How Does My Time Use Align With My Values? Personal Informatics for Connecting Abstract Values to Everyday Life

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Abstract

Can self-tracking technology be designed to help us learn how our everyday activities align with our values? Existing personal informatics systems can help track time use, but rarely explicitly connect time use with personal abstract values. We designed, built, and deployed *eValuATE*, a personal informatics system that helps individuals reconstruct their everyday activities, annotate those activities with their values, and visualize relationships between their activities and values. Fifteen participants used the system in a think-aloud study, a 2-4 week deployment, and a closing interview. The system helped participants refine their own values, understand how those values were supported through their daily activities, view their time use differently, and in many cases change their behavior to better align with their values. We discuss design considerations for self-tracking abstract values, motivate a shift towards short term *life studies* over perpetual self-tracking, and present a multi-level reflection model for personal informatics system design.

CCS Concepts

• **Human-centered computing** → **Interactive systems and tools**; **Empirical studies in HCI**; **Natural language interfaces**; **User studies**.

Keywords

Personal informatics, technology-supported reflection, value-centered design, Human–AI interaction, human values, interactive system design, voice interface, self-tracking, quantified self, smart journaling, lifelogging, design theory

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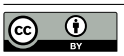
1 Introduction

Living in accordance with one's values, whatever those values may be, is a central challenge of being human. Values are abstract goals that can be defined as "guiding principles in one's life" [82], and play a foundational role in both the social sciences and in social institutions [76]. On an individual level, the way we spend our time is a primary means by which our values are enacted. However, we often struggle to "live our values," as many daily behaviors are the result of automatic or nonconscious mental processes [5, 41, 89], resulting in a *value-action gap* [12, 50]. The rise of technology with features that capture our attention (and therefore our time use) makes this challenge even more salient—and difficult. Dark patterns such as infinite scroll combined with adaptive recommender systems can lead individuals to spend more time than intended or desired on their screens [27]. The average adult (16+) spends over six and a half hours a day using the internet [46], over half of teenagers spend over four hours on a screen every day [95], and many users report habitual phone use (such as social media) to be unfulfilling and not meaningful [56].

Existing research on personal informatics (PI) and technology-supported reflection has explored the ways in which technology can help individuals purposefully gather data about their lives and foster meaningful reflection. While PI systems have been developed to monitor screen time and general time use, these systems do not provide explicit scaffolding for connecting values to time use. In addition, there are very few PI systems that explicitly support reflecting on abstract values generally. Given the significant effect that time use has on our well-being [93], there remains a significant gap in our understanding of personal informatics system design: **how can technology support meaningful reflection on the alignment of time use and values?**

In this research, we designed, built, deployed, and evaluated *eValuATE*, a personal informatics system designed to support reflection on the alignment between time use and values. The system supports "high-level" reflection on abstract values by allowing individuals to construct custom sets of personal values, with an option to use values from major world religions and psychological theories. The system then prompts for "low-level" reflection on concrete activities using the Day Reconstruction Method [43] using an optional AI-voice interface, and prompts the participant to annotate each activity of their day with the values supported (or hindered) by the activity. Participants can interact with a network visualization of their time use and values to gain insight into connections across their value system.

Fifteen participants completed an opening think-aloud session, a 2–4 week *in situ* deployment, and a closing interview and survey. Altogether, participants annotated over 1,200 activities with over 4,100 value annotations, representing roughly 1,600 hours of time



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use. Participants reported both refining their values through the annotation process and learning how the activities of their daily life supports (and/or hinders) their values. All participants reported learning something new about themselves, and over half reported changing their behavior as a result of participation in the study.

The PI system that we developed and describe here serves as a research artifact showcasing how technology can scaffold reflection on the alignment between values and time use. Our findings motivate design recommendations for personal informatics systems that seek to support self-tracking and reflection in abstract domains such as personal values. We generalize the reflection strategy implemented in the system into a **multi-level reflection model *for* personal informatics**: by prompting for reflection on "high-level" abstract values and "low-level" concrete durations of time use (activities), and connecting the two with reflective prompts and visualizations, individuals can identify alignment across scales of the self. Our findings also suggest shifting from designing a pervasive, persistent PI system to designing for short-term "life studies" that may be repeated at some frequency. Overall, the contributions of this study include:

- *eValuATE*, a flexible PI system (design artifact) that supports multi-scale reflection by collecting and visualizing data about time use and values in the specific context of the activities of everyday life;
- Design considerations for personal informatics systems that support reflection on abstract values;
- A multi-level reflection model for personal informatics systems that motivates connecting general, abstract domains (such as values) to specific, concrete domains (such as time use); and
- Qualitative evidence that annotating time use data with abstract values can lead to positive outcomes such as improved self-perception, refinement of personally-held values, increased desire to live aligned with one's values, and even value-aligned behavior change

2 Background and Related Work

Our work is situated at the intersection of the psychology of human values, time use, and technology-supported reflection in personal informatics systems. In this section, we provide a brief overview of human values and previous personal informatics work for reflecting on time and human values.

2.1 Human Values and HCI

Values are "abstract, desirable goals" [75] or "guiding principles in one's life" [82] that shape behavior in various situations, either consciously or unconsciously. Values are associated with cognition (thoughts about the goodness of a behavior or outcome with respect to a particular value), affect (being able to "feel" how well a behavior or outcome is aligned with a value), and behavior (values can lead to action) [76]. The complex relationships between an individual's values are known as their "value system," which suggests that there is a hierarchy (or ranking) of values held by an individual that serves as guiding evaluative criteria when the individual is put in a situation where values may be in conflict (for example, *success* vs. *honesty* when deciding to cheat on a test) [76].

The importance of values has led to the growth in HCI of value-sensitive design, which seeks to incorporate human values throughout the design process of software systems, for example, by designing notifications to facilitate consent of a user for enabling cookies on websites [31]. A value-sensitive design process might incorporate surveys to elicit the relationships between stakeholder values and the specific design features of a technology [63]. While value-sensitive design is a general design orientation that can be used for a variety of different kinds of technologies, it is focused more on considering values in the *design* of technology. In this work, we are most interested in designing personal informatics technologies that explicitly help individuals reflect on their values in everyday life. Rather than seeing value elicitation as a *means* to improve a particular design, the reflection on values is itself the *end*. The intended system is designed *for* values, both for eliciting values and for understanding how values are expressed in everyday life.

HCI researchers are increasingly interested in designing for eudaimonic (as opposed to hedonic) well-being and living a "life well lived." Several value elicitation studies have been conducted in the context of patients managing multiple chronic conditions [8, 9, 55] as understanding and communicating values with care providers leads to better patient-aligned outcomes. Personalized paper prototypes helped participants externalize their values, leading to productive conversations with facilitators and personal insights [8]. Lim et al. conducted a study asking participants to elicit their high-level values, and then used a physical card activity to help participants discover connections between values and specific self-care activities [55]. This activity led participants to better understand their own values (which they may not have known before), showing the importance of reflection in value elicitation.

Pommeranz et al. had participants capture and label participant-taken photos with custom value-tags [71]. The same research also presented a mobile application designed for reflecting on situations in everyday life with value-tags [70, 71]. Another related work is *Reflections*, an online system that prompts participants to select work-related values from different scenarios [39]. While these studies exist from outside the domain of personal informatics, they represent a movement in HCI to explicitly consider an individual's values within technology-supported reflection [52]. In addition, the exploration of personal informatics to help individuals reflect on the alignment of their time use and their (own) values aligns with a grand challenge call to better understand the lived experience of values [30].

2.2 Measuring and Reflecting on Values

Values are stored as cognitive structures that can be retrieved from memory [84], indicating that self-report of individually held values is possible. Values, and how they are enacted, are relatively stable [76], but can change through various mechanisms [4]. Benevolence value-related behavior (such as volunteering to help others) increased for participants who completed a self-reflective narrative-writing intervention [2]. *The findings suggest a role for technology in supporting human values: prompting reflection on values that the individual holds to be important.* This insight led to our overall design intention for the system: **to scaffold reflection by prompting**

individuals to recall how they express their values in their everyday life.

Psychological scales, such as the Rokeach Values Survey [77] and the Schwartz Values Survey [81], were developed with an intention of providing a standard way of measuring an individual's values in a general sense. However, individuals often have difficulty espousing and eliciting the importance of abstract values [75]. People tend to think that values, in general, are "good," and will rate many values as desirable [75]. Rather than attempting to have the user conduct high-level, abstract reflection on values, Lee and Law reason that technology should establish a specific *context* in which the reflection on values should take place [52], and prior HCI studies resulted in participants refining their values by connecting them to specific contexts and care activities [55, 71]. Abstract values are difficult to reason about, and providing a specific context helps to scaffold reflection.

The mechanisms of how mental representations of abstract goals (values) are cognitively translated into behavior is not well understood. However, experimental studies have shown that *priming* specific values can lead to value-aligned behavior [92]. Value priming occurs in various everyday situations, such as through advertising and marketing, and serves to "remind" an individual of their values in specific contexts, therefore increasing the chances the individual will act in ways aligned with that value [75]. Priming is most effective when the values are central to the individual's self-concept (i.e., the values primed are really important to the individual being primed) [92]. In this work, we draw on McConnell's Multiple Self-Aspects Framework (MSF) in order to help operationalize self-concept [61]. The MSF proposes a network structure of the self, composed of individual but interconnected context-dependent *self-aspects*. Self-aspects can be values themselves, identities, or relationships, and can generally be elicited by participants (perhaps more easily than values) [61]. These findings suggest two design goals to support reflection on the alignment of one's time use and values:

Design Goal DG1 Support elicitation of values that are central to the individual's self-concept.

Design Goal DG2 Support reflecting on high level values in the *specific context* of activities of everyday life.

2.3 Technology-Supported Reflection on Time Use

Apart from commercial applications like Toggl[1], various personal informatics systems have been designed by researchers to help individuals gather data about their time use [48, 94]. *TimeAware* is focused on helping individuals track their use of time on a computer, and resulted in participants having improved productivity [48]. *MeTime* also helps people track their computer use, and led to participants having a reduced perception of capacity to stay focused, regardless of whether or not an automated or manual tracking method was employed [94]. Both systems indicate the effectiveness of highlighting time spent unwisely as an impetus for behavior change (from the perspective of the participant). However, they are limited in scope, and only support tracking time spent on a computer.

[1]https://toggl.com/

ExtraSensory is an app that facilitates manual collection of time use data using two methods: an experience-sampling method (ESM) [35] and a retrospective Day Reconstruction Method (DRM) [43]. The DRM asks participants to recall the specific episodes of their day (in one sitting, at the end of the day), and annotate each episode with particular variables of interest (such as mood). Participants preferred the DRM over the ESM as it did not interrupt their day [90]. *Activity River* is a proof-of-concept system for planning, logging, and visualizing time use. In a role-playing situation, participants found the visualizations helpful for reflection [3]. The *MyMove* system utilized a smart watch and voice interface for collecting activity data (activity, duration, and perceived effort) from elderly persons *in situ* with an ESM method [47]. *PEARL* is a calendar-based technology probe that supports users tagging events with "concepts" to support well-being goals [42]. Sefidgar et al. created a time-tracking system focused on supporting customizable behavior change goals in work / non-work time allocations, gathering activity data via the ESM with an option for participants to backfill time records (similar to the DRM) [86]. The system also supports annotating activities with location data, which supported participants in identifying alternative behaviors [86]. While all these systems support tracking all time in a day, they do not support annotation of, or reflection on, explicit abstract values in the context of the tracked activities.

Drawing from this existing literature, we can see the importance of visualizing time use for reflection, and a user preference for using less intrusive or burdensome tracking (such as retrospective recall methods like the DRM instead of experience sampling [37]) for personal data gathering. Recent HCI work has explored Technology-Assisted Reconstruction as a way to support less burdensome tracking via the DRM [36, 45], which was reportedly helpful to participants. These findings lead to our next two design goals:

Design Goal DG3 Provide a visual interface for reflecting on activities, values, and other context-specific variables (such as location or people co-present).

Design Goal DG4 Reduce the cognitive burden of self-tracking time use

3 System Design

In this section, we discuss the design of **eValuATE**: **E**lectronic **VALU**e **A**nnotation-based **T**ime-use **E**valuation, a personal informatics system that helps individuals reflect on their values and time use. We focus our discussion on how the design supports the design goals, derived in the previous section.

3.1 Design Goals

To scaffold reflection on values and time use, our design sought to meet the following goals (derived from the related work and background, above):

- **DG1** Support elicitation of values that are central to the individual's self-concept.
- **DG2** Support reflection on abstract personal values in a specific context (daily activities/time use).
- **DG3** Provide an interface for reflecting on activities, values, and other variables (such as location or people co-present).
- **DG4** Reduce the cognitive burden of self-tracking time use.

3.2 Scaffolding Reflection with a Customizable Library of Values

To meet **DG1**, we designed features to support high-level reflection on custom and pre-defined sets of values. While Schwartz suggests 10 universal values (self-direction, stimulation, hedonism, achievement, power, security, conformity, tradition, benevolence, and universalism) that are present in multiple cultures [83], there is no standard taxonomy of values held by all individuals in all places at all times. Drawing on previous flexible PI systems, such as *Omnitrack* [49], we sought a flexible system that allowed participants to customize the values they tracked, and create multiple sets of values ("value sets") to track as a group.

Given the challenge of reflecting and deliberating on general, abstract values, we pre-populated the system with a *library of values*, a series of sets of values drawn from secular psychological theories and major world religions. The various taxonomies of values in the library were intended to provide exemplars that provoke participants to consider values from different perspectives, similar to prompting participants to think about values in different aspects of life such as emotions or relationships [55]. As Schwartz's set of 10 values is in part derived based on biological and social needs [82], we include various theories of need such as Maslow's [57] and Max-Neef's [58, 59]. Table 1 shows the list of all value sets pre-defined in the system, along with their origin (see Appendix A for a complete list of values included in each pre-populated value set). Participants had the freedom to modify (or delete) any of these value sets and use them as they wished when annotating their activities. Participants could also create any number of their own custom value sets. Each value had a corresponding description that populated a tooltip available when annotating activities with that value.

Participants can "activate" any number of these value sets to enable annotation of activities with values from those value sets. Figure 1 shows the interface where participants can click to expand the value sets and toggle a value set's activation by clicking on the red or green indicator.

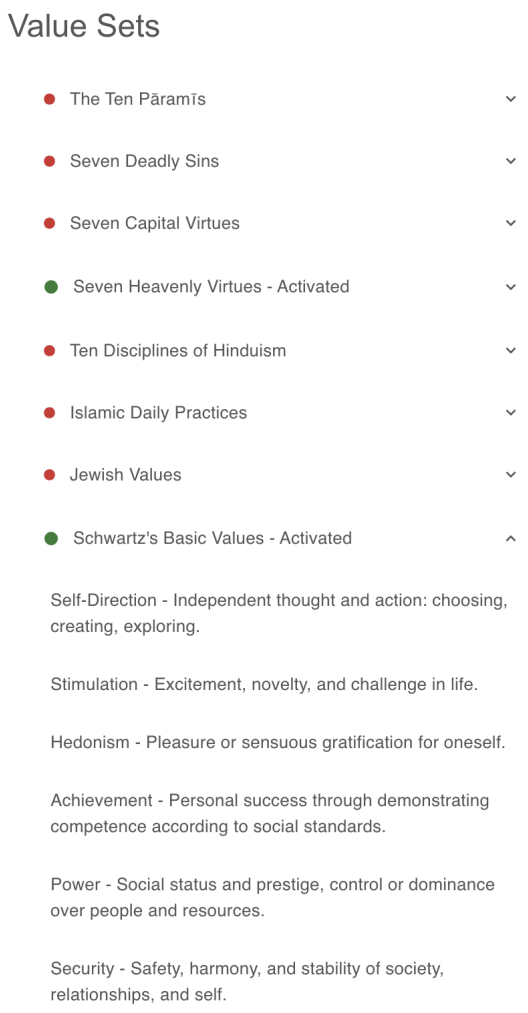

Figure 1: A value set library containing both pre-built value sets from various world religions and psychological theories, as well as custom value sets created by participants. Participants can view the values and "activate" a particular value set in order to enable annotation of activities with the values in the value set.

3.3 AI-assisted Narrative-Based Self-Tracking of Time Use

To support **DG2** and **DG4**, we built a calendar interface for gathering time use data, similar to Google Calendar or Microsoft Outlook (see Figure 2). A calendar interface was chosen to utilize pre-existing mental models about time use [68], and calendar interfaces have been previously used to implement digital versions of the Day Reconstruction Method [36, 64]. The system supports a hybrid form of interaction with the calendar: manual clicking and dragging on the calendar to create and modify events, or using an AI-augmented voice interface to record information about their day, which is then parsed into calendar events automatically.

Manual interaction is similar to popular calendar interfaces. When participants click on a time on the calendar, an event is created. Participants can also click and drag to specify an initial start and stop time on the calendar. Existing events can be dragged to a new location. Clicking on an event displays a modal pop-up window for annotating the event with values and additional contextual information including event category, location, and people co-present. This contextual information is collected in order to provide more variables for visualization and identifying patterns and relationships to values. The category variable helps support aggregation of activity data via meaningful generalizations of activities, and produces a less cluttered visualization compared to visualizing all unique activity names. Location was tracked as simply being in a specific location can prime or activate certain values [73], and resulted in participants identifying behavior opportunities in prior work [86]. Other people co-present was tracked given the nature of social roles in activating and motivating value-aligned behavior [61, 83].

To reduce the cognitive burden of tracking, participants can optionally use an AI-augmented voice tool to create events and some

Value Set Name	Origin	Source
The Ten Pāramīs	Buddhism	Vipassana Research Institute [40]
Seven Deadly Sins	Christianity	Seven Deadly Sins website [87]
Seven Capital Virtues	Christianity	The Summa Theologica [1], Catechism of the Catholic Church [17], some wording from Couche [20]
Seven Heavenly Virtues	Catholicism	Catechism of the Catholic Church [17]
Ten Disciplines of Hinduism	Hinduism	Scholarly Community Encyclopedia [34] and Learn Religions [21], verified with an individual familiar with Hindu ethical traditions
Islamic Daily Practices	Islam	Personal communication with an individual familiar with Islamic daily practices
Jewish Values	Judaism	Rosenfeld Community of Practice [29], personal communication with an individual familiar with Jewish ethical traditions
Schwartz's Basic Values	Psychological Theory	Schwartz's theory of values [83]
Basic Psychological Needs	Psychological Theory	Self-Determination Theory [78, 91]
Maslow's Hierarchy of Needs	Psychological Theory	Maslow's theory of motivation [57]
Max-Neef's Fundamental Needs	Psychological Theory	Human Scale Development Publications [58, 59]
The Five Love Languages	Other	Gary Chapman's theory [14], some wording from Ebgert and Polk [23]

Table 1: The sets of values pre-built in the values library of the system, including their origin and specific sources used for the values and descriptions

Figure 2: The calendar interface is similar to existing calendar systems, but includes hybrid interaction with both manual interaction capabilities, as well as an AI-augmented voice-interface for recording and parsing voice commands and spoken narratives about time use.

annotations, as a form of technology-assisted reconstruction [45]. Participants can click "Start Recording" to activate the microphone (powered by the Web Speech API), and then can speak a narrative about their day, or provide any other command to the calendar, requesting additions, modifications, or deletions to events on the calendar (see Figure 3). When done speaking, users click "Stop Recording," and the transcript of their speech is combined with a system prompt and a string representation of the current events on the calendar. This is then sent to the OpenAI API (paid tier)[2], which returns a string containing the modified set of events, one event per line (requests sent to the paid API are not used for model training). To further preserve participant privacy, no additional information about the user is included in the API requests. The prompts used to call the LLM can be seen in Appendix B.

The system parses the string into events and creates the new set of events on the calendar. After the event state has been modified by the AI, an "Undo" button becomes enabled, allowing users to undo the most recent action made by the AI. The system has both a standard AI and an enhanced AI. The standard AI makes changes, additions, and deletions to event titles, start times, and stop times. The enhanced AI infers the category, location, and people co-present for all new events. To prevent the system from overwriting annotations made by the participants, the system does not try to infer annotations for existing events. Participants can turn both standard and enhanced AI on and off in the settings of the system.

3.4 Annotating Specific Activities with Abstract Values

To further support **DG2**, the annotation modal (see Figure 4) allows participants to record an event category, location, and a list of tags

[2]https://openai.com/api/

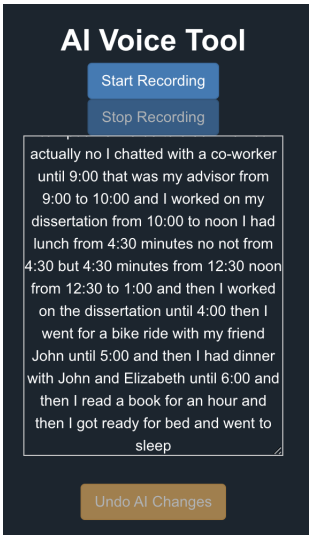

Figure 3: The AI voice tool allows participants to issue voice commands to the system, which can be short commands, or long narratives about their day. The system provides a live transcription of their narrative, which is then processed by an LLM when they are done recording. The system then modifies the events on the calendar based on the processed voice commands

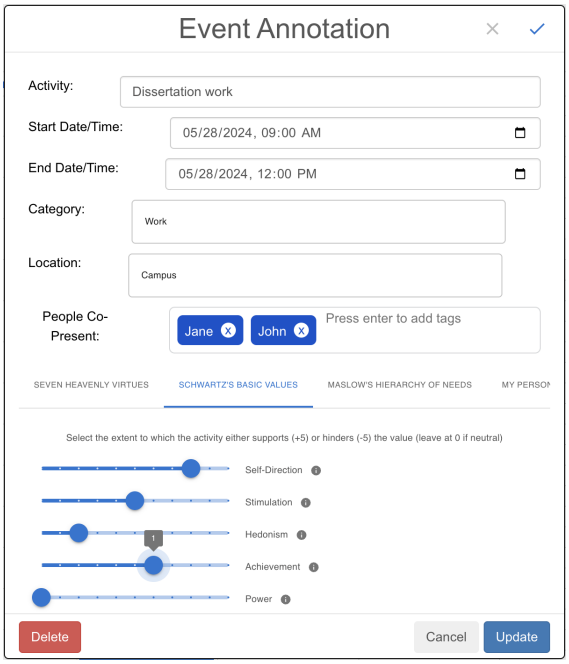

Figure 4: By clicking on an event, participants can modify the title and durations, and provide annotations about the event. Participants can annotate events with a category, location and list of people co-present. In addition, participants can assign value ratings.

that represent other people co-present during the activity. The location and category fields include an auto-complete feature that will auto-populate options based on the set of previous responses in these fields.

Below the basic annotation data is a multi-tab interface where participants can select a value set, and apply value annotations to the event (see Figure 4). The value annotation is implemented via an 11-point end-labeled Likert-style slider ranging from -5 to +5. The instructions are "Select the extent to which the activity either supports (+5) or hinders (-5) the value (leave at 0 if neutral)." Using 11 response options may improve the psychometric properties of the scale (after [88]) and was intended to lower the barrier of assigning values to events by avoiding "all or nothing" assignment. For a single activity, participants can annotate as many (or as few) value ratings as they wish.

3.5 Interactive Network Visualization to Explore Time Use and Values

To support **DG3**, the system includes a *Reflection* tab where participants can view a dynamic network visualization of their time use data and corresponding annotations. Drawing on the complex-system perspective of values and self-aspects, and prior HCI work using a network to visualize values [79], the visualization utilizes a bipartite network to show connections between various attributes about events, such as event title, category, location, people co-present, and annotated values (grouped by value set). The interface for the visualization is shown in Figure 5.

Participants can brush over particular nodes in the visualization, which drills down and filters the opposing side of the network (see Figure 6). Participants can adjust the date range and select the attribute to visualize on either side of the network. Participants can also choose to show and hide untracked time, as well as ignore negative value annotations. This dynamic visualization enables participants to explore connections across sets of values, locations, people, events, and event categories. For a short discussion of the challenges of visualizing many-to-many event duration data, and more specifics as to how the present visualization was implemented see Appendix C.

3.6 System Implementation and Telemetry

The system was implemented in React[3], with a pre-compiled front-end hosted on Google Firebase[4]. The system has a serverless back-end consisting of AWS Cognito[5], DynamoDB[6], and Lambda[7]. Telemetry data was collected about how long participants spent on each page, as well as modification histories for each event created or modified. The system allows downloading event and value set data in a machine-readable JSON format.

4 Evaluation

To understand how participants reflect on their values and time use while using the system, we conducted a three-stage evaluation

[3]https://react.dev/
[4]https://firebase.google.com/
[5]https://aws.amazon.com/pm/cognito/
[6]https://aws.amazon.com/dynamodb/
[7]https://aws.amazon.com/pm/lambda/

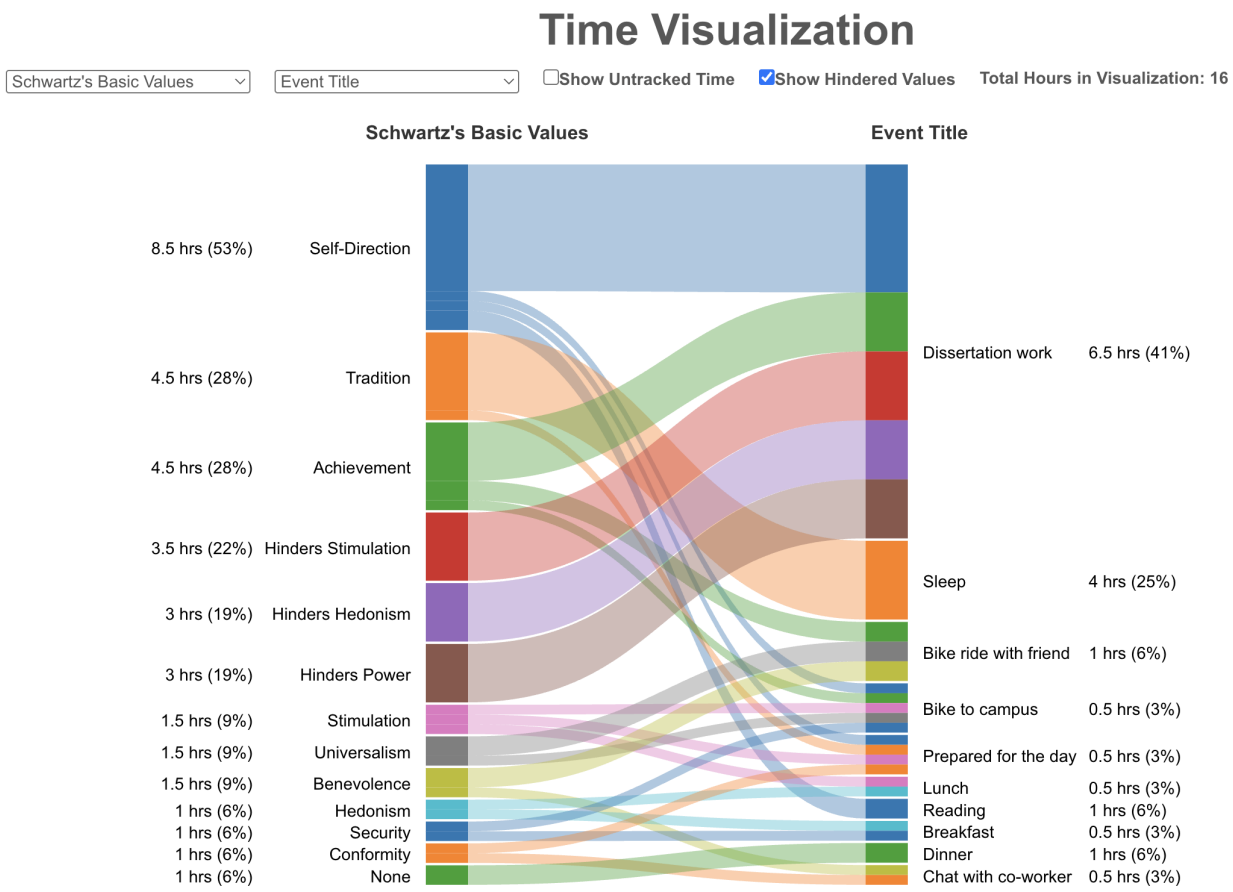

Figure 5: A screenshot of the interactive network visualization interface. Participants can adjust the date range, left attribute, and right attribute, show and hide untracked time, and show and hide data about hindered values.

study that included an opening think-aloud study, a 2–4 week *in situ* deployment, and a closing interview and survey.

4.1 Participants

A convenience sample of 15 participants was recruited through word-of-mouth, email and direct messaging contacts, snowball sampling, posting on various Slack and Discord channels, and by contacting previous study participants. The demographics of the participants are shown (in aggregate to better protect participant privacy) in Table 2.

The majority of participants were 25–34 years old, without children, and well educated. All participants had obtained a bachelor's degree, and over half had earned additional graduate-level credentials. There was a diversity of different religions represented. Most participants had self-tracked in the past, and all but one had previously used some kind of calendar system to manage their time.

4.2 Procedure

Participants completed an introductory demographic and background survey before the first session. The survey included the Satisfaction with Life Scale (SWLS) [22] and the Self-Reflection and Insight Scale (SRIS), a two-part instrument that seeks to capture a construct of self-reflection (SRIS-SR) and awareness of internal state (SRIS-IN) [32]. The SRIS instrument was included to understand participants' inclinations towards reflection and their current perceived levels of self-understanding.

The first session lasted for one hour and included a demo of the system capabilities, a brief explanation of values and self-aspects, and then the participant used the system while thinking aloud [53]. The participants were asked to construct their own custom set(s) of values, reconstruct their day [43] on the calendar using either manual, AI voice interaction, or hybrid interaction, and annotate the events of their day with their previously-selected values. Lastly, participants were prompted to explore the dynamic network visualization of their time use and values.

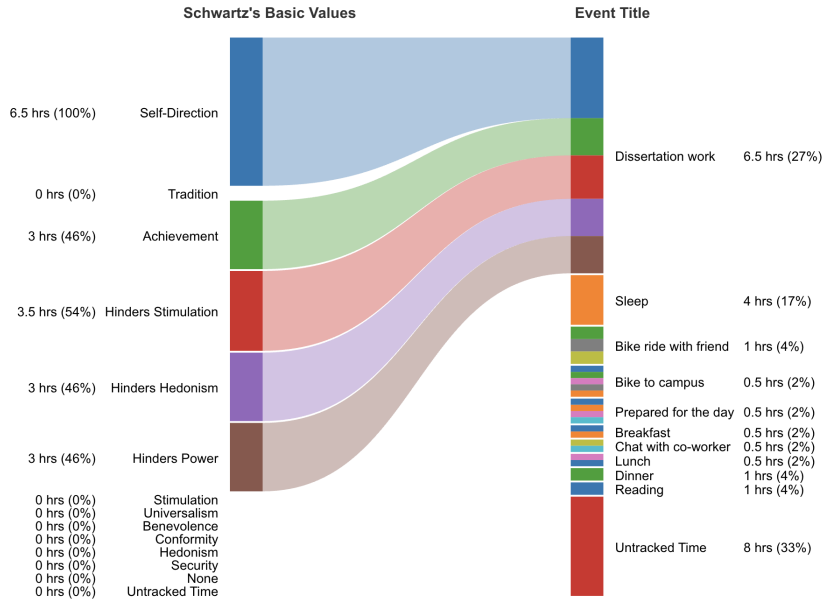

Figure 6: A screenshot of the network visualization showing the drill-down feature where participants can hover their cursor over part of the network, which then filters the data to only show connected activities. The visualization updates the labels automatically to provide percentages at the drilled-down level.

During the *in situ* deployment, participants used the system freely for a period of 2–4 weeks, until attending the closing interview. Participants could add, modify, delete, and activate values and value sets as they wished, gather data using both manual and voice interfaces, and interact with the visualization. Participants were compensated for up to seven days of system usage, defined as any day on which at least 6 hours of activities were recorded on the calendar. There was no other stipulation about system usage, with an intention of understanding how (and how much) participants wanted to use the system on their own, *in situ*.

The closing session included a think-aloud study as participants reconstructed and annotated the events of the day while thinking aloud their thoughts [53]. Participants then participated in a semi-structured interview which included questions about each design feature. The study concluded with a final survey which included the Satisfaction with Life Scale (SWLS) [22], System Usability Scale (SUS) [11], the Technology Supported Reflection Inventory (TSRI) [7], and free-response questions for sharing feedback about the design and/or functionality of the system. An overview of the study can be seen in Figure 7.

Both the initial and final sessions took place over Zoom, and were recorded (with participant consent) and transcribed. Transcripts were initially open-coded (in MaxQDA) by the first author with review from the last author. The first author grouped codes into themes using inductive thematic analysis [19] focused around each of the design goals. We denote participant quotes from opening interviews with a "-O" (such as P10-O) and quotes from the closing interviews with a "-C" (such as P10-C). Participants could earn up to a $51 Amazon giftcard for completing all components of the study: $15 for the opening session and survey, $15 for the closing session and survey, and $3 per day for up to seven days of using the system during the *in situ* deployment, defined as any day on which participants recorded at least 6 hours worth of activity on the calendar.

The study was approved by the University of Colorado Boulder's institutional review board (IRB protocol 24-0166).

4.3 Results

4.3.1 System Usage. Fifteen participants used the system over a period of 2 to 4 weeks, with an average study duration of 26 days. During the study, participants collectively recorded over 1,600 hours (roughly 67 days) of activity data, an average of 108 hours (4.5 full 24-hour days) per participant. The minimum number of recorded hours was 28, and the maximum was 253. Participants tracked data for, on average, 8.5 days during the study, with the minimum being 2 days, and the max being 24 days. A total of 1,254 activities were recorded, an average of 84 activities per participant.

Figure 8 shows a scatterplot of the number of days of recorded data by the average number of hours of recorded data per day. The majority of participants (9) used the system beyond what was required to earn the maximum compensation. Four out of the fifteen participants did not complete all activities required to receive full compensation.

One reason mentioned by participants as to why they did not use the system more (or as much as was requested) was the fact that it was sometimes uncomfortable to see how they spent their time. P10-C said, "I think there is something that is quite powerful about this kind of thing, in that, it does really force you to... confront the

Participant Demographics (N = 15)	
Age	1 (18–24 years old) 12 (25–34 years old) 1 (35–44 years old) 1 (65–74 years old)
Religion	3 Protestant 2 Roman Catholic 2 atheist 2 something else 2 nothing in particular 1 Muslim 1 Jewish 1 agnostic 1 prefer not to say
Gender	8 male (incl. trans m) 7 female (incl. trans f)
Race	10 White 3 Asian 1 Black or African American 1 other
Parent Status	14 do not have children 1 have children
Employment	6 for-profit organization 4 student 2 non-profit or government 1 self-employed 1 unemployed 1 retired
Education	6 bachelors degree 5 masters degree 4 doctorate or professional degree
Location (US state)	8 Colorado 2 California 2 New York 1 Georgia 1 Arizona
Self-Tracking History	12 previously self-tracked data 3 not previously self-tracked data
Previous Use of Calendar System (Sums to greater than 15 due to participants using multiple tools)	13 Google Calendar 2 Apple Calendar 1 Microsoft Outlook 1 Samsung Calendar 1 Physical Calendar 1 Fitness Application 1 None

Table 2: Participant demographics (presented in aggregate to preserve identity).

way that you're spending your time in a, like, sort of unavoidable way. And I think that that also made me avoid it."

4.4 User Experience and Subjective Feedback

In the following sections, all emphasis in quotes was added by the authors to improve readability.

4.4.1 Evaluating DG1 ("Supporting Reflection on High-Level Values"): A Library of Values Scaffolds High-Level Reflection. To gather evidence for the success of meeting DG1, we asked questions in the opening and closing sessions about participants' experience reflecting on their values. Participants generally thought that having the value set library was useful for getting ideas about values they could

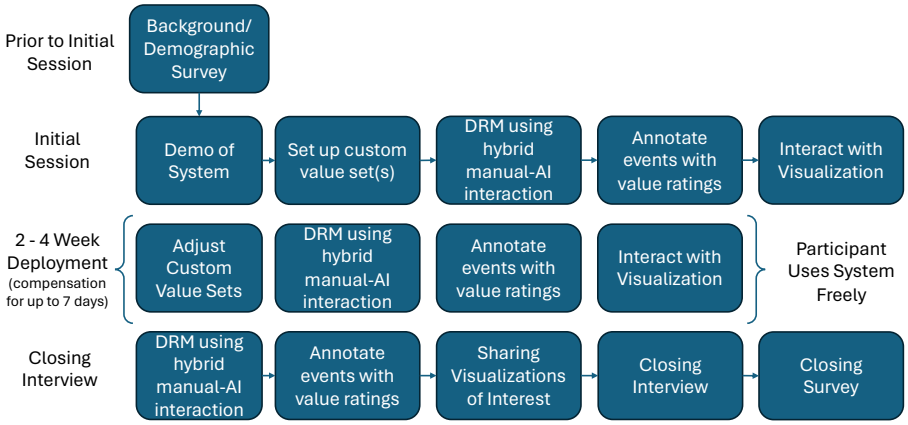

Figure 7: The overall flow of the study. After taking an intro survey, participants viewed a demo of the system's capabilities, and then participated in a think-aloud study while constructing a custom set of values, reconstructing their day with the DRM, and annotating their activities with the custom values (or other values of their choosing). Participants then used the system freely for 2-4 weeks (compensated for up to 7 days) before participating in a closing interview. The closing interview consisted of the DRM and annotating their activities, sharing visualizations of interest, a closing interview, and a closing survey.

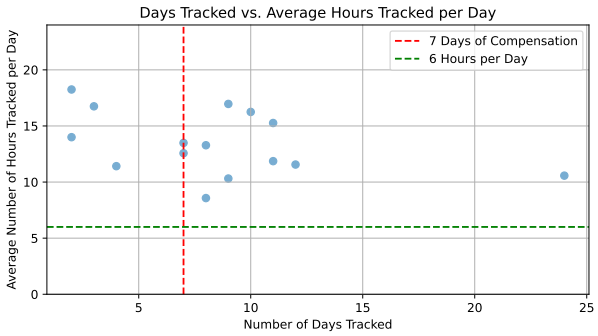

Figure 8: A scatterplot showing the number of days data was collected for by the average number of hours tracked across those days, by participant. The red vertical line indicates the 7 days for which compensation was provided, while the horizontal line indicates the minimum number of hours of tracking required to earn compensation for any given day (6 hours).

use. Three participants only used predefined value sets for annotation during the study, while seven only used their own custom sets, and five did a combination of both. Participants generally named their custom value sets generically, such as "My Values" or "Priorities." Examples of custom values (drawn from multiple participants) include *mindfulness*, *love*, *self-awareness*, *nutrition*, *determination*, etc. P6 started creating their custom value set by copying two values from a predefined value set (*Autonomy* from Basic Psychological Needs Theory [78] and *Freedom* from Max-Neef's Needs [58]), and then added 10 custom values, saying, "they [*autonomy* and *freedom*] sounded good, but then the rest were things that I actually think about when I go throughout my day" (P6-O). P10 chose to use three value sets: Seven Heavenly Virtues, Seven Deadly Sins, and Max-Neef's Fundamental Needs. P10-C said the virtues and sins were "moral things" while Max-Neef's needs were "amoral, but they are, like, important things that you need to do... They feel like this sort of soil, or something, that these guys [virtues/sins] live in."

The system helped P3-C to clarify their values, as they said "the experience itself is something that was like, really useful for me, and like, kind of made me start to realize over time like, **oh, what do I actually value?** Like, how do I actually want to try to, like, live into these values?... **that initial identification of...what values are important to me when it comes to my everyday living, that was probably the biggest takeaway**." P9-C said that the values in the library helped to provide a new common language with which to think about their activities, saying, "it was like a nice motivator to do a lot of the things that I felt like I should do but like, maybe didn't have like the words in the forefront of my head to like, describe." When coming up with custom values, P11-O explained it was a unique experience, "**it's sort of...a thing I don't talk about with other people**, like what's important. Yeah, it helped me reflect a bit on what is important to me. I think a lot of these thoughts [values] are kind of implied every time I choose what I'm doing next."

Some participants had a clear sense of values that were important to them, and it was easier for them to elicit a set of custom values to reflect on. For example, P1-O said, "I already kind of knew what I wanted to put down there, because these three things [values] are things that I've been trying to focus on lately." Others had a much harder time, for example, P6 said, "**I don't know what my values are!**" and, later, "it's kind of putting me in existential crisis mode… **I saw those value sets that people are living their lives by**, and then… I wasn't really sure if any of those even apply to my daily life, if I'm living by any of those values. And then my values

are like, what kind of values are these? They're all about me [as opposed to others]" (P6-O).

4.4.2 Evaluating DG2 ("Support reflection on abstract values in a specific context"): Annotating Activities with Values Led to Insights. Thirteen participants expressed learning about themselves, their values, and/or their time use simply from the process of annotating activities with their values. P3-C clearly described how the act of annotating the values on an activity could help motivate living in alignment with their values: "If I noticed that like, there was something every day that I was logging that I had to drag one of those, like, values to the negative on, I think that would really make me pause, and [think] if I wanted to continue doing that." P6-O, after annotating a day's worth of activities, said, "there's something missing in my life because it feels like a lot of those things that you had on your list [predefined value set library]... I'm not hitting any of them. I have no transcendence or anything like that." P1-C found the system helped them "[use] **my values as a kind of tool to interpret the day**... I could look at it [the day]... from an interpretation of productivity, and that would make me feel really bad. But if I look at it from, like, **the interpretation of... what values is this supporting? It feels a bit better**." P10-O noted that it was "kind of interesting trying to think about why you do everything... I don't think I normally think about things like this."

Some participants learned specific things about how they spend their time or learned something about specific activities. P4-O said the system was a helpful reflective tool, adding, "I also notice that I do spend most of my day sitting down... which is something I don't think about often, but maybe I should." Three participants discovered new insights into how their values were in conflict during certain activities. P15-C realized that work activities tended to hinder most values, saying "**I realized that there are conflicts between like what makes me happy and what brings me achievement**."

Figure 9 shows a plot of the changes that participants made to their value sets over the course of the study. The majority of participants did not make any changes after the first day of the study, while six did. One reason for not changing values was a sense of inertia, described by P9-C as, "It was really just like, I started with this, and so I'm going to continue going with it."

One motivation for changing sets of values was the burden of tracking a large number of values. P8 started with a custom value set that was 34 values long. P8-C said, "the strategy I chose was not remotely scalable. I chose to add a ton of priorities... such that it [self-tracking and reflecting] took me about 30 minutes... every single day, which made it impossible to comply with." P12-C reported a similar experience, saying "having all of those [values and value sets activated] was too many to think about... so I just narrowed it down to the ones that I felt like were more on my heart."

While annotating activities with values, seven participants discovered high-level values they had missed during their initial value elicitation. For example, when annotating a "walk" activity, P3-O said, "it was really a wonderful walk... **maybe this is one of the categories I'm missing**... just, like, **happiness**." Another reason for modifying values was a change in what one noticed or wanted to track and record over the course of the study. P9-C ended up modifying their value set by adding two additional values, saying,

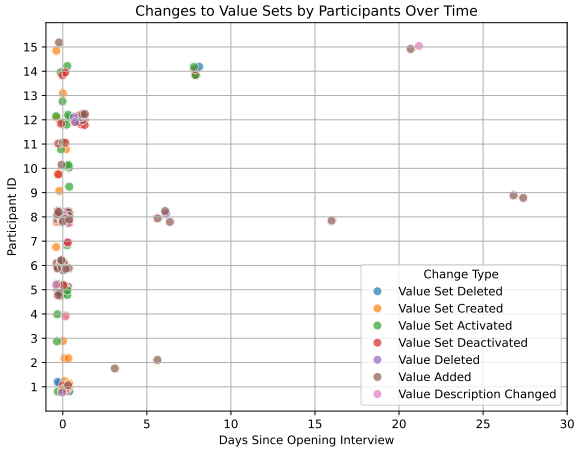

Figure 9: A plot showing the changes made to value sets by each participant as the study went on. Points are color coded by the kind of change that was made. Most activity occurred on Day 1 when participants first created and customized their value sets.

"the ones [values] I started off with were like... how do I fit into the world? And the other [new values]... shifted towards, like, **what are aspects of how I interact with the world that feel really valuable**?"

4.4.3 Evaluating DG3 ("Provide a visual interface for reflecting on activities, values, and other context-specific variables"): Data Visualization Aggregates Connections Between Abstract Values and Activities. Overall, participants liked the interactive visualization. P3-O said, "Oh this is really cool. Oh, this is sweet!"

A common use of the visualization was to identify activities that hinder values. P2-O said "**I also wanna see if there's time that is not contributing to my values**, or... maybe even hindering it... like too much Instagram or something." In contrast, P3-O suggested that the visualization might help them realize positive aspects of activities previously thought of as negative, saying, "**Maybe, like, something that I think is really bad for me is actually, like, good**, in some of these other ways [values], and I need to just like stop beating myself up over it." P8 had a similar experience during the study. In the opening interview they said they "put leisure in there [a custom value set] because I would like to track how much time I spend on that" (P8-O). At the closing interview, after tracking for a few weeks, they said, "**I think my level of self-hatred for lazing around on the couch went down**... because **I realized how little leisure I had in my life** and how I deserved that and need it" (P8-C).

The visualization helped some participants feel good about the ways they were using their time. For example, P12-C said, "it's quite effective... [for **discovering] what things, like, bring me more joy**." For P13-C, the visualization helped them to see "the local impact and the impact I can have in my immediate world, like, **stuff that transcends money and, like, status was helpful**. It... **made**

me feel better about my life." P6-O said about the visualization, "**It makes me want to incorporate my values into more of the things I do**. I'm like, 'Oh, **maybe I can incorporate peace into everything I do**.' "

Eight participants reported learning about their relationships by visualizing values and people co-present during activities. For example, P9-C learned about how "being in these meetings with, like, this person [a co-worker] is just, like, an exercise in patience." P1-C said, "I definitely see why [co-worker name] is co-occurring with humility. He's a better coder than me. And I'm always messing up in front of him."

4.4.4 Evaluating DG4 ("Reduce the Burden of Self-Tracking"): AI Can Help Shift Effort from Self-Tracking to Reflection. The AI voice interface was used a total of 62 times across all participants, resulting in 376 changes. Participants utilized the AI voice interface to varying degrees. Some participants were quite impressed with this system capability, saying things such as "Oh, my gosh, this is so good! ... Wow, this is like perfect" (P1-O). P4-O said, "I'm gonna use that [the voice interface], because that one is fun." P15-C said, "AI voice recording is definitely more efficient than manually recording if I had a lot of activities going on in a day." P12-C concurred, saying "I think by doing voice dictation, it's a lower barrier to entry than, like, typing it up or writing it out."

While the voice interface helped to reduce the effort of self-tracking activity data, reflecting on values was still a cognitive and temporal burden. Five participants mentioned how much effort it took to annotate each activity with their values and other context data (people, location, category). P9-C said the daily reflection was "a little time consuming... doing the annotations takes time." P11-C said "I see this as kind of similar to... logging your calories that, like, **you really want the information**, but the...**effort of logging it is so much** that... I don't end up doing it."

To reduce the burden, two participants wanted the AI to have an even larger role in data collection, allowing the AI to assign values to activities via voice commands rather than manually adjusting the sliders in the modal pop-up window. For example, P2 spoke to the system, saying "For this day, fill in any open time between 8 AM And 11 PM with a block that says 'Work.' Label the category as 'work' and increase the data scientist value to the maximum amount" (P2-O). The system (by design) did not support making value annotations via the AI in order to encourage active reflection on each activity. P14-C appreciated this, saying "**the additional focus** that this whole software might require **enables me to... think more deeply than I might otherwise**."

4.4.5 Overall Perceptions of Reflection, Self-Knowledge, and Behavior Change Outcomes. The average System Usability Score (SUS) was 76 (out of 100) and the average Technology Supported Reflection Inventory (TSRI) was 42 (out of 63). All participants reported learning something about themselves through participating in the study. Fig 10 compares each participant's opening and closing Satisfaction With Life Scale (SWLS) score alongside the total hours tracked. While the study did not reveal statistically significant change, nine participants had an increase in SWLS score, four had a decrease, and two had no change. Even though the system was not designed to support any particular lifestyle change, 53% of participants reported changing something about their behavior as a result

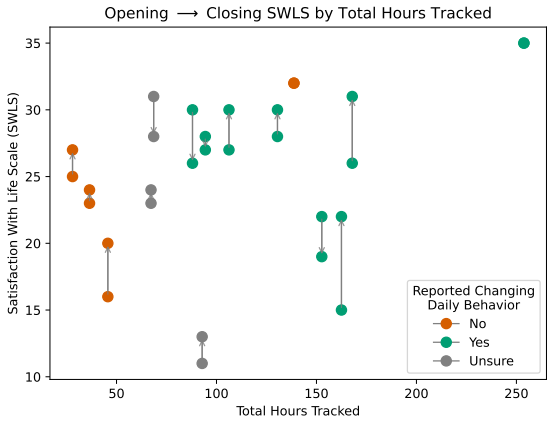

Figure 10: Pre vs. Post Satisfaction With Life Scale (SWLS) measures, opening survey compared to the closing survey, plotted against total hours of activity tracked during the study.

of using the system, 27% reported not changing their behavior, and 20% were unsure. There was a correlation of 0.65 between the total hours tracked and whether or not participants reported changing their behavior (Pearson's r=0.65, p=.008). There was a slightly positive correlation between hours of activity tracked and SWLS score increase, but it was not statistically significant. There were a variety of lifestyle changes reported as a result of participation in the study. P13-C said "**since I did this, I have been avoiding screens as much as possible**... I realized, like, that [expletive] was bumming me out." P7-C said they "tried to fill in the gaps in my schedule with more movement" after noticing free time and realizing how much walking supported their values. P2-C said they "spent more time doing certain hobbies," and P1-C said they generally "did more activities that were better aligned with my values."

P3-C was unsure if they changed their behavior, saying, "**I noticed more about my values and how my actions align with those values**...but this **noticing didn't necessarily lead to a change** in actions." This was a concern shared by four participants, in that using the system led to insights about how their time use aligned (or did not align) with their values, but did not support specific behavior change. P8-C said, "the system does not tell you why or what to do if your values do not align with with how you spend your time." P15-C expressed a similar sentiment, saying "there's a gap between the awareness and the taking actions to change. It's hard... it's not motivating me to change, it's just presenting the information to me."

5 Discussion

5.1 Design Considerations for Incorporating Abstract Values in Personal Informatics

One of the grand challenge calls in value-sensitive design is to answer the question, "what are best practices for the initial discovery of values?" [30]. Building on prior hypotheses [52], the present study provides evidence that individuals can discover and clarify

their values by engaging in structured reflection on specific contexts of everyday life (in particular, daily activities and time use). Participants elicited their values in a variety of ways: some participants knew their values ahead of time, others came up with them on the spot, others drew from existing sets of values, and others developed their values incrementally by considering how they spent their time and making changes after attempting to annotate their time use with values. By connecting abstract values with concrete activities, participants refined their own values throughout the study.

Deliberating about one's high-level values is challenging [70], and we often unconsciously grab our values "off the shelf" when we use traditional PI systems [66]. The *eValuATE* system can support deliberate high-level reflection on values through customizable sets of values combined with the predefined library of sets of values. Participants utilized the library of values that they could look over, learn from, and use in their own reflection. Some participants were particularly challenged by the sets of values, as it seemed to provoke a kind of implicit comparison between the predefined values and the participant's individually held values.

The inclusion of the library served as an affordance for *transformation*, a design principle of reflective informatics that supports an individual changing how they conceptualize a situation [6]. The library also appeared to promote *premise reflection*, where previous assumed presuppositions are questioned [62]. By looking at different values from various religious and secular frameworks, some participants questioned their own values and motivations. For example, P6-O said, "The Seven Capital Virtues, you're not, like, living each moment thinking about how to be humble or, like, patient. I mean, maybe you are. *[Pauses]* Yeah, maybe I should."

Another design recommendation that emerged from the evaluation of the *eValuATE* system is to allow for tracking of *multiple sets* of customizable values. Participants thought about their values in a wide variety of ways, and tracking multiple *sets* of values provided the flexibility to scaffold reflection across different "axes" of values. This design recommendation aligns with Schwartz's suggestion that values are represented in different dimensions (goal types, interests served, and motivational domains) [84].

Throughout the study, participants expressed a variety of desired changes to the system. Three participants expressed that they wanted to rank the values by priority, so that their most important values would show up first. Implementing rankings of values would better align the system with psychological instruments for eliciting values, such as the Rokeach Values Survey (RVS) that instructs subjects to order a predefined list of values "in an order that is important to them as guiding principles in their lives" [77]. Prior HCI studies have also asked participants to provide some rating of importance on their values [55]. Implementing this in a system (with customizable values) could help in reflection via annotation, by having the most important values show up at the top of the list for annotation (the current system ordered the values in the order they were created by the participant). If participants find themselves skipping past their important values when annotating, it might trigger additional reflection about the nature of the activity and/or values. In addition, the rankings could be encoded in the aggregate visualization as an ordering along the y-axis, with the most important values appearing at the top. If the network is "bottom heavy," it could suggest the individual may not be spending their time supporting their most important values.

Three participants wished that there was a *meso-scale* level of reflection about the day as a whole (as opposed to only micro-reflection on activities). P6-C wanted the system to allow users to report an "overall rating of the day" and "then see how that correlates to different values." Four participants wanted to use the system for proactively planning out their time use in addition to (or instead of) retrospective reflection. Six participants wanted the system to provide more feedback, such as helping to identify patterns automatically. Four participants wished the system would support specific goals or behavior change intentions. Participants expressed that they would have liked the system to prompt them with reflective questions to help initiate self-driven behavior change, such as "What are three good things that you've done today that matched your values? What changes do you want to do tomorrow?" (P15-C).

Participants seemed to gain more insights simply from the micro-reflective act [86] of annotating activities with values, even without viewing or interacting with the visualization. However, the visualization served as a motivator for some participants. P9-C said "I definitely wouldn't have been doing those annotations if there was like, no visualization to come out of it." This suggests another design consideration for personal informatics systems that seek to scaffold reflection on abstract values: consider the visualization not as the primary means of supporting reflection, but rather a reward for a cognitively challenging, but reflectively rich, data collection and annotation process. Future work might explore specific design factors that increase or decrease the sense of motivation instigated by the visualization [38].

A valuable finding of this study is that every single participant was able to assign value ratings to specific activities of their everyday lives (similar to how they could assign values to specific self-care activities in a prior study [55]). Simply by providing a context (a specific activity) and a numeric slider, participants were able to provide ratings of how well specific activities supported (or hindered) an abstract value that they had identified as being important. In addition, the ratings were perceived as being useful, both in terms of the process by which these ratings were determined (reflecting on the value in the context of the specific activity) and in terms of the aggregate reflection this process enabled in retrospect (identifying patterns in the visualization). These observations motivate the design of PI systems to help focus attention on values important to individuals, helping them to use their own values as a "tool to interpret the day" (P1-C). In addition, this study provides further evidence that humans can utilize an integer scale to represent elusive "feelings" in a useful way [44]. Consequently, PI systems can serve as a way for people to connect high level abstract values with specific contexts of everyday life.

5.2 From Personal Informatics Systems to Personal Informatics Experiences: The "Life Study"

Many participants found the study burdensome, even with AI features that were intended to help reduce the effort of self-tracking. Some participants expressed regret that they did not use the system

more during the study. This sentiment brings up a tension between the perceived benefit of tracking and reflecting on values and time use—and the cognitive and time cost of doing so. Participants overwhelmingly wanted to use the system again (13/15), but not always on a daily basis. Participants felt that it would be good to use a system like *eValuATE* every few months, or even once a year, to check in and see how well they were living in line with their values. Others suggested that a system of this type might be most useful during significant life changes such as marriage or retirement, in order to help reflect and plan how one might live in line with their values (which may potentially be changing [33]) during these periods of time use change.

This feedback could be taken in two ways for the personal informatics community. One way would be to further iterate on the design of the system to further reduce the cognitive burden of self-tracking and reflecting. The PI community generally wishes to avoid the "device in the drawer" effect, also known as lapsing [25]. Even the term *lapsing* implies a failure or deviation from an expected norm of tracking.

Alternately, PI designers could embrace sporadic use of such systems, and even design technologies specifically intended to be used infrequently. Users may wish to engage in intensive, cognitively demanding self-tracking and reflection for short periods of time in order to gain insights or help to order their life. P1-C said "I would use it [the system] more often when I had a stronger intention in my daily life that I was trying to meet, or trying to dissect why negative patterns are recurring in my life." P13-C said reflection activity would be "really cool to do, like, hardcore for a week, just to...learn some things about yourself." We suggest that this type of usage might be called a **life study** to help reorient designers and users to this form of intentionally-short-term self-tracking.

This consideration aligns with prior work in goal-directed tracking, which motivates tracking only what is needed, for an appropriate timeframe, in order to meet a goal [18, 80]. A life study on an abstract domain, such as values, may differ from fitness-related goal-directed tracking which moves top-down from abstract needs, to qualitative goals, to quantitative goals [67]. The present system suggests a life study includes both a top-down *and* bottom-up reflection process. The system supports reflection on abstract values, and concrete activities, and the two *meet in the middle* via value ratings of specific activities in order to support reflection on the alignment between the two. As mentioned by participants, the reflection on values in the context of specific activities can lead to both a refining and changing of values (or value clarification [33]), and a potential changing in behavior or desired behavior.

Designing PI systems as tools to conduct life studies can be beneficial to users in multiple ways. First, privacy concerns may be lessened, as the user would simply collect less data with the system and in more intentional circumstances. Second, the systems may not need to be designed with attention-capturing features that are intended to promote long-term use [65], leaving users with more freedom in how they direct their attention. Third, PI systems designed for life studies can lessen the potentially negative reactivity effects associated with self-tracking. While the *eValuATE* system supported the user coming up with their own custom sets of values, there are still "hidden" values embedded in the design of all PI systems (the present one included). For example, the design decision to have a calendar interface where all time is represented equally promotes a "quantified" view of time, and the task of assigning discrete numeric values to represent "how much" an activity supported a value (as opposed to a qualified "how") could have an unintended effect on how values are thought about. While the system appeared to be generally beneficial by prompting the user to consider questions they might not otherwise (such as "what values does this specific activity support or hinder?"), long-term use might result in subtly shifting the user toward an unintended quantified mindset about values.

5.3 A Multi-Level Reflection Model for Personal Informatics

Prior HCI studies show the importance of grounding reflection on abstract values in specific contexts of everyday life, such as self-care activities [55] or photos of specific situations [70]. We suggest that the reason for this is that the contextual grounding helps individuals navigate levels of abstraction, in two separate (but correlated) dimensions suggested by Bolognesi et al.: *specificity* and *concreteness* [10]. These two dimensions form the basis for a *multi-level reflection model for personal informatics* (see Figure 11): a framework for understanding how PI systems can support reflection across both the specificity and concreteness dimensions of abstraction.

Specificity can be represented by a scale from "highly specific" to "highly generic" [10]. An individual *shower* activity would be very specific, while an aggregation representing all showers taken in a year (or all hygiene activities), for example, would be more generic. This corresponds with the concept of granularity in self-tracking [49]. *Concreteness* can be represented by how much "sensory-based information" is available for a particular thing [10]. For example, a generic *showering* activity is more concrete than the generic value of *determination*. While both are generic, the *determination* value is abstract while the showering activity group is concrete. Personal informatics systems currently excel at gathering data about domains of life that are concrete, particularly, those related to health [24]. Traditional PI systems help users navigate across the axis of specificity by collecting data on specific phenomena and presenting generalized representations created through aggregation of the specific (the *integration* stage of Li's Stage-Based model [54]). However, most personal informatics systems do not currently support reflection on abstract domains such as *values*, despite PI's potential "capability of revealing something of the individual's self" [74]. Our findings suggest that personal informatics systems can be designed to support reflection by helping users navigate across both the *specificity* and *concreteness* dimensions of abstraction.

Different design features of PI systems support reflection across the different levels of abstraction as shown in Figure 11. The self-reflection strategy implemented in the *eValuATE* system involved prompting the user for self-report data across all four quadrants. In the first quadrant (abstract and general), participants elicited personal values, using the value-set library as exemplars. In the third quadrant (concrete and specific), participants simply reported the activities they did during the day, using the optional voice interface.

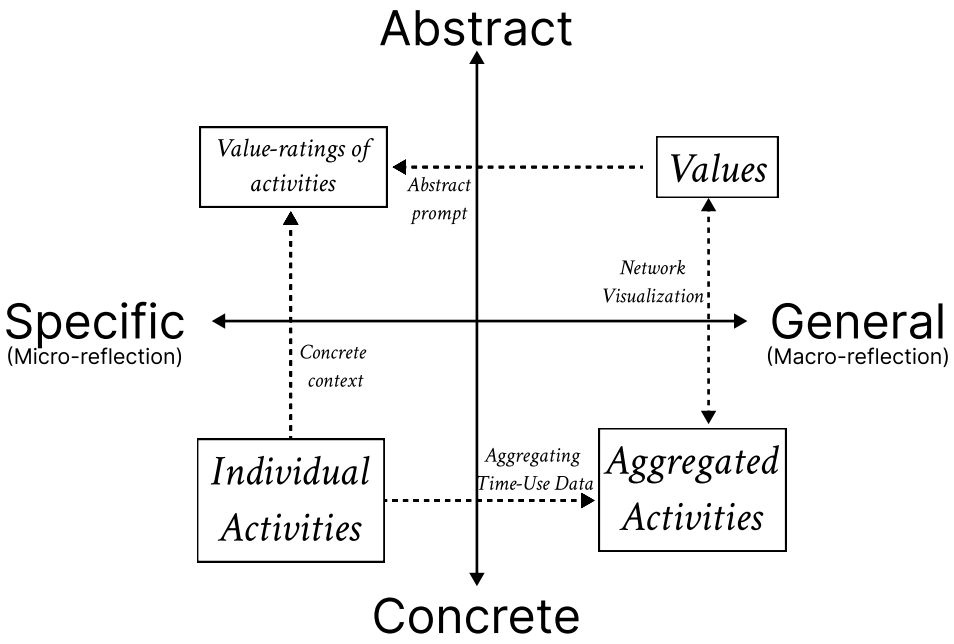

Figure 11: A conceptual diagram of the multi-level reflection model for personal informatics. The model suggests PI systems can support reflection by helping users navigate across levels of abstraction in two dimensions, specificity and concreteness. Square boxes represent data collected (or produced, via aggregation) by the PI system. Dashed arrows represent system design elements that support navigating abstraction levels.

In the second quadrant (specific and abstract), the participants assigned abstract values (from quadrant I) to specific activities (from quadrant III). In the fourth quadrant (concrete and general) participants assigned general categories to events (and these specific instances were aggregated in the visualization).

Broadly speaking, this strategy can be characterized as a model for PI system design where the PI system helps to connect a more abstract domain (in this case, general personal values) to a more concrete domain (in this case, specific activities that take up time) (Figure 12). Gathering data that is highly specific is akin to a kind of *micro-reflection*, reflection on a small segment of activity (as opposed to an entire day, for example) [86]. This micro-reflection resulted in participants better refining their general values, suggesting feedback loops across the specificity scale (or, between the "globally defined" and "locally relevant" [51]). Macro-reflection was supported through the bipartite network visualization (similar to the network representation used in [79]), which connected the concrete domain of time use with the abstract domain of human values. As both of the representations were very general (or "global"), the visualization could support individuals adopting new perspectives of the self by bringing into objective focus something that was previously assumed to be part of the subject—a kind of transformative or premise-level reflection [6, 62] that has historically been acknowledged as a difficult thing for technologies to foster [15, 28]. With *eValuATE*, participants both learned about and refined their abstract general values (for example, by being confronted by activities where no values were annotated and realizing there was a missing value) and learned about how their concrete activities add meaning and value to their life (for example, realizing that their daily routine actually supports the virtue of diligence). This general idea of supporting reflection at multiple levels of abstraction can apply to contexts beyond time use. Financial transactions, for example, could be used as the concrete domain of everyday life, and a variant of *eValuATE* might encourage annotation of these transactions with custom sets of values determined by individuals.

The three distinct stages of collection, integration, and reflection in Li's original stage-based model [54] are present in the multi-level reflection model. First, users collect data about their general, global self (such as their values), and their specific, concrete self (such as their activities). Then, this data is *integrated* in reflective prompts connecting the abstract values to the concrete activities. The collection phase is largely indistinguishable from reflection—reflection is necessary in order to both elicit one's abstract self and determine how that sense of self is expressed in concrete, everyday life. The visualization falls primarily within the *integration* stage of the model, with iterations circling back to the collection and reflection stages as individuals modify their annotations based on what they see in the visualization.

The peripheral components of Li's model, such as its iterative nature and cascading barriers [54], also apply to the multi-level reflection model. Barriers can cascade when navigating across abstraction levels. For example, one participant elicited a custom set of values that contained 34 values. This not only took a long time to elicit at the general and abstract level, it became difficult and time-consuming to annotate that many values for specific activities. In addition, this barrier cascaded into the integration of the visualization, as the visualization was too complex and "messy" to support meaningful reflection.

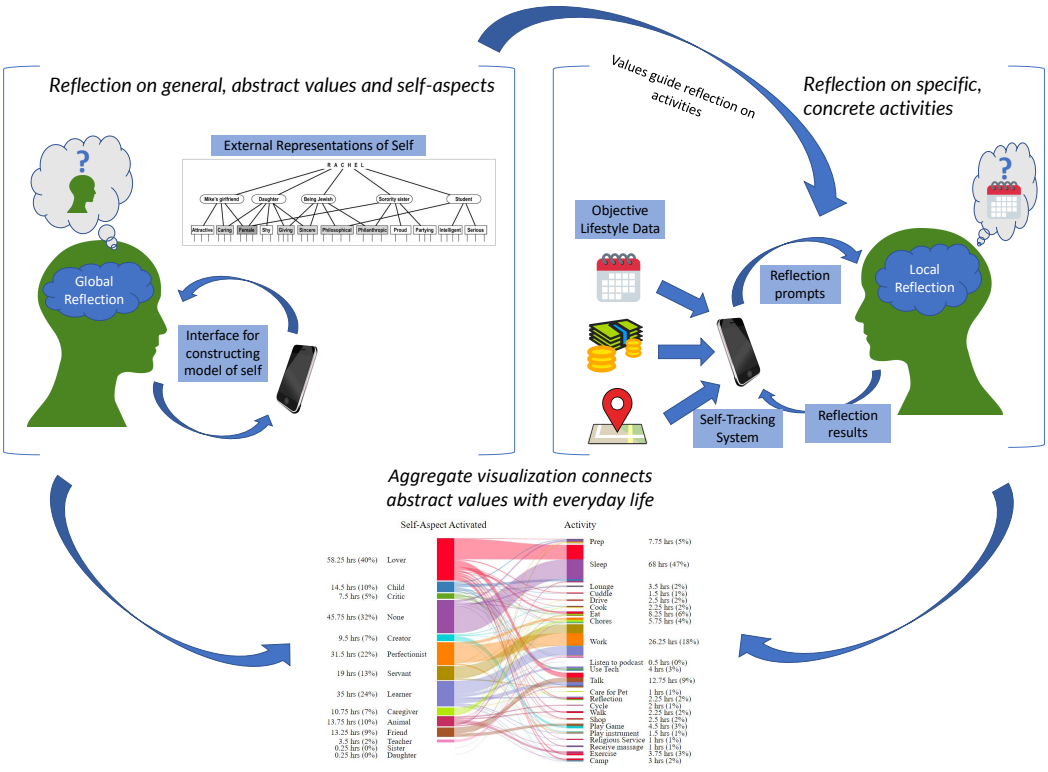

Figure 12: A pictorial representation of the multi-level reflection model for personal informatics. The system prompts individuals to reflect on their "global/generic" self, and create external representations of their self. This representation is used to inform reflection prompts on the specific, concrete "quanta of everyday life," such as specific activities or financial transactions. Reflection from both levels are combined into a visualization that helps individuals reflect across abstraction levels.

Multi-level reflection also finds resonance with other PI related models, such as Rapp and Tirasa's theory of self for PI [74] and Epstein's Lived Informatics model [26]. Rapp and Tirasa's theory motivates considering (and designing for) a past self, present self, future self, and connected self. The *eValuATE* system aligns with Rapp and Tirasa's intention to focus on self-knowledge first, rather than behavior change. The generalized multi-level reflection model focused on different *levels* of concreteness (abstract values and concrete contexts), as opposed to the temporal differentiation of past, present, and future selves [74].

Epstein's Lived Informatics model sees the collection, integration, and reflection stages as being intermixed and part of an ongoing process. Epstein's model is informed by the transtheoretical model of behavior change, which suggests "self-reevaluation" and "consciousness raising" as processes that occur in the stages of change [72]. The multi-level reflection model may support these processes by connecting abstract views of self with concrete ways in which that self is expressed (see Figure 12), as well as by helping individuals to make connections between abstraction levels that they may not have otherwise considered. The multi-level reflection model suggests a strategy for designing personal informatics systems to support personal growth in the areas most important to individuals, by helping them connect how they live with what matters most, or, as P3 said, "helping you refine...the values that are important to you in your life, and how you want to live your life."

Lastly, the multi-level reflection model integrates well with the tracker goal evolution model [67] and goal-directed tracking more generally [85]. We expect that different classes of goals would be best facilitated by reflection across different levels of abstraction or specificity. For example, *tracking goals* [85] might be most likely supported with reflection in quadrant III (specific and concrete) and quadrant IV (general and concrete), by supporting the user to track specific instances of activities, and aggregating those instances to determine if a tracking goal is met. *Management goals* [85], however, might be best supported by reflection in quadrant I (abstract and general values) and quadrant IV (concrete and general aggregations), helping individuals visualize how their lifestyle is supporting particular values, for example.

6 Limitations and Future Work

Our sample of participants was not representative of the general population. Specifically, our participants were highly educated and mostly under 34 years old. While this demographic profile matches that of digital self-trackers generally [13, 69], our results may not generalize to the overall population. In addition, the abstract nature of values, and the diversity of ways in which they can be expressed

and experienced make studying values challenging. While this study encouraged participants to customize their values, this led to participants having significantly different experiences with the system that can be difficult to generalize to other populations. More focused and generalizable studies could explore having participants use systems like *eValuATE* with specific predefined value sets, and study the individual experience in a more narrowly defined use-case. For example, a system could be configured to only allow annotation of a particular set of values, and then a longitudinal study of that system could explore if usage led to any changes in perception or recording of those particular values in daily life.

Many participants wanted the system to support specific goals and help them close the intention-behavior gap. Future work can explore the design of features specifically intended to support lifestyle changes that align with values. For example, the system can incorporate additional features to support goals drawn from goal-directed tracking literature, such as aligning tracking prompts to specific goals, allowing for goal evolution over time [85], and supporting if-then scenarios such as is done with implementation intention and mental contrasting [86]. In addition, different data collection strategies can be explored other than the Day Reconstruction Method. For example, the experience sampling method (ESM) could be used to gather in-the-moment value annotations via a mobile app. In addition, semi-automated tracking methods can be used to help collect activity data [16], further reducing the cognitive burden of self-tracking.

Another limitation is the presence of the Hawthorne effect [60], where participants modify their behavior in response to knowing that they are being observed. This can lead to participants altering their behavior (and self-report) in unknown (and unknowable) ways. At least one participant noted that it was "funny" to be constructing a custom set of values in front of someone else, as it is something they would generally do on their own. Although it is unclear how to ethically avoid the Hawthorne effect in a research context like this one, releasing a public version of this system with strict data and privacy controls would give other individuals a chance to engage in reflection on time use and values away from the watchful eye of a researcher. For a reflective informatics system like the present work, we agree with Baumer that we cannot simply ask "did it work?" [6], but rather hope to identify different ways in which the system led to reflective experiences of participants.

7 Conclusion

In this study, we designed, built, deployed, and evaluated *eValuATE*, a flexible personal informatics system for connecting abstract values with concrete activities of everyday life. The system helped participants elicit abstract values important to their self-concept by providing a library of preexisting sets of values from world religions and psychological theories, and annotate how those values were supported (or hindered) by their use of time. To reduce the cognitive burden of self-tracking, the system included an AI-augmented voice interface that automatically parsed activities from their spoken narratives and commands. An interactive bipartite network visualization helped participants make connections from general, abstract values to specific, concrete contexts of everyday life.

Participants found that eValuATE helped them refine their own values, understand how those values were supported through the concrete details of their daily life, view their lifestyle differently, and, for some, change their behavior as a result of the study. We synthesize these findings into design recommendations for personal informatics systems that help individuals reflect on their values in everyday life, motivate designing PI for short-term "life studies" of intensive self-tracking and reflection, and present a multi-level reflection model for personal informatics using two dimensions of abstraction. Overall, this study provides evidence that personal informatics systems can be designed to scaffold reflection on the alignment of abstract human values with the activities of everyday life.

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A Detailed Value Set Descriptions

This appendix contains a list of all the "default" value sets that were pre-populated in the *eValuATE* system. The following tables contain the value names and corresponding descriptions.

Table 3: The Ten Pāramīs [40]

Value	Description
Nekkhama (Renunciation)	Renouncing the householder life and living without personal possessions.
Sīla (Morality)	Ethical and moral conduct.
Viriya (Effort)	Making effort in to purify the mind.
Paññā (Wisdom)	Understanding gained through direct experience of reality.
Khanti (Tolerance)	Feeling love or compassion for those who disturb or irritate us.
Sacca (Truthfulness)	Continually seeking the truth at all steps of life.
Adhiṭṭhāna (Strong determination)	Making a strong effort.
Mettā (pure, selfless love)	Wishing for the happiness of others.
Dana (Generosity)	Giving for the good of others, in whatever way one can.
Upekkhā (Equanimity)	Keeping the balance of the mind.

Table 4: Seven Deadly Sins [87]

Value	Description
Pride	Excessive belief in one's own abilities, that interferes with the individual's recognition of the grace of God. It has been called the sin from which all others arise. Pride is also known as Vanity.
Greed/Avarice	The desire for material wealth or gain, ignoring the realm of the spiritual. It is also called Avarice or Covetousness.
Envy	The desire for others' traits, status, abilities, or situation.
Wrath/Anger	Manifested in the individual who spurns love and opts instead for fury.
Lust	An inordinate craving for the pleasures of the body.
Gluttony	An inordinate desire to consume more than that which one requires.
Sloth/Acedia	The avoidance of physical or spiritual work.

Table 5: Seven Capital Virtues [17]

Value	Description
Humility	Being inclined to the lowest place.
Charity	Loving God above all things and our neighbor as ourselves for love of God.
Kindness/Mercy	Being bountiful to others, supplying for the defect in one's neighbor.
Patience	Enduring difficult circumstances.
Chastity	The successful integration of sexuality within the person and thus the inner unity of man in his bodily and spiritual being.
Temperance	Moderating the attraction of the pleasures of the senses and providing balance in the use of created goods.
Diligence	Carefulness and persistent effort or work.

Table 6: Seven Heavenly Virtues [17, 20, 87]

Value	Description
Prudence	Disposes the practical reason to discern, in every circumstance, our true good and to choose the right means for achieving it.
Justice	The firm and constant will to give God and neighbor their due.
Fortitude	Firmness in difficulties and constancy in the pursuit of the good.
Temperance	Moderates the attraction of the pleasures of the senses and provides balance in the use of created goods.
Faith	Belief in God and all that he has revealed to us and that Holy Church proposes for our belief.
Hope	Desiring, and with steadfast hope awaiting from God, eternal life and the graces to merit it.
Charity	Loving God above all things and our neighbor as ourselves for love of God.

Table 7: Ten Disciplines of Hinduism [21, 34]

Value	Description
Ahimsa (Non-violence)	Benevolence or love or goodwill or tolerance of all living creatures.
Satya (Truth)	Being truthful, not acting fraudulently or dishonestly. Not brooding over losses due to speaking truth.
Asteya (Non-stealing)	Refraining from theft of objects and from exploitation. Earning one's own way fairly.
Brahmacharya (Celibacy or fidelity)	Respect of personal boundaries, abstinence from wine, sexual congress, meat-eating, tobacco, drugs, and narcotics.
Aparigraha (Non-possessiveness)	Living simply, keeping only what is necessary to sustain the demands of daily life.
Śauca (Purity)	Internal and external purification of both body and mind.
Santosha (Contentment)	Conscious reduction of desires, limiting of attainments and possessions, narrowing the area and scope of one's desires.
Tapas (Austerity)	Physical and mental discipline through asceticism, such as silence, begging for food, remaining awake at night, sleeping on the ground, isolation.
Swadhyaya (Self-study)	Reading scriptures and using them to create a neutral, unbiased and pure mind.
Ishvara Pranidhana (Devotion)	Surrendering to the will of God, performing every act in a selfless, dispassionate and natural way, leaving the result of one's deeds to God.

Table 8: Islamic Daily Practices (informed by communication with practicing Muslim)

Value	Description
Salat	Ritual prayer required of every Muslim five times a day.
Daily Adhkaar	Remembrance of Allah in the morning, evening, and at bedtime - readings or other specific prayers
Fasting	Optional weekly fasts on Mondays and Thursdays and on specific days of the lunar month.
Other Adhkaar	Remembrance of Allah throughout the day.
Sadaqa	Performing acts of charity to benefit others.

Table 9: Jewish Values [29]

Value	Description
Tzedakah	Helping those in need.
Tikkun Olam	Repairing the world.
Talmud Torah	The study of the Torah.
Being a Mensch	Being a good person who helps.

Table 10: Schwartz's Basic Values [83]

Value	Description
Self-Direction	Independent thought and action: choosing, creating, exploring.
Stimulation	Excitement, novelty, and challenge in life.
Hedonism	Pleasure or sensuous gratification for oneself.
Achievement	Personal success through demonstrating competence according to social standards.
Power	Social status and prestige, control or dominance over people and resources.
Security	Safety, harmony, and stability of society, relationships, and self.
Conformity	Restraint of actions, inclinations, and impulses likely to upset or harm others and violate social expectations or norms.
Tradition	Respect, commitment, and acceptance of the customs and ideas that one's culture or religion provides.
Benevolence	Preserving and enhancing the welfare of those with whom one has frequent personal contact.
Universalism	Understanding, appreciation, tolerance, and protection for the welfare of all people and nature.

Table 11: Basic Psychological Needs from Self-Determination Theory [78, 91]

Value	Description
Autonomy	Experiencing volition and willingness.
Competence	Experiencing effectiveness and mastery, capably engaging in activities and experiences for using skills.
Relatedness	Experiencing warmth, bonding, care. Connecting to and feeling significant to others.

Table 12: Maslow's Hierarchy of Needs [57]

Value	Description
Physiological Needs	Biological requirements for survival (air, food, drink, shelter, sleep)
Safety Needs	Experiencing order, predictability, safety, and control
Love and Belonging Needs	Being in interpersonal relationships, affiliating, connecting, and being part of a group
Esteem Needs	Self worth, accomplishment, and respect
Self-Actualization Needs	Realizing one's personal potential, self-fulfillment, and seeking personal growth
Transcendence Needs	Moving beyond personal concerns, achieving a deep sense of unity, acting altruistically

Table 13: Max-Neef's Fundamental Needs [58, 59]

Value	Description
Subsistence	Feed, procreate, rest, work
Protection	Cooperate, prevent, plan, take care of cure, help
Affection	Make love, caress, express emotions, share, take care of, cultivate, appreciate
Understanding	Investigate, study, experiment, educate, analyze, meditate
Participation	Become affiliated, cooperate, propose, share, dissent, obey, interact, agree on, express opinions
Leisure	Day dream, brood, dream, recall old times, give way to fantasies, remember, relax, have fun, play
Creation	Work, invent, build, design, compose, interpret
Identity	Commit oneself, integrate oneself, confront, decide on, get to know oneself, recognize oneself, actualize oneself, grow
Freedom	Dissent, choose, be different from, run risks, develop awareness, commit oneself, disobey
Spirituality/Transcendence	Experience inner peace, transcendence, meditation

Table 14: The Five Love Languages [14, 23]

Value	Description
Words of Affirmation	Sharing encouraging messages, providing meaningful praise.
Quality Time	Time spent engaged in shared activities, with undivided attention.
Receiving Gifts	Giving and receiving tokens of affection.
Acts of Service	Doing helpful things for another, providing service.
Physical Touch	Being physically engaged in close proximity.

B LLM Prompts

For the full system, four different prompts were used: two for regular AI, and two for enhanced AI. The system prompts for the enhanced AI includes the previous categories and locations, and prompts the LLM to utilize the existing categories and locations when possible. If there are no pre-existing category or location annotations, then the prompt will not include any "default" categories or locations.

B.1 Prompts for Regular AI

The prompt for when the calendar had no events was as follows:

```
You are to help parse the narrative the user
     provides into a structured list of
    activities that the user has done in
    their day.
Please parse this narrative of my day into a
     csv list of activities like so:
start time 1, end time 1, activity 1
start time 2, end time 2, activity 2

Only reply with the structured list, no
    other text or narration. Return all
    times in military time.
```

When previously existing events were on the calendar, the following prompt was used:

```
You are to make modifications to the list of
     activities below, to comply with the
    changes requested by the user. When
    replying, respond with a complete list
    of all activities in the same format as
    the original list, but with the
    requested changes.

Include all activities, even the original
    activities. Replace "original" with "
    modified" if you modified the activity,
    or add "new" if you created a new
    activity. All times are in military time
    . If no changes are requested, reply
    with the original set of activities, no
    other text or narration.

The list is formatted as follows:
{id}, {activity}, {start time}, {end time},
    {original}

Only reply with the structured list, no
    other text or narration. Return all
    times in military time.
```

B.2 Prompts for Advanced AI

The advanced AI also sought to determine the category, location, and people co-present in the different activities.

```
You are to help parse the narrative the user
     provides into a structured list of
    activities that the user has done in
    their day.

Please parse this narrative of my day into a
     csv list of activities like so:
start time 1, end time 1, activity
    description 1, activity category 1,
    location 1, [people co-present 1]
start time 2, end time 2, activity
    description 2, activity category 2,
    location 2, [people co-present 2]

Ensure all people co-present are listed as
    comma separated values within brackets.
    Only reply with the structured list, no
    other text or narration. Return all
    times in military time.
```

When previous events were present on the calendar, the following prompt was used:

```
You are to make modifications to the list of
     activities below, to comply with the
    changes requested by the user. When
    replying, respond with a complete list
    of all activities in the same format as
    the original list, but with the
    requested changes. Include all
    activities, even the original activities
    . Replace "original" with "modified" if
    you modified the activity, "deleted" if
    the activity should be deleted, or add "
    new" if you created a new activity. All
    times are in military time. If no
    changes are requested, reply with the
    original set of activities, no other
    text or narration.

The list is formatted as follows:
{id}, {activity}, {start time}, {end time},
    {activity category}, {location}, {[
    people co-present]}, {original}

Ensure all people co-present are listed as
    comma separated values within brackets.
Only reply with the structured list, no
    other text or narration. Return all
    times in military time.
```

For enhanced AI, the following was appended to the system prompt if there were any previous locations annotated for any previous activity:

```
For locations, pick from this list or create
    a new location:
Location options: { location 1, location 2,
    location 3, ...}
```

The following was also appended to the system prompt if there were any previous categories annotated for any previous activity:

```
For activity categories, pick from this list
    or create a new activity category (this
    only applies to activity categories,
    not activities):
Category options: { category 1, category 2,
    category 3, ...}
```

C Visualization Discussion

When any of the controls of the visualization are modified, the visualization is recreated by scanning all of the events within the date range, and connections from one attribute to another are created if an event contains both attributes. For example, if an hour-long event "Breakfast" was annotated to have a location of "Home" and a category of "Meals" and the location and category attributes are selected in the left and right drop-downs, then a link with a weight of one hour is created between "Home" and "Meals."

The same method is used to visualize any value annotations, allowing the user to visualize connections across scales (across values, activities, or specific pieces of context of an activity). As there may be more than one value annotation per value set, these links are created for each value and the other corresponding annotated attribute (such as location or people co-present). For example, consider a situation where a participant is trying to visualize the value annotations for Schwartz's values [83] and event locations to identify the locations where particular values are supported or hindered. In the case of the "Breakfast" event, if "Breakfast" was annotated with a positive rating for the values "Hedonism" and "Stimulation," then two links would be created in the visualization. In this case, there would be a link with a weight of one hour from "Hedonism to "Home" and a link with a weight of one hour from "Stimulation" to "Home."

This many-to-one visualization strategy represents the complex nature of the relationships between locations and values (for example), but also poses visualization problems. In a one-to-one network visualization, the heights of the nodes on the network meaningfully show the duration of the events (or time spent with a particular annotation value—for example, time spent at home). In a many-to-one visualization, some events are duplicated (for example, our annotated values from the breakfast event described earlier), meaning that the bars of the visualization no longer represent distinct intervals of time. In the same example, the bar for "Hedonism" and the bar for "Stimulation" would both represent one hour of time, but they represent the *same* hour of time.

This problem becomes particularly amplified in the case of many-to-many visualizations, such as when participants visualize the network of relationships between two different value sets, or between a value set and people co-present (as there can be more than one person co-present during an event). To work around this issue, the visualization code automatically calculated the labels of the events to accurately represent how much time they took. The labels, therefore, truthfully indicate how much time was spent in events supporting the value of "Hedonism," for example, and truthfully indicate how much time was spent at "Home," for another example. However, the heights of the bars are based on the sum of the weights. In this case, the node for "Home" would be twice as long as if it only had a value annotation of a single value.

One solution would be to equally divide the duration of the event based on the number of annotated values. In the example above, the link between"Hedonism" and "Home" receives a weight of 30 minutes, and between "Stimulation" and "Home" receives a weight of 30 minutes. These weights could also be divided out proportionately based on the amplitude of the value annotation. While this approach would preserve the visualization's representation of duration, it fails to recognize the importance of what Max-Neef called "synergistic satisfiers." Max-Neef explained that some activities satisfy more than one need at a time (or in this case, support more than one value at a time). These synergistic satisfiers are important and should be the focus of optimization by policymakers and communities [58, 59]. If an event's duration was equally divided among the values that it supports, then the overall value of the event is diluted, when, in reality, it should be amplified. The present visualization therefore seeks to amplify synergistic satisfiers visually, while remaining truthful to the actual duration of events. Future work can explore creating new forms of visualizations that can accurately show these part–whole relationships and many-to-many connections in this context.