# “Between Dinner and Children’s Bedtime”: Predicting and Justifying Routines in the Home

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**ABSTRACT**
Much previous research in availability, whether in the office or in the home, has developed linear regression models to help predict appropriate times for interruption. Although these models work well, they tend to be accurate only about 75% of the time. In this paper, we reconceptualize this problem as one of determining routines, rather than availability. We show that the same sensor measures, which predict availability accurately 75% of the time, can predict mealtime, bedtime, and leisure routines accurately 90% - 97% of the time. We argue that better identification of routines can help us to better identify individual availability, as we can develop more tailored models of individual availability in given household routines. In this paper, we also present findings from a day reconstruction method (DayRM) study, which provides more detailed descriptions of three routines in the home: mealtime, bedtime, and leisure.

**Author Keywords**
home, availability, diary study, awareness, interruption.

**ACM Classification Keywords**
J.4 [Computer Applications]: Social And Behavioral Sciences - sociology, psychology. K.4.3 [Computing Milieux]: Computers And Society - computer-supported collaborative work.

**INTRODUCTION**
With the growing import of ubiquitous communication technologies, the American family is more accessible to family and friends than ever before. Telephones reach into over 98% of American owner-occupied home units and 95% of rental households [2]. Mobile phones are nearing ubiquity (over 158 million subscribers in America) [2]. But, are we actually available to those close family and friends who are calling? When planning an important family gathering or simply connecting with family members, are we able to attend to the conversation and to the person? Or are we distracted by demands of current home life situation, like preparing dinner or getting the children to bed? As potential interlocutors, we can rely on general patterns, but it is difficult to predict the availability of any given household without knowing more information. Is this the afternoon for soccer practice? What is the time of day in their time zone? Do they eat at 6 or 7 p.m.? Determining the “availability window” between dinner and bedtime routine presents a challenge to family and friends outside the household.

Studies of technology benefits in home life, show beneficial interruptions may result in finding a time to exercise with a friend [16] or *just-in-time* reminders of healthy living choices [10]. One way technology may positively effect social interactions is to provide information to the human that will help in determining or negotiating a time for interaction, whether walking with a companion or conversing. Other between-home family awareness prototypes reveal social benefits when activity, pictures, or messages are shared with distributed family members [6, 14, 23]. The Digital Family Portrait shares patterns of movement within the home over the course of weeks and months, as well as the most recent month’s activity [23]. However, none of these systems extends the theme of awareness to focus on and identify specific factors that predict availability or routine patterns in the home.

To understand between-home availability, we began with workplace availability indicators, where much more research has been conducted. For example, Horvitz and Apacible synchronize keyboard and mouse activity with video imagery of the user in a neural network to determine availability [7]. Fogarty and Hudson [4] have used microphones to detect talking in the office as a reliable indicator of interruptibility for programmers and administrative assistants. Temporal patterns arose as a way that some managers in the workplace coordinate interruptions, which they view as integral to their job [8]. Sensing technology coupled with an intelligent modeling technique looks promising in work environments. The desktop interactions and office-based sensors used in these models may not be appropriate for the home. Can environmental factors be harvested from home life to reliably predict interruptibility? Our prior Experience Sampling Method study of home life provided encouraging correlations between environmental cues in the home and availability [17]. Our results replicate similar studies of interruption and time use in the workplace [4, 8]. Our study shows face-to-face conversation, watching TV, and playing games are significant predictors of availability.

Although the regression models for predicting availability that have been developed in our previous work—as well as those developed in office-based research ) [4]—are about as good as the human predictions, they could still be better. Are there other ways of characterizing home life that will provide more insight? In our previous study [17], participants often spoke of their activities and accessibility in terms of routines. What can we do if we reconceptualize availability research as a problem of identifying routines? Can we use routines—which is how humans talk about availability—to better predict availability? In doing this, our focus shifts from determining availability, to identifying routines based on environmental indicators. Our research questions concerning the relationship of household routines and availability include:

How accurately can environmental cues model some routines?

How are household routines defined by the family members?

Can family routines be recognized and effectively used for availability sharing?

## POTENTIAL OF ROUTINES

Rhythms of work in the office [8] help synchronize communication and manage interruption of workplace activities. Medical workers use temporal patterns within the hospital to coordinate work and information [20]. Similarly, office workers may use rhythms of computer interaction and email access to predict availability of colleagues at geographically remote work locations [1]. Although several recent studies in office work have found reliable predictors of availability [7, 9] and indicators of presence [1] by monitoring the desktop computer and its location, home life activities are dispersed through a house and not necessarily collocated with a computer [15]. There is often a fundamental difference in how one manages and views their "work" life vs. "home" life, as evidenced in "boundary making" actvities [18].

Just as temporal rhythms exist in work practice, time-based routines both define and interact with home life. Longitudinal studies of home phone use in the U.K. revealed the patterns of interactions and social use and how callers are expected to know life rhythms and use that knowledge to call at appropriate times [13]. Routine behaviors are frequently seen in home life, not just in the allocation of activities and childcare, but to minimize the overall mental cost of when and what to do, ordering the chaos of competing roles in the home [18]. Social protocols explicitly pay attention to these boundaries, especially when interrupting at home, one is keenly aware of the prevailing routines of the household. While exploring how to make technology "invisible in use", Tolmie et al. provide a working defintion of domestic routines [25],

> *"Routines mean that people can get out the door, feed themselves, put the children to bed, and so on, without having to eternally take pause and invent sequences of action anew or open up their every facet for inspection or challenge or to constantly have to "account" for what they are doing with explanations or rationales.*"

This sets the challenge, defining routines is a task of revealing the unnoticed. Ethnographic studies have investigated domestic routines involving "the knock on the door" [25], organizing systems [24], and communication activities [3]. These studies show the communication centers of the home are distributed, but articulated in routines [3]. Organizing systems in the home, such as lists, calendars, and notebooks, organize the routines and schedules, and also the social interactions among the household members. [24]. Each of these accounts of the home point to looking deeper into everyday life of the home, examining the details that more richly describe the family specific routines and space allocations.

## STUDY

Richly detailed and measurable descriptions of routines could guide applications that infer higher-level activity based on simple metrics of activity. Some of the interesting routines for families with young children are dinner time and the bedtime routine and will be the focus of our study. While there are privacy concerns in revealing details of each of these intimate family rituals, participants in the sampling study were very open in detailing these everyday routines. Understanding these routines in detail for specific families will provide insights into the recognition of when they begin and end, as well as when they are out of the expected range.

### Day Reconstruction Method

We chose to use Day Reconstruction Method (DayRM), a hybrid approach combining the collection of time-use data and an accurate representation of the experience of these activities. The Day Reconstruction Method (DayRM) provides time-use data in a relatively efficient manner, but for only one day, rather than over several days [11]. DayRM participants first construct a diary of their home life activities from the prior day, refreshing those events in their memory and the associated feelings. Next subjects answer questions about specific situations from the "reconstructed day" and the feelings they experienced, similar to the intent of ESM surveys. Using only the most recent day is intended to evoke very specific affective memories to minimize recall errors and biases [11]. This method enables more complete coverage of the day and the assessment of routines, contiguous activities, and experiences spread over the course of the day, that are not amenable to sampling studies. The DayRM survey is efficient in collecting data, enabling a larger number of participants, which is important to study routines across households. We designed a questionnaire to mirror the survey in two prior ESM studies [8, 17]. By using nearly identical questions, we would be able compare both the accuracy of the availability model generated and the significance of specific factors seen in the ESM data analysis. The Day Reconstruction Method theoretically was a good fit to the questions we ask, but it is unproven in HCI research.

### Day Reconstruction Method Survey

The DayRM survey we developed was a four-part, self-administered paper and pencil instrument constructed to gather data appropriate to analysis of routines and availability policies for the household. A critical component was the participant generated diary. It is essential to have the participants reconstruct the diary of previous day episodes before they are aware of the questions about those activities, asked in subsequent parts of the survey. Prior knowledge of the nature of the questions may bias the reconstruction of the day and recall of feelings associated with the activities. This approach provides a baseline comparison to other models of availability and to parallel ESM data.

Part one profiled both the individual and the household, including age of children and working hours and location of parents. Part two structured the recall of the prior day's home life activities in a confidential diary. The day was reconstructed in time sequence, envisioning home life as a series of episodes, similar to making a movie. For each episode, the diary entry included who was involved, where it happened, and the activities. This diary was confidential for the participant and was not returned to the researcher. Part three asked the respondents to use the diary to answer a series of questions describing each of their home life episodes. There was a mini-survey for each episode including start and ending time and asking:

> Where is each member of the family?
> What activities were you doing?

The checklist of twenty-three activities were grouped by function: food related, household tasks, communication, and leisure. Additionally, for each episode, two questions determined availability to another adult family member:

> Would this have been a good time for an adult family member outside your home to get your help with an activity or task you would want to give your full attention?
>
> Would this have been a good time for an adult family member outside the home to catch up on the family events and activities?

The last question for each episode prompted for routine:

> This episode is part of your normal routine during...
>
> Mealtime
> Children's Bedtime
> Leaving or returning home
> Schoolwork time
> Leisure time
> Other routine
> Not part of a routine

Part four consisted of open-ended questions concerning their dinnertime and children's bedtime routines and others probing their household policies concerning availability for phone conversations.

The questionnaire was administered individually, and was designed to be completed in 45 to 90 minutes. Respondents were given gift certificates to neighborhood restaurants and stores in appreciation for their participation.

### Subjects

We were interested in the routines of "busy families" with young children, where care-giving tasks and daily activities require coordination and communication, often across households. We choose to survey during the children's regular school term, to study routines while school is part of the *routine* of family life. We recruited from the community and the university, focusing on parents of children participating in team sports and extracurricular school activities. This ensured participants had at least one child of the appropriate age, as well as being *busy* with activities outside the home and school. While the children were engaged in the sports or extracurricular activity, the participating parents were able to use that time to begin work on the survey. Most participants took the survey home to complete, returning them at the next after school activity or by mail.

Forty-one questionnaires were distributed over two weeks, 25 were completed and used in this analysis. There were 17 females and 8 males, this included 4 couples. Almost all were married (22); one participant couple were parenting children as significant others, and there was one single mother. The average age was 38 years, ranging from 29 to 50 years of age. All had elementary aged or younger children in the home, the youngest child was less than a year old. Most were Caucasian (17), with 4 black participants, and 4 of other ethnic background. They were very well educated; 13 held graduate degrees, only 5 did not have a college degree. Their occupations include: parent, teacher, executive assistant, physician, engineer, financial analyst. None of these were technologists by vocation, but our participants used email, and cell phones, and computers in their homes.

## RESULTS

Across the twenty-five participants, the average number of episodes recorded for the day was 10, the fewest reported was 8, the most 18. The average duration of an episode was 58 minutes (SD=41); 57 of the episodes were 30 minutes. The shortest was 5 minutes and the longest 3 hours and 40 minutes. Distribution of episodes reported was proportionate to the gender distribution of participants.

### Routines in Home Life

Home life is characterized by simultaneous activities, and this tendency to multiple activities was also seen in 60% of the episodes. Because we often talk about home life in terms of routines, rather than individual activities and locations, the survey asked whether each episode was part of a specific routine or not at all, see Table 1. It is not surprising that our data shows home life is nearly always situated within a routine.

These routines are the ones that subjects talked about in our earlier diary study interviews as significant in home life. We purposely left off personal care routine, to minimize the intrusion on subjects' privacy, but we had many reports of showering and dressing. Subjects also listed a number of

| | Type of Day | |
|---|---|---|
| | Typical | Different |
| **Mealtime** | 26% | 20% |
| **Children's Bedtime** | 10% | 6% |
| **Leaving or returning home** | 15% | 15% |
| **Schoolwork time** | 3% | 1% |
| **Leisure time** | 23% | 19% |
| **Other routine** | 19% | 17% |
| **Not part of a routine** | 4% | 23% |

**Table 1. Routines Cover Home Life**

other routines, such as shopping, yard work, or "Saturday" activities.

We are interested in routines which may vary whether it is a normal vs. an unusual day in the household. For each participant, we asked

*"Was yesterday a typical day for your family?"*
*" What was different or what made it typical?"*

They were evenly split with 12 typical and 13 different days. We expected to find 60% of the days typical as in other time use studies [21]. However, our sample days occurred at the end of the school year (which may not be typical), so a somewhat larger percentage of different days is expected. Special events and activities were cited twelve times to describe why days were atypical, including trips to school, swim practice, and car repairs. Out of 113 episodes on the 12 "typical" days, only 4 (4%) were not part of a routine. On the "different" days, there were 31 (23%) of the total 135 episodes not in routine. Clearly, routines are pervasive, and provide near coverage of waking hours on a "typical" day.

#### Hierarchical Logistic Regression Results

In keeping with research both at home [17] and in the office [5, 8], we were interested in whether or not we could use measurable variables—location, talking, etc.— to help us predict availability at any given moment. However, we hypothesized that we might be better able to predict routines, which could provide us with a more nuanced understanding of how to determine availability on an individual or household level. Ultimately, we are interested in determining a set of externally measurable variables that help predict whether or not the household is in a "routine", and whether or not this prediction is more accurate than our prediction of availability. To examine these questions, we conducted four separate hierarchical logistic regression analyses—one for availability and three for significant household routines (mealtime, bedtime, and leisure). We choose this analysis because statistical regression analysis specifically asks questions about the ability of predicting an outcome based on a set of variables. Logistic regression simply refers to the fact that the dependent variable in all of these analyses was binary.

Since each survey asked participants to indicate their current routine (if any) and their availability, we were able to use reported information about the household state to attempt to predict these answers. To obtain a binary availability variable, we coded both

| | Measurable | Activities |
|---|---|---|
| **Availability** | 72% | 76% |
| **Mealtime** | 89% | 94% |
| **Bedtime** | 96% | 97% |
| **Leisure** | 85% | 90% |

**Table 2. Model Accuracy**

*"Yes, I could be available for a few seconds to a minute, and*
*"Yes, I could be available for (estimate minutes) or longer*

as available, and

*"No, it would be difficult or awkward to be interrupted, and*
*"No, I would prefer not to be interrupted*

as unavailable. Similarly, for each routine of interest, we coded the routine as "1" and any other routine as "0".

We chose to divide our analyses of data into two steps. In the first step, we entered location and interaction variables, that we felt we could be accurately captured from soon-to-be available sensor technology. For example, this step included variables such as whether or not someone was located in a specific room. The second step of our analysis involved the twenty-three activity variables that we believe computing might be able to measure as reliably in the near future. For example, here we entered eating, conversation, reading, paying bills, watching TV, doing laundry. While we can easily determine whether the TV is turned on, we are not as certain as to when someone is or is not watching. Summary results are listed in Table 2.

For each step, hierarchical logistic regression produces a linear equation for predicting the dependent variable from the (many) independent variables. By running each data point independently through this equation, we can determine how accurate it is. In other words, if our resulting equation only predicts a subject's actual availability or routine half of the time, then we would say that our equation is only 50% accurate.

Results indicate that we were able to measure individual routines with high accuracy, while we were only able to measure availability with moderate accuracy. Based on the first step of each of these regression analyses (i.e., using readily measurable variables), we were able to predict availability with 72% accuracy, which is on the same order as results from other studies in both the home and the office [5, 17]. Using these same variables, however, we were able to predict mealtime with 89% accuracy, bedtime with 96% accuracy, and leisure with 85% accuracy. When we include the second step of these analyses (i.e., less easily measurable variables), the accuracy increases to only 76% for availability, while mealtime reaches 94%, bedtime 97% [1], and leisure 90%, as shown in Table 2.

[1]Due to the small number of bedtime routines relative to the large number of factors used, the second step of bedtime routine used a subset of factors most likely to relate to bedtime.

### Day Reconstruction Method Results

The Day Reconstruction Method provided data points comparable to our prior Experience Sampling Study for constrcrting a model of availability. While others have applied DayRM in other fields [11], this study represents a validation of DayRM against a comparable study using ESM [17]. The results of the prior ESM study are similar to office-based sensor models of availability [4]. The ESM study used eight participants for one week, while the DayRM study used only one day for each of twenty-five subjects. The DayRM method was more efficient, requiring only a few minutes of participants' time vs. a week of carrying a PDA and responding in the ESM study. DayRM provided more complete coverage of the day and the routines of family life, by collecting experiences occurring over the entire course of the day. The sampling method may fail to spot interesting events, and requires more days of these sparse samples. The DayRM study method provided the coverage of home life, required to study routines of home life in detail, with more economy of resources than the sampling study.

## RELEVANCY OF ROUTINES

Although it is interesting to see that measurable variables allow us to predict routines with high accuracy, these regression analyses included everything and the kitchen sink (almost literally!) as independent variables. If we are going to develop more parsimonious models of home life, we need to provide a deeper analysis of each of these routines. For each, we look at the specific variables with predictive value, the correlation to availability, and the families' characterization of each routine.

For each routine, we include the table listing those variables which were either significant or marginally significant to the linear regression model for that routine. Since we intended this as an exploratory analysis, we have chosen to use rather loose measures of significance. Therefore, we refer to $\alpha < 0.1$ as significant, We refer to $\alpha < 0.2$ as marginally significant. With these significance ranges, we cannot make definitive statements about our data. Rather, we hope to provide indicators of promising areas. Values in each table indicate the final values in our regression analysis, not the intermediate values at each step. $\triangle R^2$ was significant at $\alpha < 0.05$ for steps 1 and 2, for each routine. Positive B-coefficients indicate that individuals are more likely to be in that table's routine and negative B-coefficients indicate less likely in that routine. Full statistical analysis is available from the authors upon request.

### Mealtime

Mealtime routine can be predicted with up to 94% accuracy, but is not a reliable indicator of availability. Our data highlights the importance of location in mealtime routine, see Table 3, listing only significant and marginally significant variables. Mealtime is comprised of a diverse and large number of activities as reported in the episodes and in participant descriptions of dinnertime. Many individuals' mealtime preferences are correlated to availability. Meal times are more also more available on days that are out of the ordinary routine. Recognizing the mealtime routine is important to understanding availability of the family, but is not sufficient.

The mealtime routine is dominated by activities in the kitchen and dining. Fifty percent of the 56 meal episodes involved eating and meal preparation activities. Face-to-face conversation was also prominent, occurring in 13% of mealtime episodes and cleaning up meal in 11%. But, with 3.5 activities per episode, there is much more to mealtime routine than simply food-related actions. Somewhat surprisingly, out of 23 possible activities, 18 of them were cited within mealtime routine episodes. This indicates that mealtime is either quite varied across households to span that breadth or family concept of mealtime is broad and diverse within each household.

In general, mealtime routine does not predict availability, but individual households seem be more consistently correlated. Participants were available in 63% of the 56 mealtime episodes. However, looking at the availability profile for each individual during mealtime, there is a high correlation, in some individuals. Examining those 16 participants with multiple mealtime episodes, eight of them were consistent: six were always available and two were never available. The study households were more likely to be available during week-end mealtime (73%) than during the weekday (53%). When the family was having a typical day their mealtime availability was 52%, but when the reported day was unusual, availability increased to 74% during mealtime, perhaps in compensation for the differences in the day. When we look at the effect of age of the youngest child in the household, the trend is to be less available during mealtime routine as the youngest child is more mature. This may reflect increased social interactions among family at mealtime routines as the children develop. While recognizing mealtime routine is not sufficient for understanding availability in the home, adding knowledge of household specific preferences and whether it is a typical day for the family increases the correlation.

We looked at a specific instance of mealtime routine, dinner time. Participants were asked to list three indicators dinner was starting and then three to signal the end of dinnertime. The responses were location and person-centric. For instance, to start the meal, the most frequently mentioned factor (13 times) was:

*"Everyone is seated at the table"*

Food preparation (5), time of day (5) and setting table (7) were also important:

*"cooking buzzer goes off"*
*"it's around 6:30 (+-10 minutes)"*
*"we set the table"*

The end of dinner is reflected in 18 responses including table clearing and cleaning:

*"Table is cleared"*
*"clean-up has started"*

| | Variables | Coefficient | Wald Statistic | Significance (p-value) |
|---|---|---|---|---|
| **Step 1 Individual's Room Location** | Participant in Kitchen | 3.069 | 4.272 | .039 |
| | Participant in Family Room | -2.519 | 4.254 | .039 |
| | Participant in Dining Room | 4.905 | 2.798 | .094 |
| | Participant in Child's Room | -2.915 | 3.085 | .079 |
| | Spouse in Family Room | -1.740 | 2.247 | .134* |
| | Spouse in Other Room | 1.757 | 1.719 | .190* |
| | Child in Parents' Room | 1.846 | 1.987 | .159* |
| **Step 2 Participant Activities** | Eating meal/snack | 2.251 | 6.559 | .010 |
| | Other Activities | -2.841 | 5.768 | .016 |
| | Email, Chat, IM | -5.026 | 4.403 | .036 |
| | Games | 8.257 | 9.015 | .003 |
| | Listening to music | -4.369 | 2.905 | .088 |
| | Education/School | -3.320 | 2.521 | .112* |
| | Planning/Scheduling | -1.930 | 2.571 | .112* |

**Table 3. Mealtime Model**

Other ending indicators were: finished eating (8), people leaving table (8) and moving to attend to other activities (7):

*"Children finished eating and asked to be excused"*
*"We take off from the table"*
*"Shower time/homework begins"*

These markers of the beginning and end of dinner time are quite consistent compared to the diversity of activities found in the overall mealtime routines. In describing dinner time, very few mentioned a room. Almost all included location proxies, the table and/or stove, home artifacts with very stable room locations. The participant description of dinner is characterized by a coming together in a specific location at a relatively fixed time. The ending has family members moving about the clearing and cleaning the table and moving to other rooms and activities.

We had three instances of somewhat different mealtime: going out to eat and ordering take-out to eat at home. These entailed coordinating with other family members about where to go or order:

*"husband called to ask what we wanted to do for dinner"*

Another described eating out:

*"Spouse asks, 'Where are we eating?"'*
*"We drive to restaurant"*
*At the end, "Kids have run off to play video games"*

Both of these dinners occurred on typical days. We do not know if this case of dinner, including the games, is a regular occurrence and part of their overall schedule or was it an exception. These incidents are part of the "mealtime routine", so the challenge is to learn the variety of cases, even in one home.

Recognizing the mealtime routine is important to understanding availability of the family, but is not sufficient. Our participants were asked how others know when is a good time to call them and then how others know when not to call. Good times to call were specified in relationship to either mealtime routines or specific meals in eight cases; when not to call relied upon knowledge of mealtime for ten participants. Clearly, awareness of when a household is in a mealtime routine is one part of the availability for individuals. More accurate prediction of mealtime routines using room location and activity recognition technology may provide enough inter-home awareness to allow the human to determine availability.

### Children' Bedtime

The high predictive accuracy of children's bedtime routine is based on parent and child location, including both parents' and child's room. Bedtime is negatively correlated to availability, but is effected by the parent working outside the home. Surprisingly time of day was rarely used to indicate bedtime routine. Instead the parent-child interactions around the "tuck in bed" action were the most frequent indicators of bedtime ending. Recognizing bedtime will clearly mark a time when parents are not available, but one that is not well-defined by time. Significant variables for bedtime model are listed in Table 4, where "*" denotes marginally significant. The child's bedtime routine had only 19 episodes, this number of samples limits the analysis that can be performed and its significance.

When either of the parents is in the child's bedroom there is a positive correlation to children's bedtime routine. Our participants are in homes with dual care-givers, so the high correlation of the spouse in other rooms may be attributed to the secondary and primary parenting roles assumed. This arrangement was described by one participant:

*"[husband] is chasing [child] (for his bath)*
*child is bathing*
*wife is resting alone"*

Bedtime episodes were less busy than mealtime, with only 1.6 activities on average and a narrower field of activities, just 11 different activities out of 23 possible. Face-to-face conversation was a dominant activity, occurring in 10 of 19 episodes. Reading was an activity in 7 episodes. The children' bedtime routine is predicted by the presence of parents and children in particular rooms and is more focused in the activities involved.

The child's bedtime routine is generally negatively correlated to availability (68%). But it appears sensitive to whether the parent is a full-time, stay-at-home parent or

| | Variables | Coefficient | Wald Statistic | Significance (p-value) |
|---|---|---|---|---|
| **Step 1 Individual's Room Location** | Participant in Parents' Room | -4.617 | 2.213 | .137* |
| | Participant in Child's Room | 4.709 | 5.018 | .025 |
| | Spouse in Kitchen | 3.828 | 1.884 | .170* |
| | Spouse in Family Room | 4.326 | 2.734 | .098 |
| | Spouse in Child's Room | 3.254 | 1.706 | .191* |
| | Spouse in Other Room | -3.434 | 1.863 | .172* |
| | Child in Parent's Room | 3.711 | 2.730 | .098 |
| | Child in Child's Room | 1.718 | 1.873 | .171* |
| **Step 2 Participant Activities** | Laundry/Housekeeping | 3.539 | 2.181 | .140* |
| | Bill Payment | 9.642 | 2.136 | .144* |
| | Other Activities | 5.583 | 3.790 | .046 |
| | Reading | 5.679 | 4.356 | .037 |

**Table 4. Child's Bedtime Routine Model**

works outside the home. Those working full-time out of the home are most often unavailable during bedtime routine. Our homes with infants were somewhat less-available during the bedtime routine than the family with only elementary age children.

The self-reported indicators of bedtime start and ending support the high involvement of the parent. Reading was a significant predictor in the model and is also frequently cited at bedtime beginning (7 times) and end (6 times). Specific activities with the parent mark the transition into bedtime routine: help with pajamas (7), prepare room/pack for next day (12), bathing (12), brushing teeth (10), and room changes (5). Surprisingly, time is only mentioned four times as a starting point, and just once as an ending marker. The bedtime routine is defined by the family in terms of personal interaction, activities, and locations (bed and bath). There is an overall lessening of activity, talking and lights are turned off (12). But the most prominent characteristic was the intimate and comforting parent-child interactions at the bedside, mentioned sixteen times. For instance one participant's end of child's bedtime:

> *"We finish one chapter of the book"*
> *"We kiss him good night, dad is called in from living room also for kiss"*
> *"We turn on fan and turn off light."*

These ranged from kisses and hugs, lullabies, special goodnight sayings and prayers to simply *"tuck in bed"*. This is a time of family life when parents prefer **not** to be available to others. The bedtime routine is part of their on-going relationship with both the children and spouse in how these boundaries of family life are managed. Furthermore, when specifying when to call or not call the family, the bedtime routine was used six times to mark good times and in six descriptions of when not to call. One participant provided the following guidelines:

> *(good time) "early afternoon, after meals, after children's bedtime"*
> *(not good) "morning time, i.e. prior to school, during email, bedtime"*

Since time of day was not used as a marker of bedtime routine, the recognition of the routine would provide information those outside the household would not otherwise have. Clearly, recognizing children's bedtime routine will give others an awareness of when the family prefers to be called.

### Leisure

Leisure routines are predicted through some of the same activities seen in prior sampling studies, including TV, email, managing personal information, and listening to music. Leisure is the most consistently correlated to availability, of the three routines explored. Leisure time is surprisingly predicted by several activities more often associated with a "work": laundry, managing personal information, and written communication. Significant variables are listed in Table 5, where "*" denotes marginally significant.

The variety of activities predicting leisure is seen in the breadth of leisure activities recorded. Leisure routines average 2.7 activities/episode, with every one of the 23 activities occurring during leisure. The dominant activity is watching TV or a movie (25 episodes), followed by face-to-face conversation (14). As one participant described a good time to call:

> *"during leisure time (TV, reading, etc)"*

More surprising, is the significant and positive correlation of laundry/house cleaning, email/chat/IM, and written communication, as well as the marginally significant correlation of shopping and managing personal records. One surprising negative, but marginally significant correlation was listening to music. In this case, what appears to be a leisure activity is good at predicting when not in leisure routine.

The high activity level suggests that leisure may also be a time to handle routine housekeeping tasks, while watching TV or playing with the children. Just because laundry and house cleaning occur during leisure, does not make them activities of leisure. A more reasonable characterization, based on multi-activity nature of home life, would be simply a mixing of household cleaning burdens with the leisure activities.

Leisure was most consistently correlated to availability (83%). Our participants were somewhat more available on the weekend (87%) than a weekday (79%). Whether it was a typical or unusual day did not effect availability during leisure. The full-time parent at home (93%) was more available during

| | Variables | Coefficient | Wald Statistic | Significance (p-value) |
|---|---|---|---|---|
| **Step 1 Individual's Room Location** | Participant in Kitchen | -4.920 | 3.993 | .046 |
| | Participant in Family Room | -2.172 | 1.832 | .176* |
| | Participant in Parents' Room | -3.546 | 3.867 | .049 |
| | Participant in Child's Room | -5.448 | 4.780 | .029 |
| | Participant in Other Room | -3.396 | 3.070 | .080 |
| | Child in Kitchen | -3.322 | 3.501 | .061 |
| | Child in Family Room | 2.834 | 9.137 | .003 |
| | Child in Child's Room | 1.656 | 7.400 | .007 |
| | Child in Other Room | 2.923 | 6.069 | .014 |
| **Step 2 Participant Activities** | Prepare Meal/Snack | -9.256 | 7.875 | .005 |
| | Planning Meals | -4.453 | 1.658 | .198* |
| | Laundry/Housekeeping | 4.021 | 7.634 | .006 |
| | Shopping | 1.726 | 2.550 | .110* |
| | Manage Personal Info | 3.498 | 2.560 | .110* |
| | Email, Chat, IM | 3.501 | 5.262 | .022 |
| | Written Communication | 6.524 | 6.302 | .012 |
| | Work Related | -3.121 | 1.715 | .190* |
| | Watching TV/Movie | 4.057 | 10.531 | .001 |
| | Listening to Music | -5.406 | 2.621 | .105* |

**Table 5. Leisure Routine Model**

leisure than those that worked outside the home (78%). Of the three routines explored, leisure time is the most consistently predictive of availability.

## DISCUSSION

We have shown that a combination of simple sensors and more complex, less reliable sensor measures can predict routines very well. We believe that knowing more about the specific household along with the routine, will be useful in many awareness applications. Conceptualizing awareness in terms of routines, rather than availability status, may also apply to those who work from home and to office situations.

### Routines and Availability Awareness

There are more details and nuances of routines than shown in this study, see [3, 18, 24]. This is an explorative study showing the relative power external indicators have in predicting some routines, providing more accurate predictions of routines than of availability. How would recognition of household routine help us determine availability? The participant responses reveal many ways knowledge of routine would help determine availability. As one participant expressed it:

> *(good time) "Lunchtime in general though I don't think they really know."*
> *(not good) "I don't think they know. My routine varies daily a lot"*

This person's *good time* for a call is described by routine, as well as when *not* to call, but this information is not *routine* for others to get to know. Participants often used mealtime and bedtime routines as markers for times when available or when not available. Most went further to specify a window of opportunity "after dinner and before bedtime", but in six cases this excluded children's bedtime. As one succinctly portrayed policy:

> *(good time) "between dinner and bedtime"*
> *(not good) "mornings and evening meal"*

Even in this homogeneous population of families with young children, it is difficult to find a generic "safe time" to call, respecting household policies and preferences. One family has bedtime routine completed by 8 p.m., but in another children are awake until 9 p.m. Many of these windows of availability are opening and closing relative to the children's bedtime routine, after which it is not socially acceptable to call. When is the window of opportunity between meal clean-up and children's bedtime routine for a sister or brother's household? With just knowledge of the household routine, a close family member would at least know when a call is welcomed and may be given the attention they desire. Several mention leisure routines as good times to call, as shown in the model. Clearly, knowledge of mealtime, bedtime and leisure routines can help manage the window of availability.

Prior study interview data indicates knowing when the person was "off-routine" would provide helpful availability information. Others develop a sense of when and where you are available, but if your routine is different for some reason, then perhaps their assumptions on availability would also change, without needing to know why the routine varies, just that it is not typical. In this study, when the family was having a typical day their mealtime availability was 52%, but when the reported day was unusual, availability increased to 74% during mealtime. Availability level also varies according to who is interrupting:

> *"I am always available to my immediate family (who are in the house) except when I'm on the telephone or paying bills. I do not answer the phone to people outside of those living in my house when working with my kids on school work or while we are eating a meal or snack.*"

The perceived intimacy of one's social interactions corresponds to the access afforded, even differentiating between *close* family and friends. For those with whom we are socially close there is a notion of "ever-availability", which is one of the most important measures for evaluating how good a parent, brother or sister, or friend one is [26]. Not only does our availability change with the person who wants

us, but the information shared changes, as well. The sharing of these accessibility rules is one measure of social distance; the less one knows about the household, then the more formal and structured is the communication interaction. Shared knowledge of routines is part of this accessibility and availability that varies by social closeness.

### Routines and Perception Technology

A key to predicting routines is accurate and reliable sensing of location and activities. Simple sensors can only provide part of this information. While there are technologies on the horizon to detect someone's room within the home, we may want to focus on sensing and perception techniques that recognize those factors significant for routines. Perception work is addressing the challenges of activity recognition from several approaches. If routines are important in the home, then we may want to focus sensing and perception techniques on factors significant to the rooms of interest in particular routines and their activities. With the mealtime routine the kitchen and dining room are of interest, and food preparation, especially around the stove. The children's' bedtime routine is predicted by the child's bedroom. The teeth brushing, bathing and dressing activities marking bedtime may be recognized using approaches that infer activities of daily living in the elderly [19]. In the bedroom, one would be interested in detecting reading and conversation around bedtime. From another perspective, perception work may look for markers of particular routines. For instance, the bedtime routine is characterized by parent-child interaction around the bed and a lessening of activity, talking, and light level. One could envision a perception system synchronizing the input of multiple sensing devices to define features over a "social space" and time that may directly identify the mealtime routine in the kitchen [22]. Here we stress the prediction of family routines, either indirectly using discrete location and activity recognition in locations of particular interest or the identification of specific routines by patterns in social spaces of the home.

### Learning Household Routines

Routines appear to be especially useful when coupled with some knowledge of family preferences or daily norms specific to the household. A critical factor will be establishing a default system with initial values approximating routines and policies. Routines are readily described in narrative by the family, but not so easily learned, just because they are richly contextual. In addition, to learning appropriate start-up routines, systems will also need to learn the variety of mealtime routines, like having dinner delivered. There is also the learning as the household changes, in response to school terms and extracurricular activities, or just in the maturing of the children. Any system that will be useful in recognizing routines, will need to learn to evolve it's model of any particular routine.

## IMPLICATIONS AND FUTURE WORK

Although we have shown the potential usefulness of predicting routines in better understanding availability, much work remains. First, there are challenges in developing the sensor technologies needed to do this type of work. Also, questions remain about how to move from knowing routines to knowing availability. Finally, there are questions about how to use this information in practice.

Our research on routines has lead us to believe that case-based reasoning (CBR) holds some potential for helping us implement such a system. Essentially, CBR is an AI approach built on a cognitive model of human memory [12]. CBR argues that humans use past experience to build cases (e.g., routines) which can be useful for predicting the results of a given action (e.g., availability for a phone call). As an AI technique, we believe that CBR might be useful for developing more nuanced systems of availability prediction. More work is needed to test this hypothesis.

Even if we were able to perfectly identify routines with existing sensors, however, we would still have questions about how exactly to translate from a routine into availability, especially since this seems to vary on an individual level. What feedback form will be appropriate in family life to learn the variations on routines, while not interfering in the routines?

Finally, we have yet to investigate the other side of this problem. We know a reasonable amount about the interruptee, but what about the interrupters? What sort of information do extended family and friends need to determine availability for themselves? What sort of displays will be useful? Who in the social network should share this sort of information, and at what granularity?

## CONCLUSION

We offer main contributions from the results of our study that add to understanding how to predict routines and how to use routines to support inter-home availability. First, we validated the use of the Day Reconstruction Method to gather valid time use data on home routines and availability with results matching prior ESM and simulation studies. Second, we showed mealtime, child's bedtime and leisure routines can be accurately predicted from fairly simple and accurate sensor measures. Third, we provided a richer description of the factors that predict and effect each of these routines. Finally, we portrayed the relevance of routines in availability assessment between households.

Our results offer a significant reconceptualization of shared awareness, depending upon the accurate recognition of routines, rather than the reliable assessment of availability status. We hope our work will provide a basis for future design and development of home awareness applications. By detecting and sharing routine-based awareness information, the close family and friends will be able to determine more appropriate times to communicate.

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