Can SAL support self reflection for health and nutrition?

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ABSTRACT
Important long-term goals for good health and wellbeing are challenging to achieve. Emerging technology offers the promise of easy data collection to help people monitor progress toward such goals. We designed SAL (simple, situated ambient logger) to help people track food eaten. It is minimalist with a core goal of making it easy for people to log progress towards goals, in particular, diet goals. We recruited ten participants who used SAL food loggers over 2 weeks. Our analysis of SAL use and interviews indicates it is usable and supports reflection on food intake. Our key contributions are insights into the potential of, and future directions of SAL loggers.

Author Keywords
Logger, long-term health and well-being, pervasive, diet, personal informatics

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION
Food diaries are very important for people who want to reduce weight, improve health and for nutrition research (Zepeda and Deal 2008), (Mattila, Parkka et al. 2008). Dietitians and health researchers use techniques such as food diaries (Resnicow, Odom et al. 2000), (Stone, Shiffman et al. 2003) to measure people’s food intake in the form of written notes or digital diaries. Paper-based diaries are accessible and easy to use, but it is hard to get a sense of trends and patterns. Studies show that digital diaries are more helpful for observing eating habits (Stone, Shiffman et al. 2003) and they can be easily analysed to reveal patterns over the time. A number of methods have been used for food logging. They include notes, web interfaces and mobile applications. However, there are challenges to each method. Ideally, approaches should balance convenience, ease of use and the right level of detail.

Research into personal informatics identifies a number of challenges in effective food journaling. These include: too much effort, time consuming and tedious, forgetting to journal food intake, not knowing the food content to log or not wanting to log unhealthy food, reducing the engagement level and compliance over time, the accuracy of the logged nutrition information and unreliable food entries (Cordeiro, Bales et al. 2015), (Cordeiro, Epstein et al. 2015). These findings point to a need to improve food journaling designs to make it simpler, easier and more reliable. DECAF (Diary of Emotion, Context, And Food) is an example of a food journaling application which uses photos to support capture and reflection (Cordeiro, Bales et al. 2015). The study shows that photos make data capture easier, present information that is important to them and support reflection to identify triggers and trends, while removing or reducing barriers associated with common methods (Cordeiro, Bales et al. 2015).

We have designed and created a prototype ambient user interface called SAL (small, situated, ambient, logger) for general purpose activity logging. It is a minimalist interface that enables logging the desired items (such as food) in a personal data store. SAL can be placed in a
convenient location relevant to their personal goals. The logger also provides feedback that makes it possible to see history and reflect on the entered data and help remain motivated to achieve their goals.

The main contribution of this study is to understand the ways that people use SAL as a food logger. We gained insight into their perceptions, whether SAL helped them become more aware of their data collected and if it has potential as a food diary for nutrition research.

The following sections present a review of literature in this area, an overview of the SAL logger, experimental design and results. We conclude with a discussion of our findings.

BACKGROUND
Ambient displays
Many ambient displays are designed to be peripheral in nature and deliver the intended information (Pousman and Stasko 2006). A clock on the wall is an example of an ambient display that shows the time. Other examples are displays that represent information such as changes in weather, stock and currency. They make the invisible visible through being aesthetic, informative and compelling. They might be in the form of physical objects, such as lights that change in intensity (e.g. Hello.Wall (Prante, Röcker et al. 2003)), water that ripples (e.g. ambientROOM (Ishii, Wisneski et al. 1998)) or move up and down (e.g. BusMobile (Mankoff, Dey et al. 2003)). However, these designs do not allow users to interact with their data.

Pervasive and ambient displays can be used to help people change their behaviours and make positive changes. They can be used to remind users to achieve their daily goals. For example, the Ambient Timer (Müller, Kazakova et al. 2013) was designed to remind users, unobtrusively, of upcoming events and appointments using ambient light. Breakaway (Jafarinaimi, Forlizzi et al. 2005) is notable as a carefully situated ambient display. It was designed to help people remember to avoid long periods of sitting. It is a sculpture placed near a person’s computer monitor. It slumps over if that person remains seated for long periods and sits upright after breaks.

UbiFit (Consolvo, Klasnja et al. 2008) is seminal work in physical activity sensing and feedback. Its phone-based display used positive reinforcement of activity, by showing a garden, with flowers and butterflies appearing to reflect the amount of activity. Another system for encouraging people to be more active is GoalPost (Munson and Consolvo 2012). It was designed to support goal-setting by encouraging users to set two goals per week, a primary goal and a secondary goal.

Health related guidelines and recommendations
The American Heart Association recommends a diet rich in fruits and vegetables, with whole-grain high-fibre foods, limiting saturated fat intake, and reducing consumption of added sugars and alcohol to help prevent cardiovascular disease (Eckel, Jakicic et al. 2014), (USDA 2010). Similarly, according to the Australian dietary guidelines (NHMRC 2013), most Australians need to eat: more vegetables and fruit; grain (cereal) foods; reduced fat milk, yoghurts and cheese varieties; lean meats and poultry; and water instead of soft drinks.

Many people are aware of these general recommendations, and have varying clear goals to achieve a healthy diet. Taking daily small steps can be helpful to achieve such goals, e.g. eating 5-6 serves of vegetables and 2 serves of fruit per day. In our study, we aim to help people become aware of how well their diet matches the recommended number of serves of foods (NHMRC 2013), (Panel 1998) and to have the foundations for changing their behaviour.

Our work fits within the context of many challenging issues for health. It is complementary to diverse work in related areas, such as using mobile phones to deliver personalized information about health (Heffernan, Chang et al. 2014) and the many phone apps for health (Hebden, Cook et al. 2012).

Food journaling
Food journaling provides a valuable mechanism for people to become aware of what they actually eat, and to help them alter eating behaviour (Purpura, Schwanda et al. 2011). Designing an effective food journaling interface
is challenging. Key challenges relate to the complexity of detailed logging. Some, among
the many health tracking applications, only track food (e.g. POND (Andrew, Borriello et al.
2013)). Others track other aspects as well. For example MyFitnessPal\textsuperscript{1} tracks physical
activities as well as other health related metrics (such as calories, weight and water)\textsuperscript{2}.

The most common approach for food journaling is to log all food and beverages intake (complete caloric intake) using a dietary database (e.g. BALANCE (Bangor, Kortum et al.
2009)). Users search for food they have consumed in a database or manually add them
in the system if it does not exist. This approach is time consuming and even the most up to date
databases do not cover all the foods and may be country specific (Gan and Allman-Farinelli
2011).

The second approach is to track food intake in terms of categories, such as heavy meal or fruit
and vegetables (e.g. Wellness Diary (Mattila, Parkka et al. 2008) and Few Touch (Årsand,
Tatara et al. 2010)). This approach is still manual but users do not need to find each food
item in the database. It compromises precision for ease-of-use, but can still give valuable
information.

A quite different approach makes use of images and audio files. Here users track food intake
through photo diaries and recording audio files.

Our work takes the broad philosophy of the category-based light-weight approach. We use
the core categories defined in the Australian dietary guidelines (NHMRC 2013).

Self reflection
The underlying theoretical model for behaviour change in the SAL logger is based on the social
cognitive view of self regulation (Bandura 1991), self-reflection and self regulated learning
Making previous behaviour visible supports self-reflection. It can lead to better decisions and enable people to set more effective goals to

\textsuperscript{1} https://myfitnesspal.com/
\textsuperscript{2} https://www.mynetdiary.com/
possible for the users to define the items they are going to log and specify their text, plus the desired target value for each. They can also change the default colour and the number of days for showing the history of the logged data (default is 30 days).

Another crucial aspect of the design of SAL is its situatedness. It needs to be possible to place it in a location to be noticed at the time the user wants to do logging. Ideally, it should also be in the right place to help them remain aware of their progress for the day. It is worth noting that these may well be competing goals. For example, logging a full day of food may be simplest in the evening, just before bed; so placing it near the bed may work well for logging. But it may not meet the awareness goal. A key goal of our study was to learn where people chose to put the logger and how they assessed its usefulness in that place. Figure 2 shows an example of the SAL logger near the user’s desk, used to log daily food intake. From a design perspective, it is important that people have flexibility in situating their SAL logger. In the current prototype, the main restrictions are that it must be plugged into power and have wifi available.

The logger is always on. This is so that it can server as an ambient reminder of progress and to log data.

We reached the current design after exploring several prototype interfaces. We first conducted an auto-ethnographic study by the first 4 authors, and then a second study with 6 users (Yekeh, Kay et al. 2015). In both studies, users set their own goals and targets. In light of these studies, we refined details of the interface. Importantly, we also simplified it. The early version had both an Undo and Nothing Today buttons. The latter was rarely used, over several months, even by the authors. So we removed it.

Based on our review, this is the first work that makes use of a simple ambient logger for a light-weight food journal, based on 24-hour recall, which has been demonstrated to be a valid measure.

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**EVALUATION STUDY EXPERIMENTAL DESIGN**

We now describe the design and results of our study of the SAL food logger.

The study involved the following stages: 1) initial briefing 2) use the SAL logger for one week, 3) initial interview, 4) use the SAL for one more week, 5) final interview and SUS questionnaire.

The briefing gave an overview of the study and dealt with the consent processes. We then gave participants a brief introduction on how to use the interface. This included how to log one serve in each category and how to undo it. We made sure that they were confident about using it before they took it away.
We explained the meaning of a serve in each of five groups. We gave them an A4 page summary of this information (e.g. one serve of Fruit is equal to 150 gram or 1 medium piece of fruit, 2 small piece of fruit, or 1 cup chopped/canned fruit salad). We also showed them a cup (250 ml).

Then participants used SAL for a week. The first interview was scheduled for participant convenience, most being close to the end of the first week. It asked about age and technical skills as well as the questions described above. Our exit interview asked broadly about experiences.

Users were encouraged to place their loggers wherever they thought it was most effective for them. Their logged data was stored in a private, anonymous store.

Our goals in this study are to gain insights into the ways people use a SAL logger (how much they logged and where did they place it) and their experience of using SAL. For these goals, we designed the field trial to test the six hypotheses shown in Table 1.

Our data sources for evaluation and validation of these hypotheses are logged data, two interviews and the SUS questionnaire (columns in Table 1). The data source for each hypothesis is shown by ✓.

H1, about people remembering to log, is based on the data collected by the SAL logger (Cordeiro, Epstein et al. 2015). This assessed the number and proportion of days the user logged data. We also asked about this in terms of the location of the logger. H2, is about awareness, a core design goal. Awareness might be enhanced in two ways. The act of logging can enhance awareness of behaviour. Awareness can also grow from seeing the record of daily intake over time. In the first interview, we asked about previous tool use for health goals. This allowed us to interpret the final exit interview responses about plans, monitoring progress, observed patterns, issues and insights. Both invited open responses.

H3 concerns the power of SAL to help people to achieve the recommended food intake. To assess this, we use the log data to determine whether there was any change. This, together with questions on goals, allowed us to determine whether people had improved their adherence to recommended food intake. H4 aimed to explore whether people considered the coarse grain and simple logging was reliable enough for their food intake goals. To assess this, we drew on exit interview questions about usefulness for logging, advantages and disadvantages and general comments.

To test H5, we used the exit interview responses about advantages and disadvantages of SAL. We analysed comments related to its simplicity and usefulness. Finally H6 was tested with the widely used System Usability Scale (SUS) (Bangor, Kortum et al. 2009).

In addition, we summarised all positive and negative comments to inform future design.

<table>
<thead>
<tr>
<th>Hypothesis / data</th>
<th>Log data</th>
<th>Interviews</th>
<th>SUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1 SAL enables people to remember to log their main food groups eaten</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>H2 People will consider that SAL helps them become more aware of how well they meet the nutrition guidelines</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>H3 People will consider that SAL can help them achieve the recommended food intake</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>H4 People will consider that SAL enabled them to reliably log their intake of the food groups</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>H5 People like the minimalitiy</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>H6 People consider SAL usable</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>

Table 1. Hypotheses and data sources.

RESULTS

We recruited ten participants. Table 2 shows there were 8 male and 2 female. Most are aged 25-34. In addition, all had strong technical skills, 7 expert, 1 advanced and 2 competent. Nine participants (P2-10) used the logger for over two weeks and P1 used it for 6 days due to the charger failing. The last column shows the total taps, including the (quite low) use of undo.
When asked about their long-term goals, most participants answered exercise (8) and half (P1,2,8-10) diet, but all as a secondary goal, after exercise. One more wanted to lose weight. Six participants had used goal-setting and tracking applications, mostly for physical activity. Only P1 had done food logging and found it tedious and frustrating. So these participants have a strong interest in their long-term health and half on healthy eating.

**Where users placed the SAL logger**
In table 2, the grey rows are for the participants who placed their SAL loggers on their office desk. This choice meant that P2,3,5 failed to log on several days as they did not come to work on weekends and holidays. But P4,7,8 did come in some of those days so this location worked better for them. The other four placed it in their home. Two participants placed it on their desks in their bedrooms and the other two in their living rooms. We had expected that these people would log more regularly than those who had the logger at work; this did not happen.

**Success in eating recommended serves**
Table 3 shows the number of days that each participant consumed at least the recommended number of serves of each food group. For example, the last row of the table shows that P10 met her daily goal for *Fruit*, *Grain*, *Dairy* and *Protein* on 5, 0, 0, 4, 7 days, respectively. The green coding indicates food groups where each person did best in meeting recommended levels. For P10, this is protein.

Interestingly, all but P8 met the *Fruit* target at least for one day. *Vegetables* did far less well; 6 participants never made the target. *Fruit*, *Dairy* and *Protein* were the most often met goals and *Vegetables* and *Grain* the least. This picture is in line with the literature (Australian Bureau of 2014) and indicates a consistent use of SAL.

**Logging timing and failures**
Some participants logged the previous day’s food intake every morning (P5,6,9). Others logged each night for that day (P1-3,7,8,10). P4 said that he wanted to log when he ate each meal. As he clearly did not always eat near the logger (on his desk at the university), he often had logged it after he returned (e.g. after lunch), and he did not log what he ate after going home.

**What participants liked about SAL**
In free comments about advantages, participants described SAL as useful (P1,4,7,9,10), easy to use (P2-6,8,9,10), easy to understand and useful overview available all the time (P6,7,8), liking the goal tracking by categories (P3,5) and particularly liking its simplicity (P1). When explicitly asked to rate the SAL’s overall usefulness (with five options to choose were: *not useful, a little useful, average, useful and very useful*), 7 participants rated it *useful* and three said *average*. Free comments indicate that some saw SAL as having a role in combination with other tools (P6,10).

There were several comments about SAL’s advantages for *self-awareness*. P8 noted that it reminded them to log and it made them more aware of the food intake. P6, 7 and 9 reported

<table>
<thead>
<tr>
<th>gender (M/F), age</th>
<th># days</th>
<th># logged days</th>
<th># missed days</th>
<th># all taps (log undo)</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1 M, 25-34</td>
<td>6</td>
<td>4</td>
<td>2</td>
<td>46 (45, 1)</td>
</tr>
<tr>
<td>P2 M, 25-34</td>
<td>16</td>
<td>10</td>
<td>6</td>
<td>126 (126, 0)</td>
</tr>
<tr>
<td>P3 M, 25-34</td>
<td>14</td>
<td>8</td>
<td>6</td>
<td>69 (69, 0)</td>
</tr>
<tr>
<td>P4 M, 25-34</td>
<td>17</td>
<td>14</td>
<td>3</td>
<td>122 (118, 4)</td>
</tr>
<tr>
<td>P5 M, 25-34</td>
<td>17</td>
<td>11</td>
<td>6</td>
<td>164 (160, 4)</td>
</tr>
<tr>
<td>P6 M, 45-54</td>
<td>21</td>
<td>16</td>
<td>5</td>
<td>220 (214, 6)</td>
</tr>
<tr>
<td>P7 M, 25-34</td>
<td>15</td>
<td>13</td>
<td>2</td>
<td>178 (165, 13)</td>
</tr>
<tr>
<td>P8 M, 25-34</td>
<td>15</td>
<td>14</td>
<td>1</td>
<td>150 (144, 6)</td>
</tr>
<tr>
<td>P9 F, 35-44</td>
<td>14</td>
<td>10</td>
<td>4</td>
<td>118 (117, 1)</td>
</tr>
<tr>
<td>P10 F, 18-24</td>
<td>14</td>
<td>7</td>
<td>7</td>
<td>81 (80, 1)</td>
</tr>
</tbody>
</table>

Table 2. Number of days each participant used the SAL logger and number of taps: all (log and undo).

<table>
<thead>
<tr>
<th>Number of days daily goal met</th>
<th>Fruit</th>
<th>Veg</th>
<th>Grain</th>
<th>Dairy</th>
<th>Protein</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>P2</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>P3</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>P4</td>
<td>4</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>P5</td>
<td>10</td>
<td>5</td>
<td>2</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>P6</td>
<td>4</td>
<td>3</td>
<td>5</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td>P7</td>
<td>7</td>
<td>0</td>
<td>1</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td>P8</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>P9</td>
<td>7</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>P10</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>7</td>
</tr>
</tbody>
</table>

Table 3. Number of days each user met the daily goal for each food group. Green shows participant highest groups.
that they realised they did not eat enough vegetables.

Several made comments related to improving health. P4 said it could help them to eat more healthily, P6 said that it gave an accurate view of “whether you are eating too much”, and P9 stated that it helped them track their vegetable intake and made them more cautious about their food intake. Of these, only P9 had stated that diet was a current goal. Notably P4, 5 and 7 would have liked to set their own, more achievable targets. P6 would have liked a junk food category to track that.

The SUS ratings ranged from 92.5 (P2,7,8) down to 70 (P1). The mean score 84.5 which indicates high usability.

**What participants disliked about SAL**

Participants responded to the three open questions about disadvantages, how SAL compared with other tools and general comments.

A recurring requested item was the ability to log the previous day’s food intake. Five participants said they wanted to change the previous day’s data, for example, if they missed a day, they wanted to log it the next day. One wanted to log the data for the previous three days and another user wanted to have more flexibility and be able to edit all the previous logged data.

Three participants would have liked on-board tutorial information about food serves. This was a difficult learning task and they needed to be able to determine how to count various things that they ate. They wanted to be able to do that in the logger.

Some wanted the large log button to show progress on each food type, not just green on success (P5,7). They wanted the large glanceable display to show how far they need to go to reach their target.

There were several comments about this history summary bar. P1 did not really understand it. P1 and P6 suggested a way to drill down to the details and an explanation. This would follow standard interface and visualisation design principles of details on demand (Shneiderman 1996) and providing help and documentation (Nielsen 1994). P5 wanted to be able to distinguish days they had failed to log from those where they had eaten nothing. As noted above we had dropped this after our earlier auto-ethnographic study. This might need to be revisited for the case of food logging. P6 found the colour scale confusing. P9 wanted this display linked to the dates.

There were other recommendations about the details of the interface. Some wanted to be able to record half serves. Other suggestions included: adding a comment facility; graph showing trends.

P1 did not like the display always on, because of environmental concerns in excess energy use.

**Awareness and self-reflection**

We asked users if they made any plans in relation to this logging activity. Only P1, P6, P7 and P9 agreed that they had plans to achieve the recommendations, with P1 indicating they did attempt to change vegetable intake but then gave up. In addition, P5 and P10 then elaborated on efforts to eat to meet the recommendations. In all, 6 participants reported some form of planning, with the SAL logger informing that plan.

We asked how participants monitored progress and whether they observed patterns, issues or had insights in light of their use of the SAL logger. All 10 participants reported various observations, commenting on new awareness of their eating. They added reflections and interpretations. For example P1 gave up on increasing vegetable intake, P2, P6, P7, 9 and P10 commented on failing to meet the vegetable recommendations. P3 said he made an effort on protein and dairy (hitting the dairy target on 6/8 days, but never making the protein target – Table 3). P4 noted the areas he did well in and identified dairy as too low (met target on 3/14 days). P5 noted low dairy (never met target in 11 days) and grain (met target on 2/11 days). He stated that he usually ate vegetables, and he did meet the target on 5/11 days; this was the top performance observed (Table 3). P8 reported greater awareness of what they need to do to be healthier and that they “now resolved to eat healthier”. Several participants also commented on their success in meeting recommendations. P4 felt this applied to all but dairy – they actually also failed to meet the vegetable and grain target on most days. P5 mentioned eating...
enough fruit, vegetables and protein (but actually met these 10/11, 5/11 (as above) and 10/11; so this perception was mainly accurate. P7 stated that he exceeded the grain target; he actually met it only 5/16 but this was a high level compared to others.

The detailed log data shows that one person increased his Vegetables intake (P2) and one his Dairy and Grain consumption (P9). The rest seemed to have quite stable behaviours.

Overall, the picture that emerges is that all participants described various forms of increased awareness. Their perceptions were in line with the data.

DISCUSSION AND CONCLUSIONS
SAL is the first ambient light-weight logger for daily monitoring of food intake. Our study indicates that SAL was broadly successful. We now return to our hypotheses.

H1: SAL enables people to remember to log their main food groups eaten
Our log data indicates that this was partially met. Those who placed the SAL logger at home and in the offices had similar levels of logging success.

H2: People will consider that SAL helps them become more aware of how well they meet the nutrition guidelines
Every participant reported made comments that indicated such awareness and did so in terms of a question about monitoring.

H3: People will consider that SAL can help them achieve the recommended food intake
This hypothesis relies on people’s goals and SAL’s value in supporting people in achieving them. Only 4 participants agreed that they had such goals although 6 did describe specific goals. SAL aims to help people achieve goals by enabling them to monitor and reflect on their progress. All participants indicated that SAL enabled them to become more self-aware and to monitor progress. Moreover, correlating comments with the logs, these perceptions were generally quite accurate. It is somewhat curious that our star performer on vegetables, P5, stated he was eating enough even though he only met the recommendations on 5/11 days, not even half. The combined data indicates SAL was effective in increasing awareness and supporting self-monitoring and self-reflection.

H4: People will consider that SAL enabled them to reliably log their intake of the food groups
This hypothesis is only partly met. Our participants needed and wanted ways to cover missed days. We could augment SAL with a mobile and web app or add to the interface.

H5: People like the minimality
P1 explicitly stated he liked the simplicity, all but P7 volunteered comments about ease-of-use, supporting the hypothesis.

H6: People consider SAL usable
The SUS score (84.5) and many comments about ease-of-use and usefulness support this.

Overall, the current SAL interface shows the promise of a minimalist logger. Our study provides many pointers to enhance the details of the interface. It also points to core functionality we should add: to log missed days; improve the history information; support details in request for documentation about food logging; explore support for other goals that users define themselves. Future work needs to include longer field studies. We particularly want to gain more insights into the ways people situate their SAL loggers.

We designed the SAL logger of this study as an easy way to log food intake, so people could easily become aware of how well they meet recommendations and to monitor their progress towards achieving personal goals to achieve that. SAL’s minimality, ambient display and very easy logging show real promise in this important role for helping people to achieve their personal goals to improve their health.

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