# Personal Data Exploration with Speech on Mobile Devices

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## Abstract
In this article, we envision a novel way to help people explore their personal data on mobile devices by leveraging speech interaction. Supporting visual data exploration on mobile devices pertains to two constraints. First, mobile devices' small screen cannot afford a panel of widgets. Second, exploring self-tracking data often involves entering specific date and time, or their ranges, which is tedious to do on mobile devices. These challenges can be addressed through speech because it does not require much space and is flexible enough to cover different ways to specify date and time. Moreover, common personal insight types identified from prior work allow us to narrow the scope of the speech interaction needed for personal data exploration, making it more tractable with the state-of-the-art speech recognition technology.

## Author Keywords
Multimodal interaction; mobile visualization; information visualization; self-tracking; personal informatics.

## ACM Classification Keywords
H.5.2 [Information interfaces and presentation (e.g., HCI)]: User Interfaces.

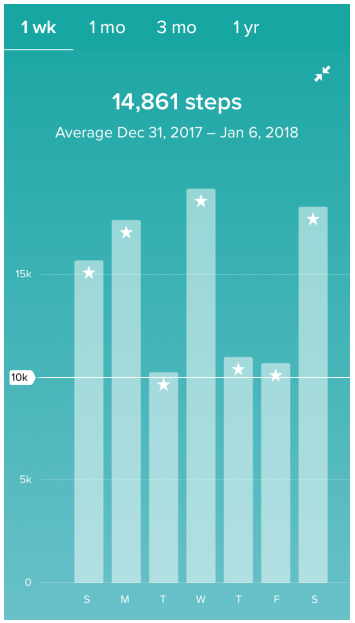


**Figure 1:** The Fitbit app shows a person's step counts for the selected period using a bar chart.

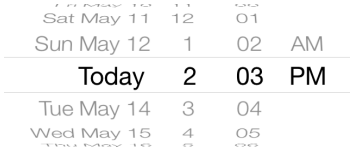


**Figure 2:** An iOS' control for the inputting of date and time values.

## Introduction

Nowadays, people can easily collect rich personal data using wearable sensing and mobile apps. Called self-tracking, its promise is that people can be aware of their behaviors, learn insights, and use the insights to improve aspects of their life. Visual data exploration can help facilitate the process of gaining insights from data [5]; exploring data through visualizations can help people reflect on their behaviors and prompt them to think about interesting questions and answers. However, for lay individuals, drawing insights from the collected data is challenging [6]. The process often involves selecting data and creating visualizations that suit the chosen data types. Although a few tools exist to facilitate personal data exploration, they are mostly designed for desktop or laptop environments [5, 9].

It is desirable to enable people to explore data and gain insights on mobile devices where they usually collect personal data and consume other information. However, due to a small screen size and lack of precise selection control, supporting visual data exploration on mobile devices is challenging. In this article, we envision a novel way to help people explore their personal data on mobile devices by leveraging *speech* interaction.

## Personal Data Visualization on Mobile Devices

Many mobile apps provide visualizations to help people understand their self-tracking data (e.g., Fitbit [1], SleepTight [4]). These apps provide an overview of daily activities, usually employing a dashboard with a set of tiles showing current status, or a timeline metaphor (e.g., Moves [2]) presenting their activities in a reverse chronological manner. Contrary to the desktop environment, they often lack support for flexible data filtering (i.e., dynamic queries [3]), which is commonly used to allow people to explore their data and see things from different perspectives. Instead, visualizations on mobile devices usually provide a set of predefined time ranges such as 1 week, 1 month (or 4 weeks), 3 months, 1 year, and so on (Figure 1), making it difficult to synthesize knowledge from the longitudinal data.

Supporting visual data exploration on mobile devices pertains to two particular constraints. First, mobile devices' small screen cannot afford a panel of widgets. Second, exploring self-tracking data often involves entering specific date and time, or their ranges, which is tedious to do on mobile devices (Figure 2). To overcome these challenges, we propose to leverage speech. Speech does not require much space and is flexible to cover different ways that people specify date and time, as well as their range.

## Personal Data Exploration with Speech

One important characteristic of self-tracking data is that it is time-based. When tracking their behaviors, people record an occurrence of a target behavior using a specific time point (e.g., coffee at 9am) or duration (e.g., exercise from 7 to 8am). It is also common to organize the data by day. For example, sleep diaries are recorded daily (i.e., one entry per day). Target behaviors' frequency (e.g., coffee intake) or the duration (e.g., reading) are summed up at the end of each day and the counter or timer usually resets each day at midnight. Furthermore, researchers recently identified ten common personal insight types (e.g., Detail, Comparison, Trend) based on situating people in exploring their own data using a web-based visualization system [5]. The unique aspects of time-based personal data, with well-defined common insight types people seek and value, will help us narrow the scope of speech interaction needed for personal data exploration.

*Data Navigation*

A person can start exploring his/her self-tracking data by specifying data source (e.g., sleep, steps, weight), date range, or chart type. (Oftentimes, date range and chart type are initially determined based on default values or simple heuristics.) These three attributes can be individually specified. For example, from a default view showing a bar chart of current month's step count, the person can change the date range with speech (e.g., *"Last year," "Last month,"* or *"January, 2017"*) after touching the mic icon in the query box (Figure 3). In other words, speech interaction can be an effective navigation mechanism, enabling direct access to an arbitrary time point.

*Supporting Common Personal Insights*

One common insight type people sought was *Detail*, retrieving low-level values such as extremes (i.e., min & max) or references (e.g., date, labels) to the extreme values [5]. Identifying Details can be easily handled with speech. For example, a person issues a *"Most steps in February"* query. (If the date range is already set to February 2018, the person can just say *"Most steps."*) Then, the system answers with an annotated chart (border highlight and text label) [8] (Figure 3). If the query involves different data source and date range (e.g., *"Minimum weight in 2017"*), the system infers the data source (weight), the date range (Jan 1 $\sim$ Dec 31, 2017), and the chart type (line chart) to present an answer. Another common insight type was to compare data segmented by time (e.g., by days of the week, by months of the year, or before & after a specific day such as New Year's day). For example, a person issues a command such as *"Weekday versus weekend"* or *"Step counts by days of the week."* Then the system shows a visualization (bar chart) comparing aggregated values of the two groups.

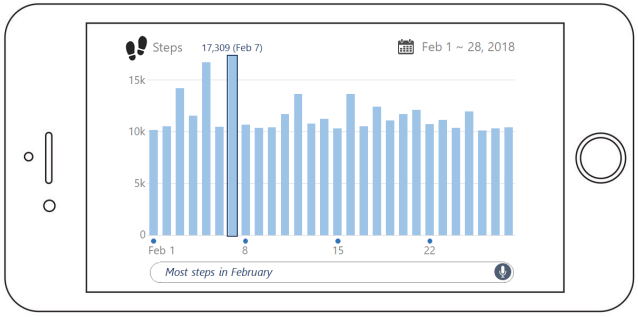


**Figure 3:** Upon receiving the *"Most steps in February"* query, the system can provide an answer with an annotated chart.

*Context Data Entry*

Visual data exploration can evoke *contextual information*, which plays an important role in understanding and reflecting on personal data [5]. Contextual information can be captured during the data exploration process via speech, which can later be reused for other types of analysis (e.g., comparison). For example, recognizing unusually high or low step counts could prompt the person to think of possible reasons (e.g., hiking, sickness). Speech interaction can ease the burden of capturing these contextual information.

## Research Challenges and Opportunities

Even though people know how to speak, they may not know what questions to ask or how to ask questions to explore their data. A query seeking for the same answer can be uttered in several different ways; this flexibility is both a strength and challenge of speech interaction. Furthermore, we cannot expect people to take an effort to learn how to explore their data using speech. Thus, it would be important to investigate ways to teach speech interaction in the context of personal data exploration.

The scenarios we described earlier address basic navigation and common personal insights (e.g., identifying low-level details, performing simple comparisons). A logical next step is to support conversational interaction, which has been found to have several relevant use cases in the context of behavior change [7]. For example, the system can detect outliers (e.g., unusually high/low values, missing data) and ask the person to explain the reason why, recording their answer as contextual information.

While a number of tracking apps are being developed for smartwatches, they often rely on their mobile counterpart for visualizing data. Even though smartwatches may not be appropriate for serious data exploration, they can be used to ask and answer simple questions about personal data when a mobile device is not available. Given that the two particular constraints we mentioned earlier impose greater challenges on smartwatches, speech interaction may play a powerful role in supporting data exploration.

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