Activity Travel Planning and Rescheduling Behavior: Empirical Analysis of Influencing Factors

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ACTIVITY-TRAVEL PLANNING AND RESCHEDULING BEHAVIOR: AN EMPIRICAL ANALYSIS OF INFLUENCING FACTORS

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ABSTRACT

An increasing interest in dynamic activity scheduling could be witnessed in travel behavior research over the past years. This research analyzes the factors influencing the actual activity scheduling process, using detailed activity-travel data from an extensive dataset that was collected in Flanders (Belgium). A first model examines the attributes that influence activity planning; a second model analyzes the factors that affect activity rescheduling. The explanatory variables considered in both models are individual, household, activity and schedule attributes and their impact is analyzed using mixed logit models. Random effects are added to the models to test for within-individual variance.

The results reveal that activity and schedule characteristics considerably affect activity planning. The rescheduling model also has several highly significant activity and schedule attributes. Most individual and household attributes considered in this paper do not influence activity planning and rescheduling behavior, although strong statistical evidence indicates that individual-specific preferences for planning and rescheduling determine the process of activity scheduling.

INTRODUCTION

Over the past decade an increasing interest in activity scheduling and rescheduling could be witnessed in travel behavior research. Transport policy measures currently focus on transport demand management policies and the success of these policies is dependent on how people schedule and change their activity-travel patterns. Gärling *et al.* (*1*) developed the first comprehensive theoretical scheduling model and authors such as Arentze and Timmermans (*2*), Pendyala *et al.* (*3*) and Miller and Roorda (*4*) recently developed operational scheduling models, which are being deployed to evaluate transport policy measures in the Netherlands, the United States and Canada.

It is generally accepted in activity-based research that executed activities are the result of a complex scheduling process, in which activity episodes are inserted, deleted and modified, and that other attributes than activity type alone are required to model the scheduling process (*5, 6*). Most activity-based scheduling models, however, assume that activities are scheduled in a fixed order and do not attempt to model activity rescheduling. This means that activity scheduling is almost always considered to be a static process, while in reality it is a dynamic combination of (re)scheduling decisions. Recognizing this limitation of existing activity scheduling models, Gärling *et al.* (*7*) and Timmermans *et al.* (*8*) developed conceptual frameworks describing the effect of time pressure on activity rescheduling. The Aurora model (e.g. (*9, 10*)) predicts how individuals change their activity schedule during the day as a result of unexpected events or time pressure.

Since scheduling and rescheduling decisions are difficult to observe and since traditional trip- and activity-based diaries are not developed to collect this type of information, specific computer-based survey instruments were designed (e.g. (*11, 12, 13*)) to gather empirical data on scheduling process dynamics. Following studies, based on these data, aim at improving the understanding of (re)scheduling processes. Mohammadian and Doherty (*14, 15*) model the time elapsed between planning and execution of activities by using hazard and mixed logit models to analyze the effect of activity type and individual and situational factors on the planning process. Roorda and Miller (*16*) present a descriptive analysis about the rescheduling decisions people make to resolve conflicts with overlapping activities. Joh *et al.* (*17*) analyze which attributes influence the probability that an activity is rescheduled between it's planning and execution. Whereas this study stresses which factors make an activity more amenable to schedule modifications in general, other studies model rescheduling choices in reaction to specific schedule conflicts. Ruiz *et al.* (*6*) and Ruiz and Timmermans (*18, 19*) look deeper into the conflict situations in which a new activity is inserted between two pre-planned activities and overlaps with one or both of the planned activities. The specific case on which Roorda and Andre (*20*) focus, is an unexpected one-hour delay. They investigate the factors affecting the rescheduling decisions that follow on this particular conflict type.

This study contributes to this line of research and aims at enhancing the insight in the activity scheduling process. Recent studies reveal that some activities are scheduled days or even weeks in advance (*21*). These activities are referred to as *planned activities* in the remainder of this paper. Other activities – so-called *impulsive activities* – do not seem to be scheduled in advance at all. Although impulsive activities frequently occur in the activity-travel schedules on which existing scheduling models are based, impulsive activities are hardly considered in these models' scheduling processes. This research studies which activities are planned beforehand and which are impulsively executed, using a mixed logit model to assess the individual, household, activity and schedule determinants of this decision.

Since activity scheduling is an ongoing process, a choice has to be made about the cut-off between planned and impulsive activities: from which moment on, activities are considered to be impulsive? This moment cannot be too far away from the activity execution, because then many deliberate planning decisions are ignored. But if this moment is too close to activity execution, the distinction between planned and impulsive activities fades away. The scheduling data in this paper stems from a paper-and-pencil survey in which planning is defined as the scheduling process that continues until the eve of the execution day; all activities scheduled thereafter are considered to be impulsive. Although by this definition activities planned on the execution day will be assigned to the impulsive category, the distinction between planned and impulsive activities was defined in this way to reduce respondent burden and to minimize the impact of the survey on the respondents' activity-travel schedules.

The continuous character of the scheduling process implies furthermore that decisions about activity scheduling are made until the actual activity execution or deletion. The fact that an activity is planned in advance, does not mean that there can be no further modifications to the activity or its planned attributes. Therefore, this paper presents a second mixed logit model that examines the attributes influencing the activity rescheduling process. As for the planning model, activity, schedule, individual and household attributes are considered as explanatory variables.

This paper is structured as follows. The survey and data sample used for the analyses are presented in the next section. Subsequently, the mixed logit models and their estimation results are discussed for both models. A summary of the main findings concludes this paper.

DATA

Feathers Data Collection

In order to perform the analyses described in the introduction, detailed information is needed about activity-travel schedules. This information stems from a large-scale data collection that has been conducted in Flanders (*22*). The data collection gathers activity-travel information for FEATHERS, an activity-based scheduling model for Flanders (*23*). For approximately 2500 households, detailed activity-travel schedules for a 7-day period are collected. The households are selected from census data and constitute a representative sample selection of the Flemish population with respect to geographical spread, socio-demographic characteristics and household composition.

For each household one person is asked to complete a *household questionnaire* that gathers data about household composition, household mobility (number of available vehicles, etc.) and key events on a household level that occurred during the past year. Examples of key events are changes in the household structure or purchase of a car.

Each individual respondent has to fill out an *individual questionnaire*, designed to collect socio-demographic data. Information about transportation (e.g. frequently used transport modes), activities (e.g. average activity frequency) and key events (e.g. changes in work situation) is collected on an individual level.

In addition to these questionnaires, an *activity-travel planning tool* was developed in order to gather data about the planning, namely the type of planned activities and their planned attributes (duration, location, start time, stop time, transport mode, etc.) as far as they are known beforehand. Since activity planning is defined as the scheduling process that continues until the eve of the execution day, the planned activities and their known attributes have to be filled out in the planning on the eve of the postulated execution day.

The fourth component of the survey consists of a traditional *activity-travel diary*: for each diary day the executed activities and their specific attributes (e.g. activity type, duration, start time, location, trip attributes) have to be completed. For each executed activity, the respondent also has to indicate whether the activity was planned in advance or not, i.e. whether the activity also occurs in the planning or not.

The questionnaires are always in paper-and-pencil format, but for the activity-travel diary and planning, both a traditional paper-and-pencil survey and a software application that is installed on a personal digital assistant (*24*) are designed.

Data Sample

The models in this paper are estimated based on data from the paper-and-pencil diaries and planning booklets gathered until the start of 2008. Whether an activity is planned or not can be extracted directly from the executed activity-travel diaries since respondents have to indicate in the diary whether an executed activity was planned or not. The planned attributes can then be retrieved from the planning booklet. After removing poor-quality records and eliminating activities for which it was unclear or unknown whether they were planned or not, 9548 activities that are either executed or planned or both are included in the final dataset.

The sample consists of 272 respondents (55% females, 45% males) that are between 19 and 83 years old (average age of 50 years). These socio-demographic statistics are quite similar to the distribution of gender and age in the Flemish population (*25*). The respondents are presented with 13 pre-defined activity types from which they can choose to fill out the planning and the diary. The frequency of each activity type in the sample is presented in Table 1, which demonstrates that all activity types occur. Although Education is only observed 45 times, this is a reasonable number since the minimum age of respondents in the sample is 19 years, so that the sample contains merely 2% full time students. Flemish time-use data (*26*) reveal that in Flanders 70% of the activities are performed at home, so that the high shares of the In Home (53%) and the Sleep activities (12%) are as can be expected.

Properties of the Data Sample

The activities in the sample can easily be classified according to their planning and execution status, as presented in Table 2.

Respondents were asked to indicate the reason why they would perform an activity impulsively. The main reasons were (1) the activity was planned during the execution day itself (19%), (2) the activity was impulsively executed (11%) and (3) interference of other people (10%). Additionally, the respondents were inquired after the reasons why 287 planned activities were not executed. Following answers occurred the most frequently: (1) the respondent did not feel like performing the activity (17%), (2) the duration of another activity changed (14%) and (3) the activity was already performed by somebody else (13%). It should be noted that these results are indicative and have to be interpreted with care, since these questions had a non-response rate of almost 40%.

Table 2 also classifies activities according to whether they are rescheduled or not and groups them by rescheduling type. Rescheduling can be captured for each planned activity by comparing the planned with the executed activity attributes. The dataset for the rescheduling model therefore consists of 7290 activities, of which 2268 were executed without rescheduling. Different types of rescheduling are distinguished: attributes can be modified with respect to timing or non-timing attributes. Combinations of these are also possible, e.g. if planned start time and location both differ from executed start time and location. Activities that are present in the planning but not in the activity-travel diary of the following day are said to be deleted. These activities may be postponed, but for this study the difference between postponement and activity deletion is irrelevant: both are defined as rescheduling.

In practice, activities are said to be rescheduled with respect to timing attributes if the planned start time or duration differ by more than 10 minutes from the executed start time or duration. The 10 minutes margin is chosen to allow for flexibility: a time difference of a limited magnitude is not significant with respect to activity-travel behavior. Furthermore, the dataset shows that start and end times, durations and travel times are rounded off to multiples of 5 minutes, so that smaller differences are difficult to capture given the data available.

Activities are defined as rescheduled with respect to non-timing attributes if location, number of accompanying persons or transport mode have changed between activity planning and execution. In case these attributes have missing values for the planning, which indicates that the respondent did not plan these attributes beforehand, the activity is also said to be rescheduled. This assumption ensures that all scheduling decisions made after the planning are captured.

MODEL ESTIMATION

Model Formulation

The planning as well as the rescheduling model developed in this paper are based upon the theory of discrete choice. For the planning model, the two exclusive choices are planning and no planning; for the rescheduling model, the dichotomous options are rescheduling versus no rescheduling. It is assumed that the probability that an activity is planned can be expressed as a function of different attributes; the same holds for the probability that an activity is rescheduled. These attributes are activity, schedule, individual and household characteristics. The activity attributes used in both models as explanatory variables are, however, not the same. In the planning model, the attributes of the executed activities are used, since the planned attributes are not available for all activities. Since planned activity attributes are available for the activities considered in the rescheduling model, these are used instead of executed activity attributes.

Classical logistic regression hypothesizes that observations used in a model, should be independent. But given the dataset available, it might not be justified to assume that the outcome of every activity is completely unrelated to the outcome of every other activity, since activities are clustered per respondent. Individuals can be assumed to have a certain preference or dislike for activity planning or rescheduling that is not explained by the activity, schedule, individual or household attributes under consideration in the analyses. Therefore, logistic regression models with individual-level random effects are applied (*27*). The assumption of independent choices is relaxed in these so-called mixed logit models. For respondent i the utility of planning an activity in choice situation j is given by Equation (1) and the corresponding probability by Equation (2):

$$U_{ij}^{p} = Y_{ij}^{p} + \varepsilon_{ij} \quad with \quad Y_{ij}^{p} = \beta_0 + \beta_1 x_1 + \ldots + \beta_n x_n + u_i \tag{1}$$

$$P_{ij}(p|u_i) = \frac{\exp(Y_{ij}^{p})}{\exp(Y_{ij}^{p}) + \exp(Y_{ij}^{np})} \tag{2}$$

where $\beta_1,\ldots,\beta_n$ are the coefficients of the explanatory variables $x_1,\ldots,x_n$ and the constant term β_0 reflects the inherent preference of respondents for planning. u_i captures the individual-level random effect assumed to be normally distributed with variance σ^2_u, i.e. $u_i \sim N(0,\sigma^2_u)$, and the ε_{ij} values are assumed to be independent and identically distributed (iid) type I extreme value with variance σ^2_ε.

A second assumption concerning the dataset is the fact that the number of activities an individual can realistically plan or execute during a day is restricted, because time is a limited resource. If time pressure (approximated by an increasing number activities in the schedule) increases, the competition between different activities will also increase. The assumption is made that stronger competition reduces the probability that an activity is scheduled and therefore the total number of executed activities is incorporated for the planning model. Similarly, the total number of planned activities is added as an explanatory variable to the rescheduling model.

The utility and the probability of respondent *i* for planning an activity in choice situation *j* is expressed by Equations (3) and (4):

$$U_{ij}^r = Y_{ij}^r + \varepsilon_{ij} \quad with \quad Y_{ij}^r = \beta_0 + \beta_1 x_1 + ... + \beta_n x_n + u_i \tag{3}$$

$$P_{ij}(r|u_i) = \frac{\exp(Y_{ij}^r)}{\exp(Y_{ij}^r) + \exp(Y_{ij}^{nr})} \tag{4}$$

where $\beta_1,\ldots,\beta_n$ are again the coefficients of the explanatory variables $x_1,\ldots,x_n$ and β_0 now reflects the inherent preference of respondents for rescheduling. u_i denotes the individual-level random effect assumed to be $N(0,\sigma^2_u)$ and the ε_{ij} values are assumed to be iid type I extreme value with variance σ^2_ε.

In the planning and the rescheduling model σ^2_u expresses the variation between individuals due to differences in the activity or the situation, while the within-individual variation is captured by σ^2_ε. The parameter estimates that result from these models express the impact of the corresponding explanatory variables on the probability of the dependent variable. A positive coefficient indicates that an increase (decrease) in the explanatory variable increases (decreases) the probability of activity planning or rescheduling; a negative coefficient means that if the explanatory variable increases (decreases) the probability of activity planning or rescheduling decreases (increases).

Planning Model

First, a multicollinearity analysis is performed on the explanatory variables available in the dataset, which reveals that the individual attributes gender and family function are highly correlated as are the activity attributes location (with categories 'in-home' and 'out-of-home') and activity type. Since the variable family function has only an administrative meaning, this attribute is removed from the analysis. Location is also removed from the model, because In Home and Sleep are performed at home by default and the other activities are almost always executed somewhere else. Location – as it is defined in this analysis – can thus be seen as inherently linked with activity type. The first column of Table 3 shows the resulting explanatory variables: 8 activity attributes and 3 schedule attributes in addition to 8 individual and 3 household characteristics on a personal level. The estimation results of the planning model are presented in Table 3.

The mixed logit model for activity planning has a good model fit compared to the intercept-only model: the log likelihood value of the mixed logit model with covariates is -3422 compared to a log likelihood of -5144 for the model with only β_0 as parameter. The likelihood ratio index of the mixed logit model for planning amounts to 0.467 and the adjusted likelihood ratio index (*28*) is 0.459, which is a considerable rise compared to the value of 0.251 for the adjusted likelihood ratio index of the multinomial logit (MNL) model with the same variables, but without the random effects. This increase is statistically significant on a 5% level and indicates that the explanatory power of the mixed logit model has improved due to the incorporation of the random effects in the model. The model fit of the mixed logit model is thus better than the fit of the standard MNL model. This finding is supported by the Akaike Information Criterion (AIC): the mixed model has an AIC of 6948 compared to the AIC of 9610 that is found for the MNL model for activity planning. These results imply that individuals have a personal preference or dislike for activity planning.

The attributes found to be significant in the MNL model are overall the same as those of the mixed logit model, but the estimated coefficients are different in both models. Most of the mixed logit coefficients are larger than their MNL counterparts. This implies that the influence of the explanatory variables will be biased if the MNL model is applied instead of the planning model with individual-level random effects.

One-by-one examination of the groups of explanatory variables reveals that the signs of the parameter estimates are overall consistent with general expectations and with results of commensurable studies (e.g. (*14*)).

Some of the activity attributes turn out to be highly significant, whereas others do not seem to influence the probability that an activity is planned in advance. The t-test indicates significant effects for start time and duration. As derived from the parameter estimates, the estimated odds of planning decrease by 6% for an increase in start time by one hour and increase by 12% for an increase in duration by one hour. This means that activities early in the day tend to be planned more in advance than those later in the day, which are logically more likely to be planned during the execution day itself. Longer activities tend to be planned beforehand, probably because they require more scheduling effort. Scheduling activities with other people is also expected to require more effort, which is confirmed by the results: the more people join in the activity, the higher the probability that the activity is planned in advance. The odds increase by 6% for every additional person. If the respondent's partner or child is involved in the activity, the odds of planning increase by respectively 23% and 19%, although the accompanying child variable is only significant on a 10% level. Surprising is the finding that if non-household members are involved in an activity, the activity in question is more likely to be impulsively performed or at least not planned until the execution day itself: the odds decrease significantly by 26% if non-household members join in the activity. These results seem to suggest that household members indeed take each other's activity-travel schedules into account by planning activities with family members in advance, a result that contributes to the justification of the recent trend of modeling activity-travel patterns at the household level, whereas activities that involve non-household members are performed more impulsively.

Since activity type and transport mode are categorical variables, the likelihood ratio is calculated, from which it is concluded that activity type significantly affects the probability of planning and transport mode does not. Work and Education, typically referred to as fixed activities (e.g. (*2*)), turn out to be the activity types that have the highest probability of being planned beforehand, followed by Sleep and In Home. Daily and Non-Daily Shopping, Touring and Social Activities are the activities most impulsively performed.

The total duration of the activities executed on a specific day is the only schedule attribute that does not significantly affect the probability that an activity is planned in advance.

The odds of planning decrease by 3% for every additional activity executed during a day. It appears that if there is still some time left after the planned activities are executed, individuals are likely to fill up the spare time with other activities. The day of the week results indicate that the probability that an activity is planned in advance is highest for weekday activities. This intuitive finding can be explained by the fact that people have more time available during the weekend and less fixed commitments.

Although the results of the planning model show that neither individual nor household characteristics affect the planning significantly, the individual-level random effects significantly affect the probability of activity planning. The assumption of dependency within a cluster cannot be rejected, which confirms the results of the above comparison of the MNL and the mixed logit model: an individual-specific preference or dislike for planning seems to exist. Traditional socio-demographic data are not able to account for these preferences, but concepts from cognitive psychology or behavioral decision-making science might be helpful for further research into this topic (*29, 30*).

Rescheduling Model

The explanatory variables incorporated in the rescheduling model are almost the same as those used in the planning model: as explained above, the planned activity attributes are used for the rescheduling model instead of the activity attributes as they are executed. Again, family function is correlated with gender and the planned activity location is also subject to multicollinearity: both variables are removed from the analysis. Table 4 presents the estimation results of the mixed logit model for activity rescheduling.

Comparison of the log likelihood value of the mixed logit model for rescheduling with covariates (-3222) with the log likelihood of the intercept-only model (-4062) reveals that the full model of Table 4 has a better model fit than the intercept-only model. The rescheduling model with covariates has a likelihood ratio of 0.251 and an adjusted likelihood ratio of 0.239. This is an increase with 90% compared to the adjusted likelihood ratio of the MNL model with the same explanatory variables, but without the random effects. This increase is statistically significant on a 5% level. The rescheduling model has gained explanatory power thanks to the incorporation of the random effects in the model. This result can also be derived from the highly significant value of the t-statistic for the between-individual variance. The model fit of the mixed logit model is clearly better than the fit of the MNL model without random effects, what can be concluded from the amelioration of the AIC from 7519 for the MNL model to 6548 for the mixed logit model for rescheduling. Comparing the coefficients of the MNL and mixed model shows that they differ in size, although the same explanatory variables are significant in both models. All these goodness-of-fit measures indicate that individuals have a preference or dislike for rescheduling that cannot only be explained by differences in socio-demographic or situational characteristics. Additional research into these individual effects could originate from decision-making science and cognitive psychology, as was suggested for the planning model (*29, 30*).

Exploration of the different groups of covariates reveals that the signs of the coefficients are overall consistent with results of similar studies (e.g. (*17*)). It turns out that several activity attributes determine whether an activity is prone to rescheduling or not. Start time and duration significantly affect the chance that an activity is rescheduled. The estimated odds of rescheduling increase by 3% for an increase in start time by one hour and by 15% for an increase in duration by one hour. This means that activities planned to be executed later during the day tend to be rescheduled more than those earlier in the day, because activities executed later in the day are presumably more subject to unexpected events, preceding activities that lasted longer than expected, etc. Longer activities are more likely to conflict with other activities and are thus more likely to be rescheduled. The odds of activity rescheduling increase significantly by 42% if non-household members join in on the activity. If other people are involved in an activity, the activity becomes less controllable: not only the schedule of the respondent, but also that of the people that join in can be modified and these modifications will spread to the other schedules. This could be a possible reason why the presence of non-household members increases the odds of rescheduling. As opposed to the planning model, no conclusive statements can be made about how the number of accompanying persons or the involvement of household members influence activity rescheduling, because the corresponding coefficients are far from statistically significant. The likelihood ratio analysis confirms that activity type is a significant explanatory variable for the activity rescheduling model. Work, Sleep and Bring/Get are the activity types that have the lowest probability of being rescheduled. As argued before, Work is typically considered to be a fixed activity type and the Bring/Get activity is also usually associated with fixed commitments and hence less likely to be rescheduled. Touring, Non-Daily Shopping and Social Activities are the most likely to be rescheduled. Non-Daily Shopping and Touring are activity types that do not usually have a fixed start or end time, so the duration is typically rather flexible. Furthermore, both activities can often be executed on a variety of different locations and this location flexibility can also cause impulsive changes in the scheduling process. Transport mode also turns out to significantly affect activity rescheduling and the model results reveal that activities reached on foot or by bike are subject to rescheduling more often than activities reached by car: the odds of activity rescheduling increase by 37% if people use a slow transport mode. Activities performed at the same location as the preceding activity decrease the odds of rescheduling significantly by 59% and are thus the least likely to be rescheduled. This indicates that trips to locations where more than one activity will be executed, also have a structuring influence on the schedule.

Day of the week is the only schedule attribute that significantly affects rescheduling and it is clear that there are less activities rescheduled during the week than on Sunday. The higher probability of planning during the week due to the lower amount of spare time available from Monday to Thursday can account for this finding.

Few individual variables turn out to be significant. On a 5% significance level, it is clear that working people reschedule their activities far more often than non-working people. One possible reason could be that working people usually have a tighter schedule than non-working people, so unexpected events disturb their schedule more vigorously. Since there is little spare time to absorb changes in the workers' schedules, more activities are rescheduled. The possession of a transit pass is only significant on a 10% level: people with a public transport pass are less likely to reschedule their activities than people without a public transit pass. The fixed timetable of public transport services could be the main reason that public transport users do not need to reschedule their activities as often as people without a transit pass, but since busses and trains do not always follow their timetable, the explanation could also be that public transport users calculate possible delays in their planning and thus do not need to reschedule when they are actually delayed.

The number of children in the household turns out to be a significant household attribute on the 10% significance level: the odds of rescheduling decrease by 20% with every additional child in the household. The presence of children in a family entails the need to structure daily activity-travel patterns more thoroughly. Depending on the age of the children, they can e.g. not be sufficiently independent to stay home alone, to travel on their own, etc. Adult family members need to structure their schedules to some extent so that the children are taken care of.

CONCLUSIONS

The aim of this paper is to contribute to the understanding of activity scheduling and rescheduling, because the factors influencing these behavioral scheduling processes are still largely unexplored in spite of the increased interest in scheduling and rescheduling research. Activity-based models driven by dynamic scheduling and rescheduling processes potentially provide more accurate activity-travel pattern predictions, which is important in the context of e.g. the evaluation of transport policies.

Two different mixed logit models are discussed. The first model analyzes whether an activity is planned in advance or not and the second model examines whether a planned activity is rescheduled between planning and execution. Both models are based on activity, schedule, individual and household attributes that are collected by an extensive, large-scale activity-travel survey in Flanders. The survey gathers traditional activity-travel schedules and information about the scheduling process for 7 consecutive days.

The following analysis results are particularly relevant to understand the role of interpersonal interactions in scheduling research. It was found that the activity planning process is significantly influenced by social interactions with other people. Not only the number of people that join in on the activity influences the planning, but also the 'type' of company is relevant. Furthermore, the effect of performing activities together with other people also affects the rescheduling process, though to a lesser extent: rescheduling is influenced by the presence of non-household members, but not by the number of accompanying people. These findings support the growing interest in activity-based modeling of household interactions and social networks in activity-travel research and encourage modelers to take up the challenge of incorporating interpersonal relations in activity-based models.

One of the most important results confirms the growing belief that activity type alone may not be sufficient to assess whether activities are planned beforehand or not. The planning model demonstrates that other activity attributes together with situational and environmental circumstances also play an important role in the planning process and the same holds for the rescheduling process. Sequential activity-based models should thus take more explanatory variables into account in assessing which activities are planned or rescheduled and in which order, than merely activity type. It should however be noted that activity type still has strong explanatory power in the planning as well as in the rescheduling model, despite the various covariates that are incorporated in both models and that are statistically significant. Given that for example Work is mostly planned in advance and rarely rescheduled, it can be concluded that Work still constitutes a part of the activity-travel schedule that has a strong structuring influence.

Most estimation results regarding activity planning and rescheduling are in line with general expectations about the determinants of individual scheduling behavior. Interesting results are found with respect to between-individual variance: although the personal preference of individuals regarding activity planning or rescheduling is often neglected in scheduling analyses, it is clear from the model results that this component cannot longer be ignored in future attempts to model the planning or rescheduling process. The substantial explanatory power added by incorporating random effects into the mixed logit models incites further research into individual preferences for planning and rescheduling.

In order to verify the above conclusions, future research will focus on reanalyzing the models in this paper based on the personal digital assistant dataset and the results of the analyses will then be incorporated in FEATHERS, an activity-based model for Flanders.

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LIST OF TABLE TITLES AND FIGURE CAPTIONS

TABLE 1 Frequency of Activity Types

Activity type	*Frequency (#)*	*Frequency (%)*
In Home	5104	53.46
Sleep	1160	12.15
Work	576	6.03
Bring/Get	556	5.82
Daily Shopping	413	4.33
Social Activities	327	3.42
Services	270	2.83
Non-Daily Shopping	248	2.60
Eat	240	2.51
Tour	220	2.30
Leisure	205	2.15
Other	184	1.93
Education	45	0.47
Total	9548	100.00

TABLE 2 Classification of Activities for the Planning and Rescheduling Model

Classification Planning Model		*Classification Rescheduling Model*	
Not Planned	2258	Not Rescheduled	2268
Planned	7290	Rescheduled	5022
Executed	7003	Timing	1746
Not Executed	287	Non-Timing	1125
		Combination Timing / Non-Timing	1864
		Deletion	287
Total	9548	Total	7290

TABLE 3 Estimation Results of the Mixed Logit Model for Planning

Parameter	*Estimate*	*Standard Error*	*t-value*	*Probability*
Intercept	-1.4013	2.0742	-0.68	0.4999
Activity Attributes				
Start time	-0.0598	0.0066	-9.12	<.0001
Duration	0.1131	0.0184	6.14	<.0001
Accompanying persons	0.0612	0.0181	3.38	0.0008
Accompanying partner	0.2063	0.0854	2.42	0.0163
Accompanying child	0.1723	0.1023	1.69	0.0931
Accompanying other	-0.3029	0.1068	-2.84	0.0049
Activity type				
Work	.	.	.	.
Services	-1.4888	0.2859	-5.21	<.0001
Eat	-1.0733	0.2991	-3.59	0.0004
Daily shopping	-1.7522	0.2566	-6.83	<.0001
Non-daily shopping	-2.1591	0.2785	-7.75	<.0001
Education	0.4507	0.7995	0.56	0.5734
Social activities	-1.7941	0.2680	-6.69	<.0001
Leisure	-1.0774	0.2984	-3.61	0.0004
Bring/Get	-1.1912	0.2603	-4.58	<.0001
Tour	-1.8288	0.3111	-5.88	<.0001
Other	-1.0303	0.3130	-3.29	0.0011
Sleep	-0.8090	0.2482	-3.26	0.0013
In home	-0.9914	0.2260	-4.39	<.0001
Transport mode				
Car	.	.	.	.
Public transport	0.4732	0.4587	1.03	0.3032
Slow mode	-0.0209	0.1588	-0.13	0.8952
No transport	-0.0948	0.1116	-0.85	0.3964
Schedule Attributes				
Total # Activities	-0.0298	0.0131	-2.27	0.0237
Total Activity Duration	0.0032	0.0061	0.52	0.6040
Weekday				
Monday	0.5896	0.1384	4.26	<.0001
Tuesday	0.2558	0.1285	1.99	0.0476
Wednesday	0.4281	0.1305	3.28	0.0012
Thursday	0.2287	0.1278	1.79	0.0747
Friday	0.2509	0.1272	1.97	0.0496
Saturday	-0.1058	0.1238	-0.85	0.3934
Sunday	.	.	.	.
Individual Attributes				
Gender	-0.2486	0.4721	-0.53	0.5989
Age	0.0115	0.0218	0.53	0.5983
Driving License	-0.1164	0.5527	-0.21	0.8334
Transit Pass	0.2033	0.4461	0.46	0.6490
Disabled	-2.0393	1.4624	-1.39	0.1644

Education				
Primary school	.	.	.	.
General junior high	1.2613	1.4394	0.88	0.3817
Technical junior high	2.1307	1.5574	1.37	0.1725
General high school	4.1361	1.3503	3.06	0.0024
Technical high school	3.8405	1.3185	2.91	0.0039
College	4.2128	1.2843	3.28	0.0012
University	3.9207	1.3737	2.85	0.0047
Income				
<750€	.	.	.	.
750-1250€	0.6451	0.8002	0.81	0.4208
1250-1750€	0.3890	0.7624	0.51	0.6103
1750-2250€	0.4550	0.9098	0.50	0.6174
2250-2750€	1.0261	1.0359	0.99	0.3228
>2750€	0.4438	1.2774	0.35	0.7285
Occupation				
Not working	.	.	.	.
Working	0.4186	0.6113	0.68	0.4941
Student	-0.0391	1.6579	-0.02	0.9812
Household Attributes				
Household size	-0.0559	0.1493	-0.37	0.7084
# Children in the household	0.2515	0.2417	1.04	0.2992
Partner	-0.5277	0.4891	-1.08	0.2816
Random Effects				
u_i	7.3908	0.9922	7.45	<.0001

TABLE 4 Estimation Results of the Mixed Logit Model for Rescheduling

Parameter	*Estimate*	*Standard Error*	*t-value*	*Probability*
Intercept	-3.8068	1.6137	-2.36	0.0192
Activity Attributes				
Start time	0.0299	0.0055	5.39	<.0001
Duration	0.1404	0.0158	8.90	<.0001
Accompanying persons	-0.0017	0.0113	-0.15	0.8837
Accompanying partner	0.0332	0.0827	0.40	0.6880
Accompanying child	0.0791	0.1003	0.79	0.4312
Accompanying other	0.3500	0.1165	3.00	0.0030
Activity type				
Work	.	.	.	.
Services	0.6318	0.2505	2.52	0.0124
Eat	0.8220	0.2691	3.05	0.0025
Daily shopping	0.7238	0.2357	3.07	0.0024
Non-daily shopping	1.0486	0.3137	3.34	0.0010
Education	0.7640	0.4703	1.62	0.1057
Social activities	1.0563	0.2785	3.79	0.0002
Leisure	0.6223	0.2867	2.17	0.0311
Bring/Get	0.2635	0.2093	1.26	0.2094
Tour	0.9185	0.3075	2.99	0.0031
Other	0.7249	0.3166	2.29	0.0230
Sleep	0.0866	0.1860	0.47	0.6420
In home	0.5800	0.1733	3.35	0.0010
Transport mode				
Car	.	.	.	.
Public transport	0.0287	0.3079	0.09	0.9259
Slow mode	0.3156	0.1413	2.23	0.0265
No transport	-0.9023	0.1155	-7.81	<.0001
Schedule Attributes				
Total # Activities	-0.0099	0.0130	-0.76	0.4457
Total Activity Duration	-0.0003	0.0044	-0.06	0.9512
Weekday				
Monday	-0.3960	0.1310	-3.02	0.0028
Tuesday	-0.2381	0.1301	-1.83	0.0686
Wednesday	-0.3686	0.1285	-2.87	0.0045
Thursday	-0.3487	0.1277	-2.73	0.0069
Friday	-0.2111	0.1313	-1.61	0.1093
Saturday	0.0490	0.1346	0.36	0.7160
Sunday	.	.	.	.
Individual Attributes				
Gender	0.3085	0.2705	1.14	0.2554
Age	0.0144	0.0120	1.21	0.2285
Driving License	-0.0388	0.3139	-0.12	0.9017
Transit Pass	-0.4115	0.2470	-1.67	0.0972
Disabled	0.5215	0.9055	0.58	0.5653

Education				
Primary school	.	.	.	.
General junior high	2.4042	1.4839	1.62	0.1067
Technical junior high	2.5018	1.5824	1.58	0.1153
General high school	2.5352	1.4317	1.77	0.0780
Technical high school	2.7531	1.4111	1.95	0.0524
College	2.4197	1.3992	1.73	0.0852
University	2.9298	1.4288	2.05	0.0415
Income				
<750€	.	.	.	.
750-1250€	0.3451	0.4287	0.80	0.4217
1250-1750€	0.0425	0.4052	0.10	0.9167
1750-2250€	0.7934	0.5013	1.58	0.1150
2250-2750€	0.4574	0.5872	0.78	0.4368
>2750€	0.6342	0.6904	0.92	0.3593
Occupation				
Not working	.	.	.	.
Working	0.7049	0.3393	2.08	0.0389
Student	0.4543	0.8732	0.52	0.6034
Household Attributes				
Household size	0.1054	0.0749	1.41	0.1609
# Children in the household	-0.2294	0.1342	-1.71	0.0887
Partner	0.1528	0.2826	0.54	0.5893
Random Effects				
u_i	1.5820	0.2245	7.05	<.0001