. Once respondents use the login credentials to participate, MOTUS will ask them to provide an email address for further communication throughout the survey.

While all the collection instruments and communication are created in their respective builders, the *research builder* sets up the overall collection process workflow. The workflow brings all instruments together and places them in a linear order based on the different stages a respondent must go through to successfully participate in a survey. As these stages typically consist of tasks to be performed (collection instruments to be completed, or reading a communication), they may also be referred to as “tasks”.

Moving through stages is based on actions governed by conditions that are defined in the research builder. The conditions can be based on the completion of tasks or can be time based (e.g., sending a reminder after 24 hours of inactivity). Actions are communicated to the respondent by means of communications that are created in the communication builder. Additionally, communication criteria can be defined as a function of the progress within a stage.

For a TUS that follows the guidelines, the workflow is complex. It starts with sampling household members that will receive credentials to log in to MOTUS and complete the tasks of filling out a household questionnaire and composing the household grid. Thereafter, all eligible household members will be invited via email to carry out several tasks in MOTUS: completion of a first individual questionnaire, completion of two focus days in the time use diary, and completion of a second individual questionnaire. Actions involve numerous communications, for example, on what task needs to be completed next, reminders to complete certain tasks, or instructions on how to record an online time use diary.

To demonstrate how this works in practice, Figure 9 gives an example of a simplified workflow of a TUS that involves an individual pre-questionnaire and a two-day time use diary. Each box defines a stage and includes the title of the stage, a short description of the stage, and the option (for the survey manager) to edit or delete the stage. Within each stage, different actions are defined (the blue bars), such as communicating, proceeding to the next task, or closing the study after a predefined period of inactivity.

The communication builder improves cost efficiency, timeliness and punctuality since communication is created online and sent to respondents through automated processes. Since the transmission of communications is conditional, it is tailored to the respondent and might increase the involvement of the respondent. In turn, this might lower their burden and therefore improve the accuracy and reliability of the data. The translation builder cannot alter the translation costs. The major advantage, though, is that respondents can easily switch between languages, which again might increase their involvement and lower their burden, especially in countries such as Belgium with multiple official languages. In a TUS, the initial invitation comes in the form of a paper letter, so the improvement provided by the invitation builder is limited at first. However, in case information is provided by the head of household, the eligible household

members are invited via e-mail, which is cost and time efficient. Additionally, automated processes for assigning credentials and linking these to UUIDs leaves less room for error which improves accuracy and reliability.

The research builder improves current practices of TUS substantially because it allows building the complete workflow in an online environment and as a fully automated process. It enhances cost efficiency, timeliness and punctuality, while also improves the accuracy and reliability of the data as it allows a more accurate and complete follow-up of respondents as they progress through the various stages. Although this closer follow-up cannot reduce the number of tasks involved, the communication between tasks might lower the respondent burden because it creates a sense of being supported.

Generic Statistical Business Process Model

Building (or reusing) the designed collection instruments and processes is central to any statistical production process and part of the GSBPM. The GSBPM serves as a framework to describe and define the business processes involved to produce official statistics in a standardised way. It started as a joint effort of the United Nations Economic Commission for Europe (UNECE), Eurostat and the Organisation for Economic Cooperation and Development (OECD). The GSBPM is based on the business model of Statistics New Zealand (Kuonen and Loison 2019). Describing the business process of the production of official statistics using the GSBPM as the reference model allows NSIs to communicate these processes more easily.

The GSBPM is considered a non-linear process model and is aimed to apply to any data production (e.g., surveys, censuses, administrative registers). It serves as a reference model, which does not prevent NSIs from arriving at national versions of the GSBPM based on organisation-specific adaptations, combining phases, or a sequential reassessment to make it a linear process description (Ahmad and Koh 2011).

As shown in the first three columns of Table 11, each of the builders discussed above refers to one or more of the subphases of the build phase (i.e., GSBPM phase 3) while, also supporting one or more other process phases (i.e., GSBPM phases 4 to 7). This highlights the non-linear sequence of the different

phases of the GSBPM and the importance of iterative processes to support, evaluate and inform different phases and sub-phases.

Discussion

Wider applications

The MOTUS applications (mobile and web) are not single purpose applications aimed at conducting a particular survey (or supporting a single area of statistics, such as time-use statistics). Instead, the MOTUS front office applications serve as a host for any survey that is defined in the back office. This modular capacity of MOTUS is based on the different builders that can be defined and put into a workflow for every different study created in MOTUS. As such, MOTUS works particularly well for complex studies that are a sequence of multiples tasks (e.g., questionnaire and diary) or studies that link survey elements with data from other, external services (e.g., geolocation data). The Household Budget Survey (HBS) is an example of a complex survey with challenges comparable to those of the TUS. Like the TUS, it is also sampled at the household level and consists of recording data in a diary over time (in the the case of the HBS, this concerns purchases by household members over a period of at least 15 days). The HBS also includes completing a household grid and questionnaire. Given these major similarities and the modular approach of MOTUS, the project CRŒSS (Minnen, Olsen, and Sabbe, 2022) realized the upgrade of MOTUS to a platform that can also offer HBS studies. This was done by extending the diary builder, which can now also use the Classification Of Individual Consumption by Purpose (COICOP) codes (instead of the OACL code used in a TUS). The adjustments took into account the uniformity of the front office such that the UI/UX is the same for TUS and HBS. This also holds for the back office. The MOTUS platform can now organize both a TUS and an HBS on the same platform and with the same applications. At the same time, MOTUS uses container technology to make the platform available as an ESS platform. Each Docker container is a separate part of the MOTUS platform, as shown in Figure 8, with its software dependencies. How and where the containers are used is the responsibility of an NSI. It is recommended to use Kubernetes to deploy the containers on ISO/IEC 27001 certified infrastructure. This setup brings natural security barriers and also provides tools for scalability and high availability.

Smart data collection

Another future challenge of (digital) data collections relate to "smart" ways of collecting data, from which time use surveys could benefit (Zeni *et al.* 2020). "Smart" refers to data collection that combines passive or sensor data from personal smart devices (e.g., GPS, accelerometer) with active data explicitly provided by the respondent (e.g., responses to queries). "Passive" refers here to not actively providing input by the respondent (Ricciato, Wirthmann, and Hahn 2020).

MOTUS interprets the "smart" concept in a very broad sense, noting that data collection can be smart not only in the way it uses or processes already available data, but also be smart in the way it supports respondents to participate in surveys. MOTUS therefore continues to develop and add builders with new possibilities to the back office. One such builder is the *event builder*. Events follow the if-this-than-that (ITTT) approach and are thus triggers that are pulled if a certain condition is met. These conditions and the actions they initiate are defined in the event builder and are available from microservices that collect sensor data and are connected by an adapter API to communicate with MOTUS. These events can on the one hand ask the respondents to perform a specific action (e.g., answering a short questionnaire), or on the other hand show tentative entries in the respondents' diary, which they can commit and as such can reduce the registration burden and increase the quality of the registration. For example, if the GPS coordinates correspond with respondents' working address, working activities might be suggested in their time use diary.

The inclusion of smart data requires a data collection platform that is able to communicate with different other environments or standalone microservices (Ricciato, Wirthmann, and Hahn 2020). As shown in Figure 8, the MOTUS platform architecture allows these external smart data sources to communicate with the core via so-called adapter APIs. An example is the connection to the GeoService that collects geolocation data points from the respondents' smartphone. Particularly in complex studies such as TUS and HBS, the inclusion of sensor data, or administrative data along the Only Once Principle (OOP), should result in increased response rates, lower time investments of respondents as data providers, a further reduction of survey costs, and an increase in the accuracy and reliability of the data.

Para- and metadata

The wealth of para- and metadata captured by MOTUS can provide insights into a lot of processes that have remained hidden from view in the traditional paper-and-pencil TUSs. For example, who actually completes the time use diaries? All household members by themselves? Or one person for all? We can only guess how this might have affected the intra-household correlation of the time use diary registration. Similarly, when were time diaries completed? Throughout the day? At the end of the day? Or just before the interviewer came to pick up the diaries? Again, we can only guess how this might have affected the reliability of the time use diary registration in the past. Furthermore, if respondents drop out during the fieldwork, all information prior to drop-out remains available in the database of the server running the survey.[11] This might be useful to evaluate the dropout. On the negative side, it is yet to become known what all this will bring to light in terms of accuracy and reliability. On the positive side, at least then we know – and may be able to compensate for it.

Communication

One of the future challenges of online research, and especially with surveys like TUSs, are the multiple and complex tasks respondents must complete. The absence of face-to-face contact puts substantial pressure on online communication and gives rise to questions such as how much to communicate, by which means and in which wordings – and whether the communication should be differentiated by background characteristics. Options for respondents to switch on or off optional communication, such as reminders, suggestions, tips and tricks and select preferred media channels (e.g., email, text message, on screen notifications) could further tailor the user experience to the respondent and increase the feeling of being supported and decrease the potential challenging effort to complete the survey (Yan, Fricker and Tsai, 2019).

[11] Unless the respondents exercise their rights as defined in the GDPR regulations to delete all stored information.

Conclusion

TUSs have a history of collecting data that can produce reliable and widely applicable statistics and indicators. However, the implementation of a (HETUS based) TUS is based on a complex sequence of household and individual level questionnaires and time use diaries on two different days of the week. A paper-and-pencil version comes with high postal and printing costs and with substantial cost and time investments in multiple interventions from interviewers and coders. These surveys also imply a relative high participation burden and thus a risk for accuracy and reliability. The modernization of TUSs, driven by current and future technological developments, involves more than just translating the current paper and pen-based version into a digital format. It requires a shift in the methodological paradigm of doing these surveys and an overhaul of the business processes for producing official time use statistics.

This contribution introduced MOTUS not only as an online TUS, but as a provider for the collection of these surveys by breaking down all elements of conducting an online TUS into modular builders that are congruent with and supportive to several subphases of the GSBPM. It showed that MOTUS stands for a modern approach to surveys in general and to complex surveys (such as the TUS and the HBS) in particular. The MOTUS builders inform the design phase, enable the build phase, and facilitate the collect, process, analyse, and disseminate phases of the GSBPM. It also showed that MOTUS makes it possible for modern, online data collections to provide a partial answer to recent challenges by lowering the respondent burden, by being more cost efficient, and by providing timelier, more punctual, more accurate and more reliability official statistics. MOTUS has already partly proven itself in the past for TUS both for a population sampled TUS (see Minnen *et al.* 2014) and for several target sampled TUSs (see, for example, te Braak, Van Droogenbroeck *et al.* 2022). Future challenges include further applications and use of MOTUS for TUS and other surveys in different statistical domains (e.g., the HBS – for which first steps have been taken as described above) and collecting feedback for adjustments and improvements. These applications and subsequent evaluations will continue to cement and expand the potential of MOTUS to meet current challenges of and changes in producing official time use statistics.

References

Ahmad, N., and S-H. Koh (2011). Incorporating estimates of household production of non-market services into international comparisons of material well-being. *UNECE Working Paper* No. 42. STD/DOC(2011)7.

Ashofteh, A., and J. M. Bravo (2021). Data science training for official statistics: A new scientific paradigm of information and knowledge development in national statistical systems. *Statistical Journal of the IAOS*, 37(3), 771-789.

Bonke, J., and P. Fallesen (2010). The impact of incentives and interview methods on response quantity and quality in diary-and booklet-based surveys. *Survey Research Methods*, 4(2,: 91-101.

Bruno, M., F. Inglese, and G. Ruocco (2021). Trusted Smart Surveys: architectural and methodological challenges at a glance. Working paper.

Cai, L., and Y. Zhu. (2015). The challenges of data quality and data quality assessment in the big data era. *Data science journal*, 14.

Carletto, C., H. Chen, T. Kilic, and F. Perucci (2022). Positioning household surveys for the next decade. *Statistical Journal of the IAOS*, 38(3), 923-946.

Chenu, A. (2004). Prendre la mesure du travail. In: Edited by J. Heilbron, R. Lenoir and G. D. Sapiro, (Eds.). *Pour une histoire des sciences sociales. Hommage à Pierre Bourdieu* (pp. 281-304). Paris: Fayard.

Eurostat (2018). *Eurostat, European statistics code of practice: for the national statistical authorities and Eurostat (EU statistical authority)*. Luxembourg: Publications Office of the European Union.

Eurostat (2020). *Harmonised European Time Use Surveys (HETUS) – 2018 guidelines – Re-edition*. Luxembourg: Publications Office of the European Union.

Fernee, H., and N. Sonck (2013). Is everyone able to use a smartphone in survey research? *Survey Practice*, 6(4), 2884.

Gohar, A., and G. Nencioni (2021). The role of 5G technologies in a smart city: The case for intelligent transportation system. *Sustainability*, 13(9), 5188.

Juster, F. T. (1986). Response errors in the measurement of time use. *Journal of the American Statistical Association*, 81(394), 390-402.

Keusch, F., B. Struminskaya, C. Antoun, M. P. Couper, and F. Kreuter (2019). Willingness to participate in passive mobile data collection. *Public Opinion Quarterly*, 83 S1), 210-235.

Kuonen, D., and B. Loison (2019). Production processes of official statistics and analytics processes augmented by trusted smart statistics: Friends or foes? *Statistical Journal of the IAOS*, 35 4), 615-622.

Lavrakas, P. J. (2008). *Encyclopedia of survey research methods*. Sage Publications.

Minnen, J., I. Glorieux, T. P. van Tienoven, S. Daniels, D. Weenas, J. Deyaert, S. Van den Bogaert, and S. Rymenants (2014). Modular Online Time Use Survey (MOTUS)-Translating an existing method in the 21st century. *Electronic International Journal of Time Use Research*, 11(1), 73-93.

Minnen, J., J. Olsen, and K. Sabbe (2022). *CRŒSS: Establishing a Cross-domain data collection platform for the ESS (European Statistical System).* Brussels and Bonn: Statistics Belgium, Destatis, hbits CV and Vrije Universiteit Brussel.

Pronovost, G. (1989). The sociology of time. *Sociologie Contemporaine*, 37(3), 1-124.

Radermacher, W. J. (2020). *Official Statistics 4.0. Verified Facts for People in the 21st Century*. Cham, Switzerland: Springer.

Ricciato, F., A. Wirthmann, K. Giannakouris, and M. Skaliotis (2019). Trusted smart statistics: Motivations and principles. *Statistical Journal of the IAOS*, 35(4), 589-603.

Ricciato, F., A. Wirthmann, and M. Hahn (2020). Trusted Smart Statistics: How new data will change official statistics. *Data & Policy*, 2.

Robinson, J. P. (1999). The time diary method. Structure and uses. In: W.E. Pentland, A.S. Harvey, M.P. Lawton and M.A. McColl (Eds.). *Time use research in the social sciences* (pp. 47-89). New York: Kluwer Academic/Plenum Publishers.

Robinson, J. P., and G. Godbey (1997). *Time for life: The surprising ways Americans use their time*. Pennsylvania: Penn State Press.

Salemink, I., S. Dufour, and M. van der Steen (2020). A vision on future advanced data collection. *Statistical Journal of the IAOS* 36(3), 685-699.

Salgado, D., M.E. Esteban, M. Novás, S. Sadaña, and L. Sanguiao (2018). Data Organisation and Process Design Based on Functional Modularity for a Standaard Production Process. *Journal of Official Statistics*, 34(4), 811-833.

Sonck, N., and H. Fernee (2013). *Using smartphones in survey research: a multifunctional tool.* The Hague: The Netherlands Institute for Social Research.

Stodden, V. (2014). The reproducible research movement in statistics. *Statistical Journal of the IAOS*, 30(2), 91-93.

Sullivan, O., J. Gershuny, A. Sevilla, P. Walthery, and M. Vega-Rapun (2020). Time use diary design for our times-an overview, presenting a Click-and-Drag Diary Instrument (CaDDI) for online application. *Journal of Time Use Research*, 10.

Szalai, A. (1972). *The use of time: Daily activities of urban and suburban populations in twelve countries*. The Hague: Mouton.

te Braak, P., F. Van Droogenbroeck, J. Minnen, T. P. van Tienoven, and I. Glorieux (2022). Teachers' working time from time-use data: Consequences of the invalidity of survey questions for teachers, researchers, and policy. *Teaching and Teacher Education*, 109.

te Braak, P., T. P. van Tienoven, J. Minnen, and I. Glorieux (2022). Bias in estimated working hours in time use diary research: The effect of cyclical work time patterns on postponing designated registration days. *Time & Society*, 31(4), 508-534.

United Nations. 2016. Integrating a Gender Perspective into Statistics. *Studies in Methods, Series F No. 111*. New York: United Nations Publication.

Vassilev, G., W. King, S. Wallace, and J. White (2020). *Modernization of the Production of Time-use Statistics*. UK: UK Office for National Statistics.

Yan, T., S. Fricker and S. Tsai (2020). Response burden: What is it and what predicts it? In: P. Beatty, D. Collins, L. Kaye, J.L. Padilla, G. Willis and A. Wilmot (Eds.). *Advances in Questionnaire Design, Development, Evaluation and Testing* (pp. 193-212). New Jersey: John Wiley & Sons.

Zeni, M., I. Bison, F. Reis, B. Gauckler, and F. Giunchiglia (2020). Improving time use measurement with personal big data collection–the experience of the European Big Data Hackathon 2019. *Journal of Official Statistics* 37(2), 341-365.

Zerubavel, E. (1982). *Hidden rhythms: Schedules and calendars in social life*. Chicago: The University of Chicago Press.

CHAPTER 7

Context is King. But who will own the context?

Introduction

Throughout a period of already more than 100 years, time use research underwent different changes and faced various challenges. Each step along the way brought value to this methodology. From the need to visualize difficult-to-picture social realities, to the call for standardization and harmonization for the benefit of comparability for academic research and official statistics, and to the development of (online) applications to provide an answer to the growing technological modernization (that at itself made our society change even at more rapid pace).

This dissertation highlighted studies on various elements or parameters that define the design of a time diary. The first part of the dissertation focuses on two important design options: the number of diary days and the unit level. HETUS recommends 2 days of which one weekday and one weekend day. This should keep the respondent burden to the minimum and still acknowledge the difference between to 'types' of days. An equal dispersion of all days over the entire sample makes it possible to estimate the time spend for an entire week, at least on an aggregated level. Other scholars advocate to collect 7 consecutive days mainly to map the intra-person variation allocation of time. Less respondents are needed for an equal amount of diary days, but more persistence is needed from the respondent to keep a record over this lengthily period.

HETUS also recommends the household as the unit level. Having activity records from all household members 10 years and over makes it possible to study the intra-household allocation of time. Less households need to be recruited than when individuals are the unit level. It requires nevertheless more efforts from the head of the household and the household in general. Most time studies opt for the

individual approach and stratify by different types of a household. This also removes the presence of a cluster-effect (intra-household correlation).

Time diary observation window and unit level

Chapters 2 to 4 researched these elements. Chapter 2 first showed the weekly duration of different time use categories extrapolated from 2 days and calculated from 7 days. Overall modest differences were found as long as the calculation was done on the basis of broader time use categories (e.g., childcare, paid work), while at the same time no loss of quality was found when collecting data over a period of 7 days (more on the contrary). Next, this chapter compares the work grid (e.g., an instrument to capture working times only) to the 7-day time diary (which captures working time embedded in other daily activities). It showed errors at the fringes of working times that conflict with subsequent activity domains such as travel, eating and social activities. This shows that a full diary and its context support the quality of the registration.

Chapter 3 shows the advantages of the household as the unit level for studying time relations within couples. These relations are defined making use of the full power of the method of a diary: the reporting of activities within its context (time, place and interaction). The analyses shed light on how long and when couples spend time together. It showed that working hours and having children significantly affect the time partners spend together. These kinds of analyses can only be done if households are the unit level.

Chapter 4 goes back to the weekly work grid and shows the strength of a weekly work grid to grasp the true variation of working times in comparison to the standard survey question like in the Labor Force Survey and the 2-day diary like in the HETUS-oriented studies. Benefits arise from the work grid capturing working times for 7 days and in terms of timing, tempo, and duration. Optimal matching techniques showed that this allows to identify 3 standard, 2 extended and 5 part-time work patterns. All are characterized by the time allocation at different moments of the week (day, evening, night, Saturday, Sunday). It showed that a lot of non-standard work happens at the fringes of the (standard) workday (6 a.m. till 7 p.m. from Monday to Friday) and that many different part-time work arrangements exist. Breaking down these patterns by gender and other background characteristics provided an insight in, for example, how gender and

having children relates to different patterns of (par-time) work. It also shows that the extended patterns with weekend work are mostly characterized by self-employed as a result of a deliberate labor market choice.

As mentioned in the first chapter, I investigated much more elements and parameters that together can be assembled into 'a' time diary design. Appendix A contains an overview.

Online time diary method

In the Belgian context both the HETUS-method and the TOR-method were used to collect time diary data. Table 12 recalls the main differences between both methods. Due to a lack of funding but mainly as a result of technological developments also the field of time use research became digitized. The buildup knowledge on the differences between various elements and parameters together with the funding of the HERCULES-foundation the journey started to translate the paper-and-pencil time use diary to an online time use diary. The result is the MOTUS data collection platform, which is the subject of Chapter 5 and 6.

Table 12. Overview differences HETUS and TOR time diary method

Element	HETUS	TOR
Unit level	Households	Individuals
Observation window	One weekday, one weekend day	Seven consecutive days
Granularity	10-minute intervals	Continuous
Activity registration	Verbatim	Pre-coded list

Chapter 5 described the first version of MOTUS, developed in 2012 and used for the first fully online and automated large-scale fieldwork in 2013 (Flanders). The results showed that low response rates remain an issue also for online time use data collections. There are two important phases that relate to response: the start of the study (login), and the transition from a survey to a diary, including the first use of the diary. These phases of respondent dropout are crucial for the field or time use research: getting people on board and having them continue their tasks. On the positive side the results showed that once respondents get engaged in the reporting of activities in the diary the dropout is modest, and the quality criteria as defined by Juster (1986) show the benefits of online time diary research compared to paper-and-pencil diaries. The chapter further discussed small-scale

experiments with variations on the number of diary days, the use of interviewers, the reduction to a light(er) version of the activity list, and the use of (monetary) incentives. It also looks forward to adapting the front-office and to developing a smartphone app that would also be able to capture sensor data. The discussion of the article also appeals on creating a HETUS 2.0 as a standard for conducting online time use surveys, to keep standardization, harmonization, and comparability as assets for a valid and reliable research method.

Many of these outlooks culminated in the second version of MOTUS as described in chapter 6. This chapter showed how MOTUS can become part of the European Statistical System (ESS) by mapping MOTUS on to the Generic Statistical Business Process Model (GSBPM). It also showed how it contributed to improving on the principles of the European Statistics Code of Practice such as lowering respondent burden, being cost efficient, being accurate and reliable, and being timely and punctual. Central to this process is the lay-out of the different builders that represent the build and the collect phase of the GSBPM. The chapter demonstrated how different elements and parameters can be configured with the survey, diary, grid, R, communication, translation, invitation, and research builder to arrive at a study design to handle a specific research question. In the diary builder the diary setup is configured. The research builder assembles the entire flow of a study defining and connecting the different steps respondents have to take to successfully finalize their participation and is the central mechanism of the MOTUS data collection platform. With the grid builder it is possible to scale up the study from the unit of an individual to the unit of a household. The discussion looks forward to the inclusion of external data sources/bases and to reuse/adapt MOTUS for other statistical domains.

Notwithstanding these transitions, the diary methodology remained the central research strategy within time use research thanks to its ability to collect reliable information on human activities in a valid way. However, and despite of all insights and updated versions of MOTUS, there still remains room for improvement. At the end of this chapter, I will come back to this with a proposed trajectory. Let me first halt at another strength of the dairy method: the activity context. Referring to the work of Scheuch (1972) in the book 'The Use of Time' of Szalai the validity of the method is mostly supported by the capturing of the

context of an activity. Again, there is a trade-off. On the one hand the collection of contextual information is burdensome, on the other hand the more context of an activity is known, the greater the possibility to understand and explain people's behavior. Those who capture context in the least evasive way, are King.

This last chapter concludes my journey of conducting time use research that led to this dissertation with a look into the near future by forecasting a fifth era. This era is a logical consequence of the previous era. It is an era in which the process of modernization continues and transitions into a process of integration of different data streams.

Era 5: external data and integration

This latter era will be centered around the apparent contradiction that on the one hand national and scientific institutions are finding it increasingly difficult to obtain permission and co-operation from respondents to collect data while, on the other hand, more and more personal behavioral data is tracked via the internet connected devices and are even combined by algorithms and artificial intelligence to gain a better understanding of (individual) human behavior. The questions that are therefore central to this fifth era are: Who owns such external data? How can this data be integrated for the production of official statistics and/or scientific research? And, how can the introduction of external data reduce the registration burden of respondents?

Much of this type of data will be owned by market-oriented parties. They collect data through connected devices as a continuous stream of embedded personal data (Groves, 2011). This data is collected passively without the continuous and active participation of the respondent, as most time use data is still collected today, even when this is done through the web and mobile applications developed for the domain of time use research. What sets time use data apart from other data gathering information about people's daily lives is the validity of the data. If we want to understand why people engage in an activity, we must focus on the "beneficial, immediate approach" (Hamermesh, 1999) which understands what people do within their temporal, spatial, social, and motivational context. A large part of such observations can be supported by passive data streams such as perceptual (body), environmental and even administrative data.

Sensor data

It is expected that sensory data will play an important role in this fifth era. Through sensors, the state of respondents or their environment can be observed and measured, continuously or intermittently or even at a defined level (e.g., entering geographic location, exceeding noise level, from a certain point in time). The variety of sensors is huge and almost every physical element can be detected by temperature sensors, pressure sensors, proximity sensors, accelerometer and gyroscope sensors, humidity sensors, CO2 sensors and many more. If these sensors are connected to the internet, the output is available in real time and can be used as input for another system or used to control a process of actions. It is this 'If This Then That' (ITTT) application that is the true added value of the 'Internet of Things' (IoT).

However, the current downside of sensory data is they are too fragmented, of a too high velocity and too scarce on subtlety (Marr, 2015). At this point, a link between sensory data and behavioral (read: time use) research seems ideal. After all, sensory data is time stamped and sequential. They can therefore easily be linked to the activities that are registered in the time diary. As such, these data provide additional context not only for research itself (e.g., data enrichment through sensory data), but also for the way in which respondents can participate in research (e.g., sensory data can make activity suggestions). The question remains how this data enrichment and respondent support can be realized.

Microservices and tentative and committed data

Sensors are often embedded in other devices, the smartphone being the most prominent. The data that are captured are processed into a meaningful output using developed algorithms supported by Machine Learning and/or models based on Artificial Intelligence. Smartphones are often recognized as a proxy for the individual using it (place, sound, temperature …). The most common way to send data to another environment is via a microservice. Such a microservice is often specialized in one specific function, such as geotracking or energy consumption. A characteristic of a microservice is that it is platform-independent and can communicate with other platforms by means of an API (Application Programming Interfaces). A data collection platform on which time use research runs can therefore retrieve and link the sensory data via this API.

The use of APIs facilitates the exchange of data between environments, including communication with front office applications used by respondents to participate in surveys. This makes it also possible to go beyond the rather rigid duality between active and passive data (collection), by making use of so-called tentative versus committed data in practice. Tentative data are data that are passively collected from an individual but have not yet been validated by the individual. The data are considered a proxy of (the behavior of) the individual and need interaction with the individual before they are turned into committed data. The big difference with active registration of data is therefore that tentative data are first presented to the respondent for confirmation, editing, or as a specific question, whereas otherwise the respondent must provide the input entirely him/herself. This business process, where an API exchanges tentative data between the microservices and the platform, and the platform allows the individual to confirm the data through the front office application(s), is designed to keep the respondent central to the data collection strategy. As such, it supports the trustworthiness of the collection strategy since the respondent retains control over the data collection as the data only becomes part of the research database when the respondent records (i.e., commits) the data. At the same time the front office application provides the option to the individual to delete the tentative data stored in the microservice.

Sensor data provide extra information which is often difficult to grasp in such a detail and with such a precision by an individual. When this data stream is committed by humans in the data collection loop, both systematic error and privacy concerns are reduced.

How MOTUS can deal with the future

In the way time use data is currently (online) collected there is a limit to what a respondent can be asked for, which is already being pushed. At the same time, there is more and more context out there which can be of help to the respondent. And these data are already collected in high volumes.

Time use research is praised for its micro-behavioral insight in people's lives. Yet on the other side time use research faces important limitations of which financial and personnel resources and the long data collection process are only a few of them. These limitations have an effect on the recurrency of data collections

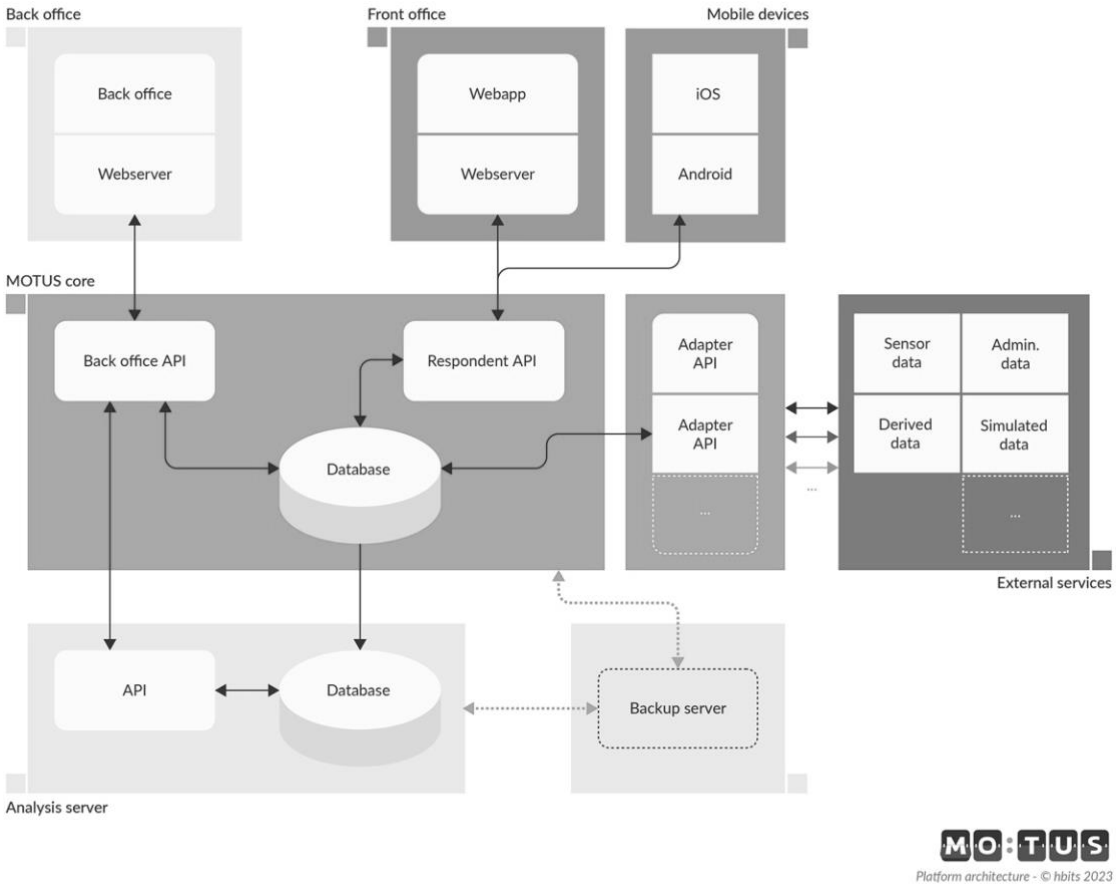
which was about 5 to 10 years but gets lengthier, leads to postponement or, even worse, cancellation. And that while our fast-changing society is actually in need of a higher frequency or even continuous data collection to be studied. The solution for this is hidden in the strength of the methodology itself: in its ability to capture the context around the activity.

The ability to link different sets of questions to different activities is already a strong modular asset of MOTUS. With the inclusion of new streams of (sensor) data, MOTUS is taking up the gauntlet to unlock the power of contextual data to, among other things, reduce the response burden and fieldwork costs, while at the same time putting privacy and security first. Key to capturing context is (1) the architecture and connectivity of the platform, (2) the shareability of the platform, and (3) the reusability of the platform.

MOTUS architecture and connectivity

MOTUS is betting strongly on combining active and passive participation in the benefit of respondents through microservices. Microservices are seen as external environments which can be developed by external partners (e.g., using wearables like a Fitbit) but which can also be developed internally, in connection to the MOTUS platform (e.g., inclusion of sensors in the MOTUS-applications). The development of microservices gives priority to the flexibility at the one hand, and to privacy on the other hand as sensor data can contain sensitive information. Recall from the previous chapter that, with privacy by design in mind, the MOTUS architecture is separated in three levels (see Figure 1). Central is the MOTUS core to which both the front office and the back office are connected via APIs. Microservices are also connected to the MOTUS core, but via adapter APIs. The MOTUS core can communicate with different connected microservices to collect the tentative data that is defined in the study design in the back office of MOTUS, and which then is presented to the respondent in the front office application to be included, edited, or even deleted. For optimization, data security, and privacy reasons, this data is handled and organized into standalone microservices.

Figure 10. Overview of the MOTUS platform architecture



MOTUS can communicate with any microservice but is currently mainly connected to own developed services. These are the GeoService for geotracking and the Receipt Scanning Service for OCR scanning of tickets. Both services make use of Machine Learning algorithms or are based on pretrained Artificial Intelligence models. These algorithms and models start from open-source libraries and are improved in view of the goals of the microservices. These microservices are developed under contract of Eurostat, and on request available under a MIT license. The MIT License is a permissive free software license originating at the Massachusetts Institute of Technology (MIT). As long as users include the original copy of the MIT license in their distribution, they can make changes or modifications to the code to suit their own needs.

The GeoService microservice interacts with the sensors of a smart device to collect geopoints (for example sensors for Location, Acceleration, Gyroscope, Gravity and Rotation) to derive the position, stops, routes and transportation modes of the smart device as a proxy of the respondent. With an API connection

to other databases (e.g., Open Street Map, Google Places, Foursquare) extra information on the stops can be merged.

The purpose of the Receipt Scanning Service microservice is to digitalize information on tickets, receipts and invoices (and e-versions) to extract information on the description of the products and services and the antecedents of these purchases. Furthermore, extra information from the ticket is collected as there are, for example, the total price, discounts, shop name, or language.

Both microservices make use of the same underlying software design architecture which departs from the idea that the respondent needs to be in the centre (and in control) of the data collection process. Therefore, output of the microservices is presented to the respondents for them to accept, change, supplement or even delete these tentative data to arrive to committed (or omitted) data. This design architecture also improves on privacy and security since the microservices do not store personal information from the respondent. All communication and data linkage between the microservice and (the core of) MOTUS happens via a RESTapi (i.e., application programming interface used to communicate between applications or devices) and the exchange of a Universally Unique IDentifier (UUID) key over https exchange.

MOTUS shareability

To make context capturing and context mapping comparable it is important to describe the business processes that entail context capturing and mapping via a generic model, like the GSBPM (Generic Statistical Business Process Model). Another option is to share the data collection platform and microservices that collect this information. Shareability is then part of a governance model. "Governance refers to a process of governing where there is interaction between stakeholders that have a common goal in the creation and usage of a product or a service" (Minnen, Nagel & Sabbe 2020). When other institutions implement this platform, standardization and harmonization of the processes can be realized easier.

For this purpose, the MOTUS architecture is refactored as Docker containers (i.e., a package of software that can run on its own). This enables installation within a data collection environment of another institution in a simple, rapidly scalable, available manner with certified and tested privacy and security. Easy deployment,

scalability, high availability and keeping privacy are the four pillars that characterize a good architecture and increase the divisibility of MOTUS so that it can grow into a modern and stable platform. In the view of sensor data not only security is important but also the scalability of the shared components, like the microservice and the database component.

Today MOTUS has all the qualities to develop to an ESS (European Statistical System) platform. Referring to Figure 10, every separate component of the MOTUS platform is a Docker container, with its software dependencies. These Docker containers can be installed anywhere, and so also within the structures of an NSI. Also, the option to only install some of the containers inhouse is a valid option. It is advised to use Kubernetes as an open-source system to deploy the containers on ISO/IEC 27001 certified infrastructure[12].

Another level of shareability is the level where the participants to the studies come into play. Respondents are the central stakeholder of data collection. As researchers we strive for a high response rate and a high quality of data. It is common good that respondents receive an incentive for their participation. In the past this was a return in money, a reduction coupon or a present. Gradually respondents were also shown their own input in tables or graphics. It however does not engage the respondent. Certainly not in the way that is imagined by the concept of the 'Quantified Self' which should support every person to get insights and learn from their own data. This concept is known from self-tracking devices like a Fitbit or a Google Watch where body related data is shown on the device (watch) and in a connected app. Via the respondent tentative (~sensor) data become committed data and thus study data. The team behind MOTUS is in the process of developing Voyager, which will be a data communication platform that provides the respondents' own data back in tables and graphics. In the background the open-source platform for statistical computing R is used. One step further, the respondents should also be allowed to compare their data with other groups of respondents broken down in background characteristics. Giving back

[12] As an example, the MOTUS environment runs on runs on a Kubernetes cluster setup with a single master node and a scalable number of worker nodes. The database is deployed on a dedicated physical machine and the whole setup is protected by a HAProxy edge router which routes and load balances traffic between internet and cluster.

data back, whether or not in comparison to others, gives respondents context to their own life and an extra incentive to participate.

MOTUS reusability

Generally, two variations of reusability exist: intra- and inter-reusability. With intra reusability the platform's capacity is addressed to setup different studies with different configurations. This is achieved by the different builders of MOTUS and by the architectural design of MOTUS to let the front-office application be a host for any study that is defined in the back-office. Without any interference different projects can use the same app, while also a new apps (web and mobile) can be built with the same codebase but with a different brand design and a different app id in the store. By this, updates to the apps and the underlying platforms are kept to its minimal.

Inter-reusability refers to the ability of a platform to organize studies for different statistical domains. While MOTUS can already handle survey questionnaires that can handle different topics (like Qualtrics or SurveyMonkey would do), the challenge lay with upgrading MOTUS to handle other complex studies such as household budget studies. Household budget studies are equally complex compared to time use research. Data is also collected on the household level and questionnaires are (more or less) the same. The diary, however, collects information on the purchase of services and goods and makes use of the COICOP classification (UNSD, 2018) instead of an activity list in time use research (e.g., HETUS). The number of items in the COICOP classification is harmonized upon 5 digits but can be considerably larger for countries. For example, in Germany this list has up to 7 digits and counts up to 1000 rows of details products and services. Also, the context of the purchases is different since, for example, quantity and the metric (e.g., liter or gram) are important information. On top of that, many expenses have a vast cycle (weekly, monthly, quarterly, yearly, ...) such as gas, rent or internet which need to be included differently because the diary window is maximum 15 days for most countries.

To accommodate HBS into MOTUS the diary builder in the back-office was reused and extended by including new functionalities, such as incorporating COICOP lists and by adding new configurational options to the design of the diary. These options mainly related to quality relevant settings to support the

registration and the (automated) closure of the diary. To support the respondent in collecting this data the front-office was reused and adapted to be able to register purchases of goods and services clustered within a ticket and a ticket within a shop/brand, and other product or service context like quantity, unit and product/service discounts. Moreover, a search algorithm was developed to better find the most fitting COICOP to (a description of) a product or service. This functionality can also run as a microservice.

The introduction of HBS into MOTUS was seen as an opportunity to rework the entire back-office of MOTUS: all functionalities of MOTUS are now written in Laravel (PHP platform) and the entire UI/UX is made more user friendly as an aid to the researchers' difficult task to participate in the design, collect and process phase of a data collection. To support the researcher even further informative guidelines are developed in how to work with MOTUS and the different builders that characterize the platform.

Let me go back to the three questions of this era to summarize. Today, data are more and more owned by commercial parties. This is even more true when comes to contextual data collected via sensors or other external devices connect to the internet. This asks for an important reflection on how to access these data, because contextual data will (have to) increasingly become part of policy and academic research. Additionally, providing this contextual data as tentative data to the respondent is also important to be able to support them in the elaborate task of completing a time use (or other complex) study. To do so, this dissertation's proposition is to work with microservices that are linked to a data collection platform developed to protect both privacy and security of the respondent. Respondents can see the tentative data and can accept, edit, supplement or even delete the data. This approach would not only bring official time use research to the next era, but the setup would also support scientific research and NSIs in collecting this data.

I strongly believe…

… in MOTUS as a platform that provides the tools for scientists to regain the power to collect data themselves, in which the platform is easy to be shared and leads to standardized processes to come to harmonized and comparable data.

… in MOTUS as a platform to collect time use data in a modular way where researchers can make design choices to fit best with the research questions a hand.

… in MOTUS where there is a clear focus on context with the goal to higher the validity of the time use methodology in order to better understand our society.

... in MOTUS as an adaptive platform to learn from interactions between scientists and between scientists and citizens to improve our service offering to (with/for) the respondents.

The latter is an absolute necessity. MOTUS and in general the time use research community, (still) have not yet succeeded in reducing the registration burden of the respondent and at the same time higher the quality of the data, despite all the technological advancements. The dialogue with citizens is a precondition for ultimately obtaining citizens' data which is further analyzed by researchers and turned into insights for policy makers to understand everyday life and respond to the challenges of our rapidly changing society.

To arrive at this point, a joint effort is needed on all levels and that includes the mode, that is, how to collect valid data. This relates back to the front-office applications. Human Computer Interaction should provide information back on how to redesign and modify the applications used. This remains a continuous task for MOTUS or any other data collection platform.

All steps together should (eventually) lead to better support respondents, researchers, and institutions in their aim to provide impactful data to study and to let grow stronger our society. If we succeed, the time use methodology is here to stay, *at least for another 100 years*.

References

Groves, R. M. (2011). Three eras of survey research. *Public opinion quarterly, 75*(5), 861-871.

Hamermesh, D. S. (1999). The timing of work over time. *The Economic Journal, 109*(452), 37-66.

Juster, F. T. (1986). Response errors in the measurement of time use. *Journal of the American Statistical Association, 81*(394), 390-402.

Marr, B. (2015). *Big Data: Using SMART big data, analytics and metrics to make better decisions and improve performance*. Hoboken, NJ: John Wiley & Sons.

Minnen, J., Nagel, E. & Sabbe, K. (2020): Source TM: Software Outreach and Redefinition to Collect E-data Through MOTUS. Towards a Modular Online Time Use Survey. Statistics Belgium, Destatis, hbits CV and Vrije Universiteit Brussel (167 blz).

Scheuch, E. (1972). The time budget interview. In A. Szalai (Ed.), *The use of time* (pp. 69-87). The Hague: Mouton.

UNSD (2018). Classification of Individual Consumption According to Purpose (COICOP). Accessed 8 June 2023 [https://unstats.un.org/unsd/classifications/unsdclassifications/COICOP_2018_-_pre-edited_white_cover_version_-_2018-12-26.pdf]

APPENDIX A

Relevant projects and publications related to time use research methodology

My knowledge on time use research spreads over 15 years of conducting field work, of coding, cleaning, valorizing, disseminating data, of writing reports, project proposals, guidelines, and academic publications, and of developing, testing, redesigning, and, eventually, marketing the online data collection platform MOTUS. This knowledge builds upon numerous projects in which I was involved and numerous publications that I co-authored. This Appendix provides an overview of the most relevant projects (Table A1) and publications (Table A2) that from the foundations of this dissertation.

Table A1. Overview of projects related to time use research

Project title	Period	Financing
SSI: Smart Survey Implementation	01/05/23 – 31/04/25	EU
IT.NRW: Support native installation MOTUS	01/04/23 – 30/03/25	IT.NRW
LWR2024: The development and installation of MOTUS software for continuous household budget research in Germany	01/01/23 – 31/03/25	Destatis
EVS2023: The development and installation of MOTUS software for household budget research in Germany	01/01/22 – 31/03/24	Destatis
CRŒSS: Developing a cross-domain platform for the ESS (European Statistical System)	01/06/21 – 31/10/22	Statbel, Destatis, Eurostat
KSH: Innovative tools and sources for diary-based sureys-Household Budget Survey and Time Use Survey - Test and Maintain	01/06/21 – 30/04/22	KSH, Eurostat
BTUS-Belgian Time Use Data Collection	01/04/21 – 30/03/24	Statbel
Phd and Promoters Survey: to define, develop and support a survey of Phd students and Phd promoters.	01/04/21 – 31/03/25	VUB
ZVE2022: The development and installation of MOTUS software for time use research in Germany	01/01/21 – 31/03/23	Destatis

Table A1. *Continued*

Project title	Period	Financing
Conduct research on time use and workload of UN Woman employees	01/10/21 – 28/02/22	UNWoman
ESSnet – TSSI	01/01/20 – 31/12/21	Destatis, Eurostat
Introduction to MOTUS	01/11/20 – 30/11/20	Statistics Norway
Installation Grant MOTUS	21/04/20 – 31/12/20	Destatis
Retrofit Living Lab	01/10/19 – 30/09/21	Foyer Anderlechtois
GeoService: Developing a microservice for geolocation point capture.	01/10/19 – 30/04/21	Sogeti, Eurostat
SOURCE TM	01/04/19 – 31/03/20	Statbel, Eurostat
BEHAVE: a behavioral panel	01/05/18 – 30/04/23	VUB-OZR
Turn-over from a 38h to a 30h workweek and back	01/09/17 - 30/08/20	Femma vzw
PRIOCLIMAT	01/09/17 - 30/08/20	Innoviris
Tijdsbesteding van leraren in het basis- en secundair onderwijs	01/09/17 – 31/08/18	Departement Onderwijs
Centre ville, piétonissation et modes de vies	01/10/18 – 31/12/19	BSI & FVM
Bruxodus: Brussel, of toch maar liever niet	01/01/17 – 31/12/20	Innoviris
Innovative tools and sources for TUS and HBS	01/10/17 – 31/12/18	Sogeti, Eurostat
DIAMOND: Diversity and Information Media	01/02/17 - 31/01/21	IWT-SBO
Arbeidslastmeting personeel Departement Onderwijs	01/01/17 – 30/09/17	Departement Onderwijs
Opinion, Advice and Study bureau through Internet Survey (OASIS)	01/01/15 – 31/07/18	Innoviris
Faculty Time Study: 10 Big universities	01/10/15 – 31/08/16	Advance program
Space & Time Project	01/10/15 – 31/08/16	University of Maryland
LFS&Time: A database on working conditions, hours and arrangements	01/01/14 – 31/12/15	BELSPO
MOTUS: Infrastructure for continuous Modular Online Time-Use Survey	26/04/12 – 25/04/17	Hercules foundation
Time use research mapped. A diagnosis of the impact of various methods of time registration supported by data analysis	01/01/08 – 31/12/11	FWO

Table A2. Overview of publications investigating topics related to time use research methodology

Topic	Observation window
Title	Glorieux, I., I. Mestdag, J. Minnen (2008): The Coming of the 24-hour Economy? Changing work schedules in Belgium between 1966 and 1999. Time & Society, 17, 1: 63-83.
keywords	*timing, sequence, schedule, 2 days*
Title	Glorieux, I., I. Laurijssen, J. Minnen, T.P. van Tienoven (2010): In Search of the Harried Leisure Class in Contemporary Society: Time-Use Surveys and Patterns of Leisure Time Consumption. Journal of Consumer Policy, 33, 2: 163-181.
keywords	*timing, continuous data, 7 days, sequence, rhythm*
Title	van Tienoven, T.P., I. Glorieux, J. Minnen (2013): Paid work as an originator of daily routine. Journal Advances in Social Sciences and Humanities, 1, 3: 11-16.
keywords	*intra-personal variation, routines, rhythm*
Title	van Tienoven, T.P., I. Glorieux, J. Minnen (2014): The impact of work and family responsibilities on healthy sleep habits. Time & Society, 23, 2: 235-257.
keywords	*intra-personal variation, routines, rhythm*
Topic	Data collection
Title	Glorieux, I., J. Minnen, T.P. van Tienoven, S. Daniels, D. Weenas, J. Deyaert, E. Mészáros, S. Van den Bogaert(2015): Technical Report TOR13. Modular Online Time Use Survey (MOTUS): Fieldwork and response analyses. Brussel: Vakgroep Sociologie, Onderzoeksgroep TOR (32 pp).
keywords	*motus, diary, population study, mode, study design*
Title	Glorieux, I., J. Minnen, T.P. van Tienoven, C. Vanderhoeft, S. Daniels, K. de Korte, J. Deyaert, J. Magits, E. Mészáros, J. Verbeylen, D. Weenas (2015): Technical Report BTUS13. Technical report of the 2013 Belgian Time-Use Survey (BTUS13). Brussel: Vakgroep Sociologie, Onderzoeksgroep TOR (27 pp).
keywords	*tus, diary, population study, mode, study design*
Title	Verbeylen, J., J. Minnen, T.P. van Tienoven, I. Glorieux (2016): Taakbelasting en taakinvulling van het ZAP aan de Vrije Universiteit Brussel. Brussel: Onderzoeksgroep TOR, Vakgroep Sociologie, Vrije Universiteit Brussel (124 pp).
keywords	*professors, diary, working time, patterns, study design*
Title	Verbeylen, J., J. Minnen, I. Glorieux (2017): Resultaten Personeelsbevraging bij het Departement Onderwijs en Vorming: Frequentieverdelingen van voorvragenlijsten en navragenlijsten. Brussel: Vrije Universiteit Brussel, Onderzoeksgroep TOR (79 pp).
keywords	*working time, diary, patterns, study design*
Title	Minnen, J., J. Verbeylen, I. Glorieux (2018): Onderzoek naar de tijdsbesteding van leraren in het basis- en secundair onderwijs. Deel 1: Algemeen. Vlaamse Overheid, Brussel: Vakgroep Sociologie, Onderzoeksgroep TOR (57 pp).
keywords	*teachers, diary, working time, patterns, study design*
Title	Slaets, A., P. Verhoest, L. D'Haenens, J. Minnen, I. Glorieux (2020): Fragmentation, homogenisation or segmentation? A diary study into the diversity of news consumption in a high-choice media environment. European Journal of Communication, 36, 5: 461-477.
keywords	*diary, media, study design*

Table A2. *Continued*

Topic	Data collection *continued*
Title	van Tienoven, T.P., J. Minnen, A. Glorieux, I. Laurijssen, P. te Braak, I. Glorieux (2021): Locking Down Gender Roles? A Time-Use Perspective on Gender Division of Household Labour during the COVID-19 Pandemic Lockdown in Belgium. Journal of Family Issues, 1-27.
keywords	*covid 19, study design*
Title	van Tienoven, T.P., A. Glorieux, J. Minnen, P. te Braak, B. Spruyt (2022): Graduate students locked down? PhD students' statisfaction with supervision during the first and second COVID-19 lockdown in Belgium, PLoS ONE, DOI: 10.1371/journal.pone.0268923, 17, 5: 1-18.
keywords	*phd, longitudinal survey*
Topic	Context
Title	Neutens, T., S. Daniels, J. Minnen, I. Glorieux, P. De Maeyer, N. Van de Weghe (2014): Spatial and temporal fluctuations in individual accessibility: a comparative analysis among subgroups of the population. Danish Journal of Geography, 114, 2: 119-131.
keywords	*space-time patterns*
Title	van Tienoven, T.P., J. Deyaert, T. Harms, D. Weenas, J. Minnen, I. Glorieux (2018): Active work, passive leisure? Associations between occupational and non-occupational physical activity on weekdays. Social Science Research, 76, November: 1-11.
keywords	*space-time, data merging*
Title	Weenas, D., T.P. van Tienoven, J. Verbeylen, J. Minnen, I. Glorieux (2019): Testing compliance to WHO guidelines for physical activity in Flanders: insights from time-use diaries. Archives of Public Health, 2019, 77: 16.
keywords	*space-time, data merging*
Title	Van Hoang, T., L. Willem, P. Coletti, K. Van Kerckhove, J. Minnen, P. Beutels, N. Hens (2022): Exploring human mixing patterns based on time use and social contact data and their implications for infectious disease transmission models. BMC Infectious Diseases, 22, Article number: 954.
keywords	*space-time, interaction*
Topic	Mode effects and quality
Title	te Braak, P., J. Minnen, I. Glorieux (2020): The Representativeness of Online Time Use Surveys. Effects of Individual Time Use Patterns and the Survey Design on the Timing of Survey Dropout, Journal of Official Statistics, 36, 4: 887-906.
keywords	*study design*
Title	te Braak, P., F. Van Droogenbroeck, J. Minnen, T.P. van Tienoven, I. Glorieux (2022): Teachers' working time from time-use data: Consequences of the invalidity of survey questions for teachers, researchers, and policy. Teaching and Teacher Education, 109: 103536.
keywords	*working time, patterns, study design*
Title	te Braak, P., T.P. van Tienoven, J. Minnen, I. Glorieux (2022): Bias in estimated working hours in time diary research: The effect of cyclical work time patterns on postponing designated registration days. Time & Society, 31, 4: 508-534.
keywords	*study design*
Title	te Braak, P. T.P. van Tienoven, J. Minnen, I. Glorieux (2022): Data Quality and Recall Bias in Time-Diary Research: The Effects of Prolonged Recall Periods in Self-Administered Online Time-Use Surveys. Sociological Methodology, 53, 1: 115-138.
keywords	*study design*

Table A2. *Continued*

Topic	Platform
Title	Minnen, J., E. Nagel, K. Sabbe (2020): SOURCE TM: Software Outreach and Redefinition to Collect E-data Through MOTUS. Towards a Modular Online Time Use Survey. Statistics Belgium, Destatis, hbits CV and Vrije Universiteit Brussel (167 pp).
keywords	*gsbpm, modularity, automatization, architecture, deployment*
Title	Minnen, J., A. Glorieux, I. Glorieux (2020): The Development of An Evaluation Questionnaire to test MOTUS. Vrije Universteit Brussel (15 pp).
keywords	*platform, functionalities, feedback*
Title	Minnen, Joeri, J. Olsen, K. Sabbe (2022): CROESS: Establishing a Cross-domain data collection platform for the ESS (European Statistical System). Brussels and Bonn: Statistics Belgium, Destatis, hbits CV and Vrije Universiteit Brussel (222 pp).
keywords	*gsbpm, cross-domain, microservices, ui/ux, deployment*
Topic	Sensor data
Title	te Braak, P., M. Fedkenheuer, J. Minnen, B. Wegener (2020): VELUX Renovactive. User Experience and Post-Occupancy Evaluation. Final Report on the Sociological Monitoring. VELUX SA, Vrije Universiteit Brussel (60 pp).
keywords	*sensor data, user behaviour*
Title	Fenton, G., A. Glorieux, Q. Letesson, J. Minnen (2020): Centre-ville, piétonnisation et modes de vie. Brussels Studies Institute – Brussels Centre Observatory, Brussel (179 pp).
keywords	*sensor data, interaction model*
Topic	Time diary
	Registration method
Title	Robinson, J.P., S. Martin, I. Glorieux, J. Minnen (2011): The overestimated workweek revisited. Monthly Labor Review, June 2011: 43-53.
keywords	*survey, diary, measurement error*
	Continuous registration
Title	Minnen, J., I. Glorieux, T.P. van Tienoven (2015): Transportation habits: Evidence from time-use data.Transportation Research , Part A, 76: 25-37.
keywords	*intra-personal variation, routines, rhythm*
	Household level
Title	van Tienoven, T.P., I. Glorieux, J. Minnen, S. Daniels (2015): If fathers care, how do they share? The temporal and spatial allocation of fathers' time to parenting activities. Family Science, 6, 1: 282-292.
keywords	*intra-household allocation, timing, place, interaction*
	Activity list
Title	Minnen, J., A. Glorieux, T.P. van Tienoven, I. Glorieux (2020): The Development of An Online Activity Classification List for Time-Use Surveys. Vrije Universiteit Brussel (8 pp).
keywords	*online activity classification list*
	Methodology
Title	Minnen, J., I. Glorieux (2016): New data collection methodologies. Future of time-use research in Europe. Brussels: Task Force TUS, Department of Sociology (EUROSTAT working report).
keywords	*methodologies, modes, parameters*