Managing In-home Environments through Sensing, Annotating, and Visualizing Air Quality Data

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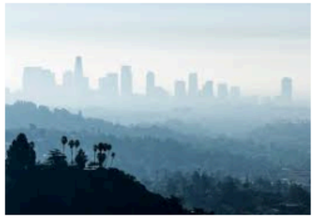
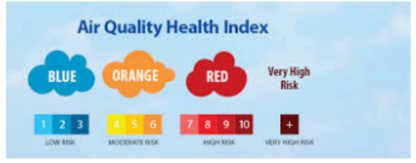
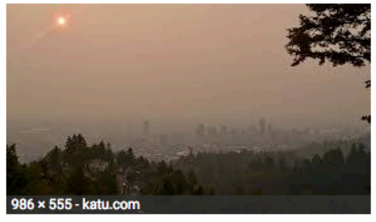
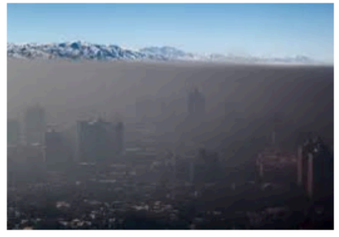
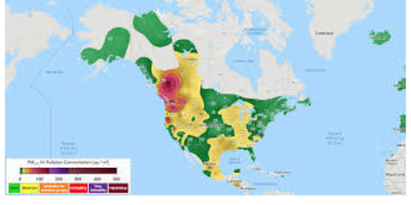
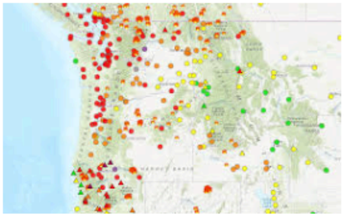
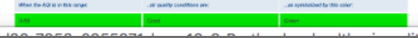
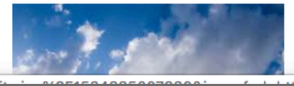
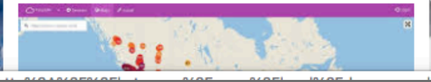








WHO: Nine of 10 people breathe bad air

The World Health Organization has released a new report showing that nearly everywhere people live, the air is polluted beyond safe levels. Polluted air doesn't just smell bad - it's unhealthy, even life-threatening.

https://www.dw.com/en/who-nine-of-10-people-breathe-bad-air/a-35898832

One in Six Global Deaths Linked to Pollution

A new report suggests that pollution led to the deaths of nine million people in 2015

https://www.smithsonianmag.com/smart-news/one-six-global-deaths-linked-pollution-180965347/

Air pollution can damage the brain, Chinese researchers find in far-reaching national study

Lead author says smog could have a bigger impact on social welfare than previously thought

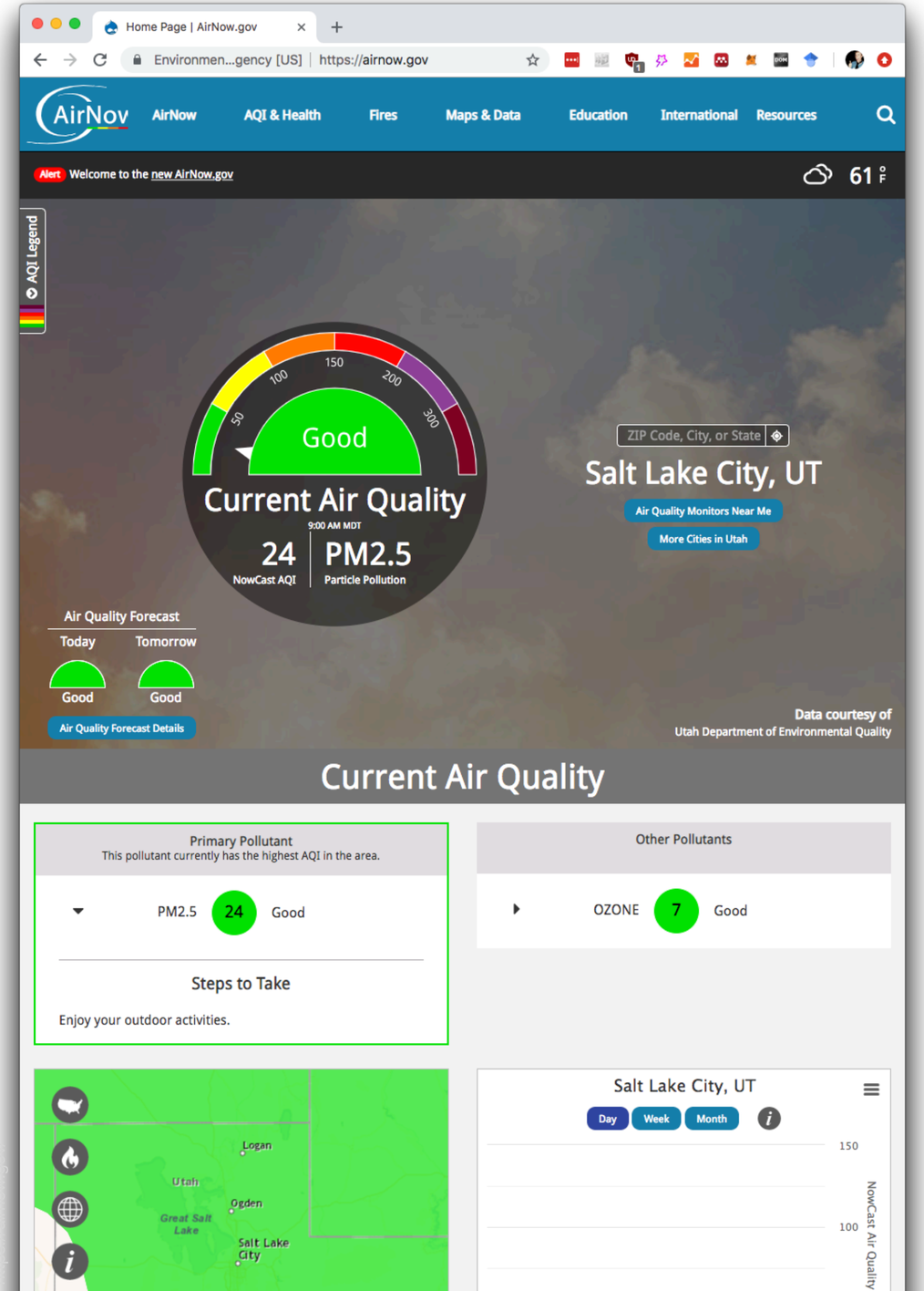
PUBLISHED : Tuesday, 28 August, 2018, 5:56am

https://www.scmp.com/news/china/article/2161592/air-pollution-causes-huge-reduction-intelligence-study-reveals

Air pollution could cause a significant reduction in intelligence, major study says

- Research finds that long-term exposure to air pollution impeded people's performance in both verbal and math tests.

https://www.cnbc.com/2018/08/28/air-pollution-could-cause-reduction-in-intelligence-study-says.html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61 °F
AQI Legend
Good
Current Air Quality
9:00 AM MDT
24
NowCast AQI
PM2.5
Particle Pollution
ZIP Code, City, or State
Salt Lake City, UT
Air Quality Monitors Near Me
More Cities in Utah
Air Quality Forecast
Today
Tomorrow
Good
Good
Air Quality Forecast Details
Data courtesy of
Utah Department of Environmental Quality
Current Air Quality
Primary Pollutant
This pollutant currently has the highest AQI in the area.
PM2.5
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Good
Steps to Take
Enjoy your outdoor activities.
Other Pollutants
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7
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Logan
Utah
Ogden
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Salt Lake City
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Week
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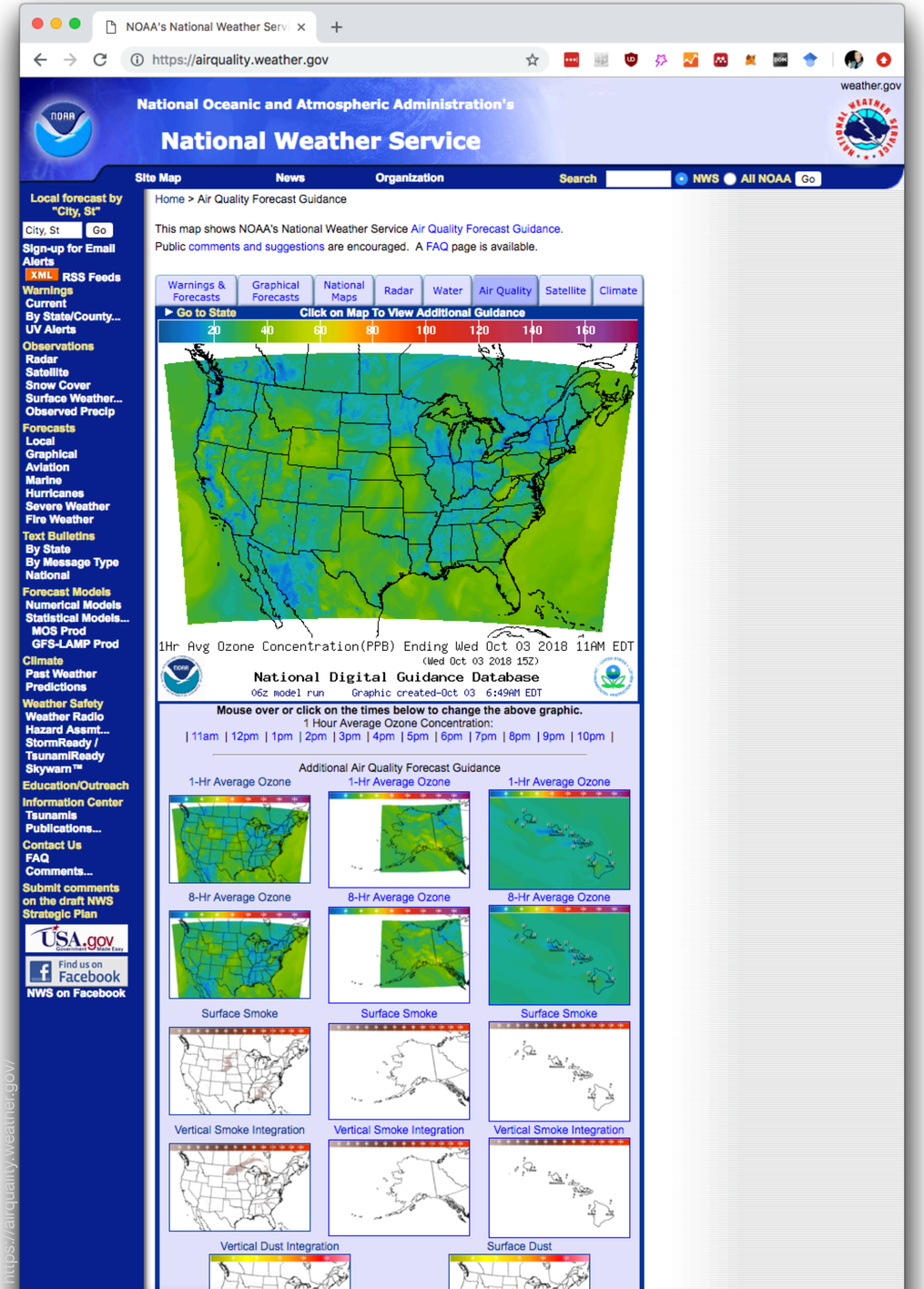
NowCast Air Quality
150
100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Observations
Radar
Satellite
Snow Cover
Surface Weather...
Observed Precip
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Marine
Hurricanes
Severe Weather
Fire Weather
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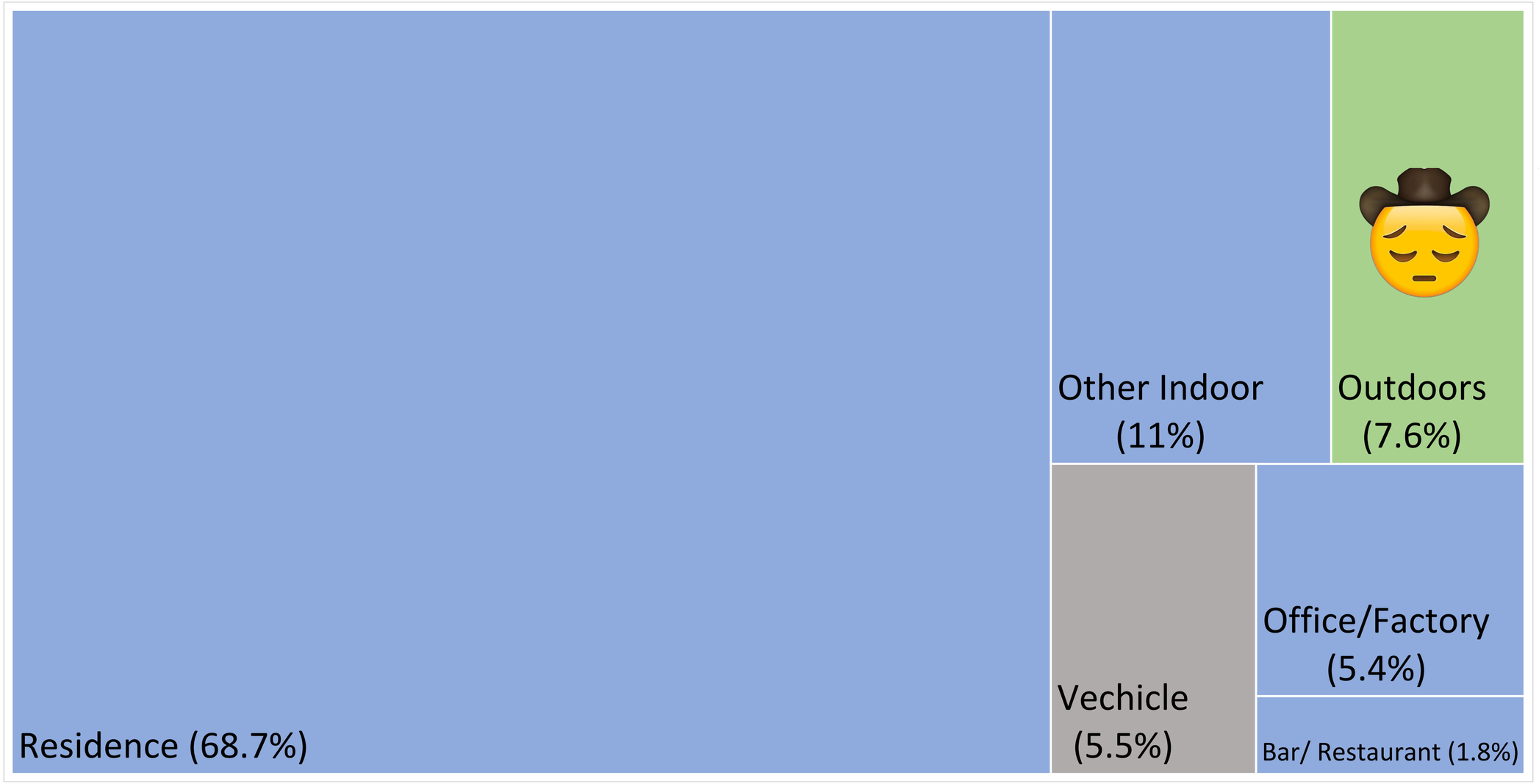
Radar
Water
Air Quality
Satellite
Climate
Go to State
Click on Map To View Additional Guidance
20
40
60
80
100
120
140
160
1Hr Avg Ozone Concentration(PPB) Ending Wed Oct 03 2018 11AM EDT
(Wed Oct 03 2018 15Z)
National Digital Guidance Database
06z model run
Graphic created-Oct 03 6:49AM EDT
Mouse over or click on the times below to change the above graphic.
1 Hour Average Ozone Concentration:
11am | 12pm | 1pm | 2pm | 3pm | 4pm | 5pm | 6pm | 7pm | 8pm | 9pm | 10pm
Additional Air Quality Forecast Guidance
1-Hr Average Ozone
8-Hr Average Ozone
Surface Smoke
Vertical Smoke Integration
Vertical Dust Integration
Surface Dust

NHAPS - Nation, Percentage Time Spent

Total time indoors 86.9%



KLEPEIS, N. E., NELSON, W. C., OTT, W. R., ROBINSON, J. P., TSANG, A. M., SWITZER, P., … ENGELMANN, W. H. (2001). The National Human Activity Pattern Survey (NHAPS): a resource for assessing exposure to environmental pollutants. Journal Of Exposure Analysis And Environmental Epidemiology, 11, 231. Retrieved from http://dx.doi.org/10.1038/sj.jea.7500165

Without a way to measure indoor air quality, we’re only guessing.

“I think previously, I really just kind of assumed the air quality inside was always really great… because, you know, our windows are shut and our doors are shut and we don't open our windows and that's what i was told -- that just don't open the windows and use air conditioning, and you're good.

But I've realized that that's not really always the case. And thats been a big eye-opener for me.”

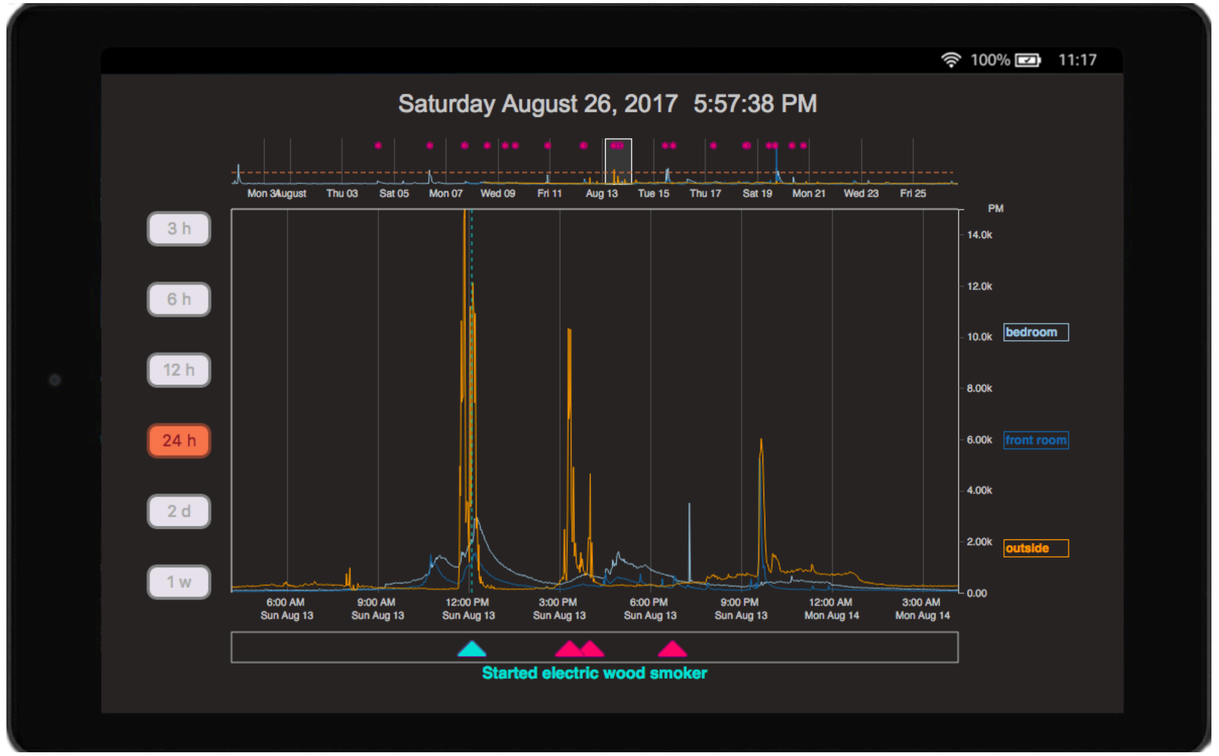
MAAV

Measure **A**ir quality, **A**nnotate data streams, **V**isualize in real-time

MAAV Components

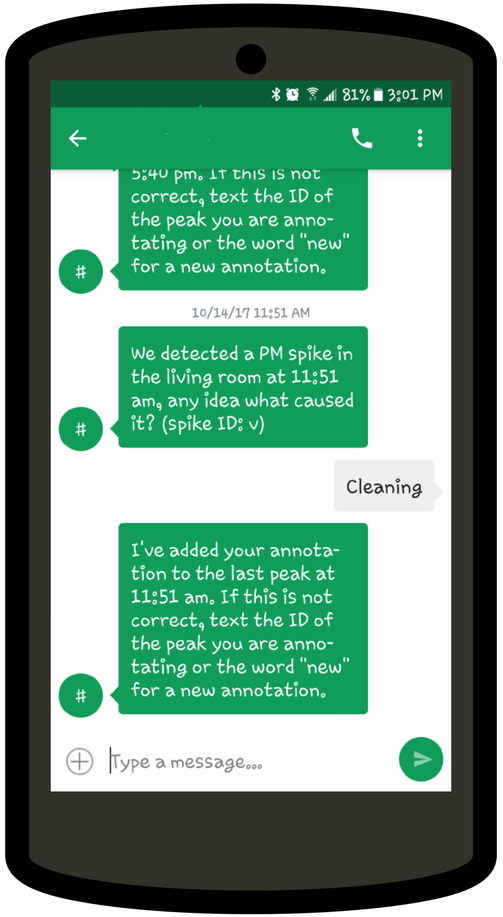
Multiple Modified $PM_{2.5}$ Monitors

Real Time Interactive Interface



MAAV Annotation

Text Annotation

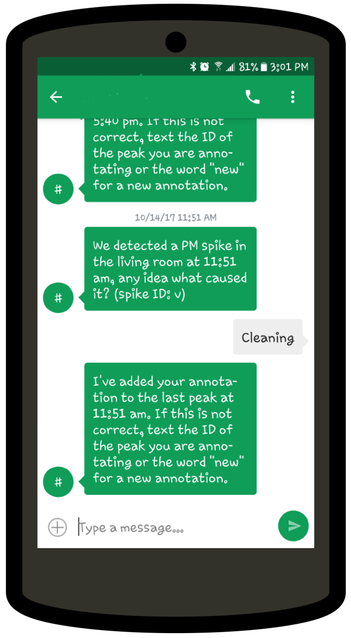


"We detected a PM spike in the living room at 11:51AM. Any idea what caused it?"

"Cleaning"

MAAV Annotation

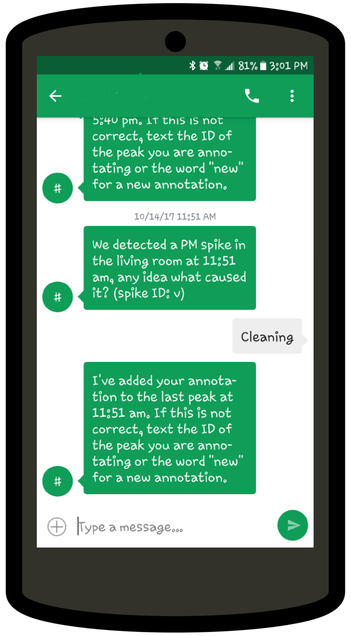
Text Annotation



Tablet Annotation

MAAV Annotation

Text Annotation



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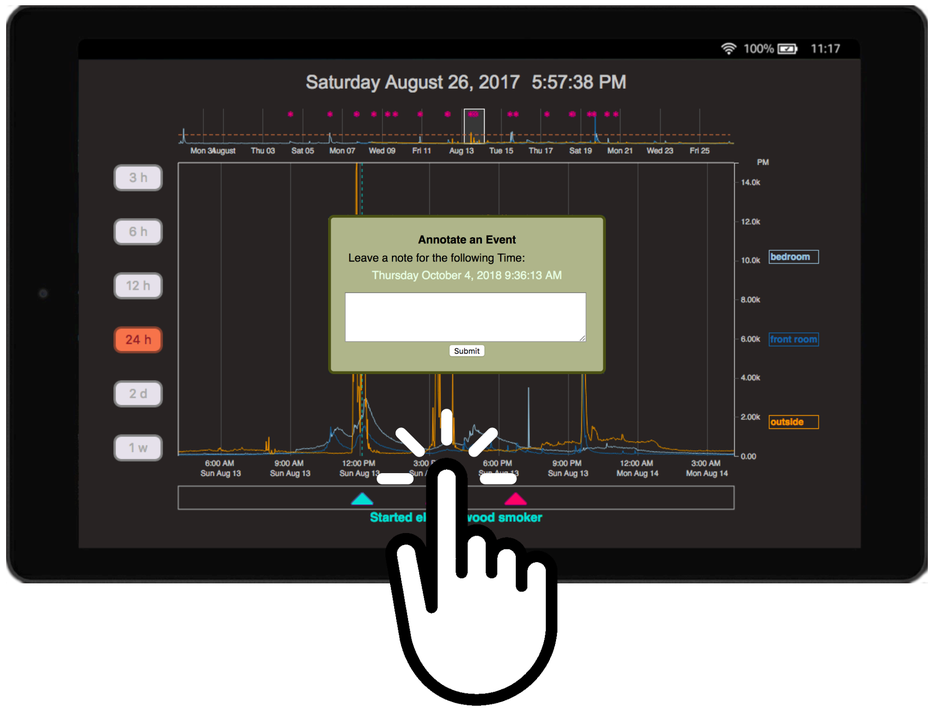
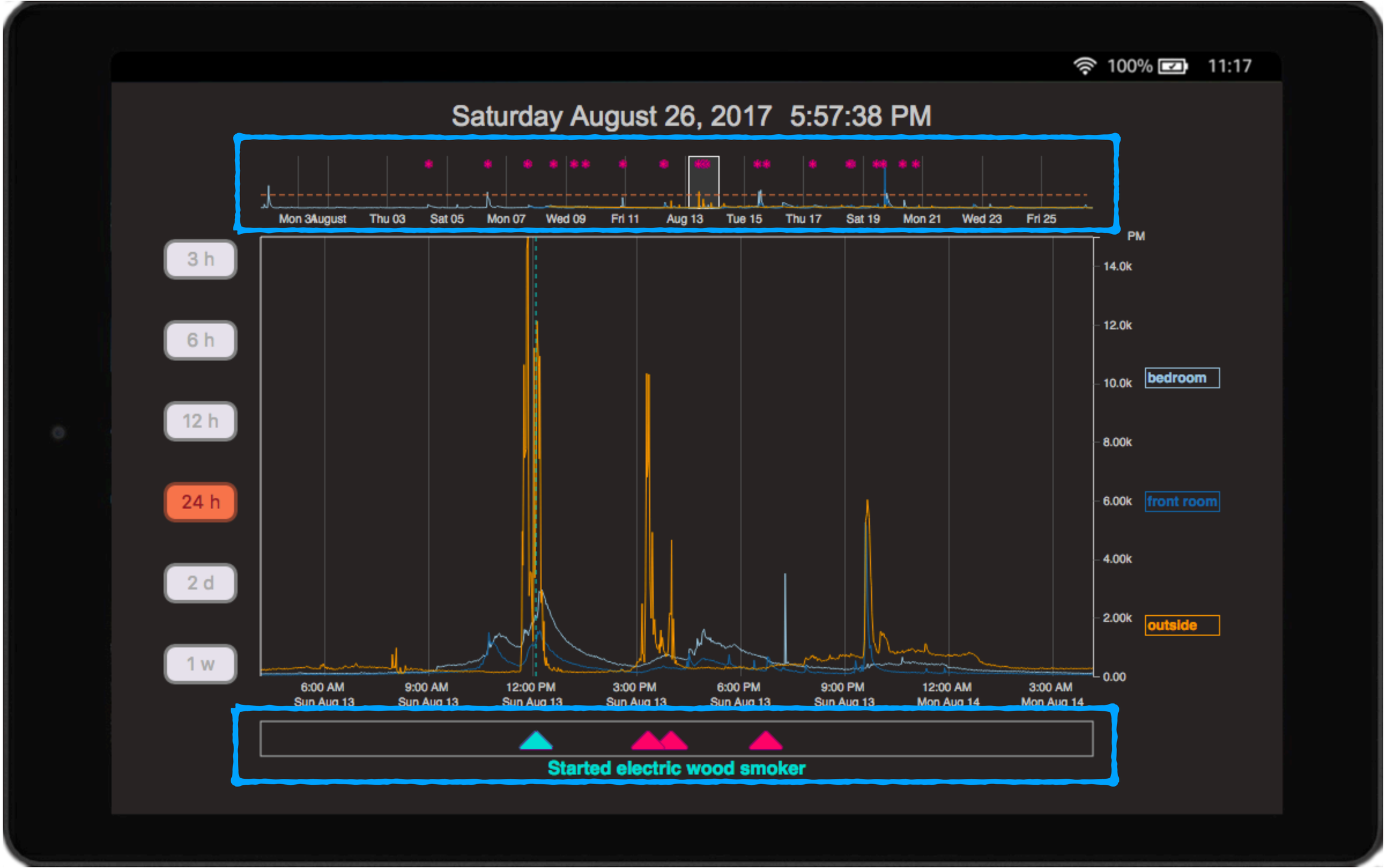


Voice Annotation

"OK, Google . . .
Tell MAAV [annotation text]"


100%
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Sun Aug 13
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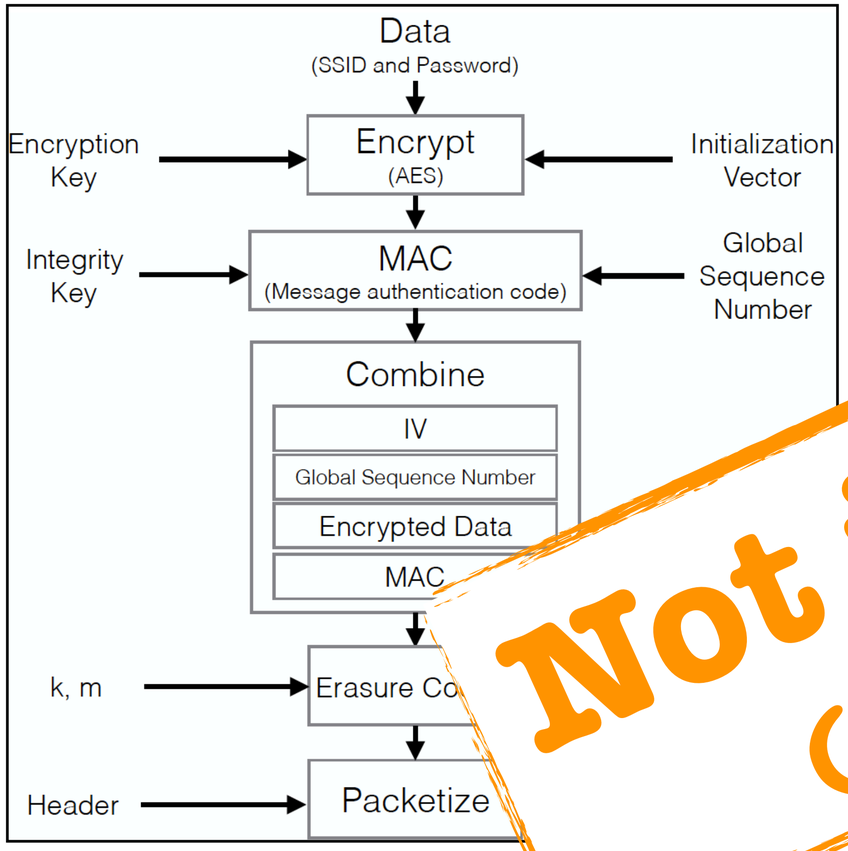
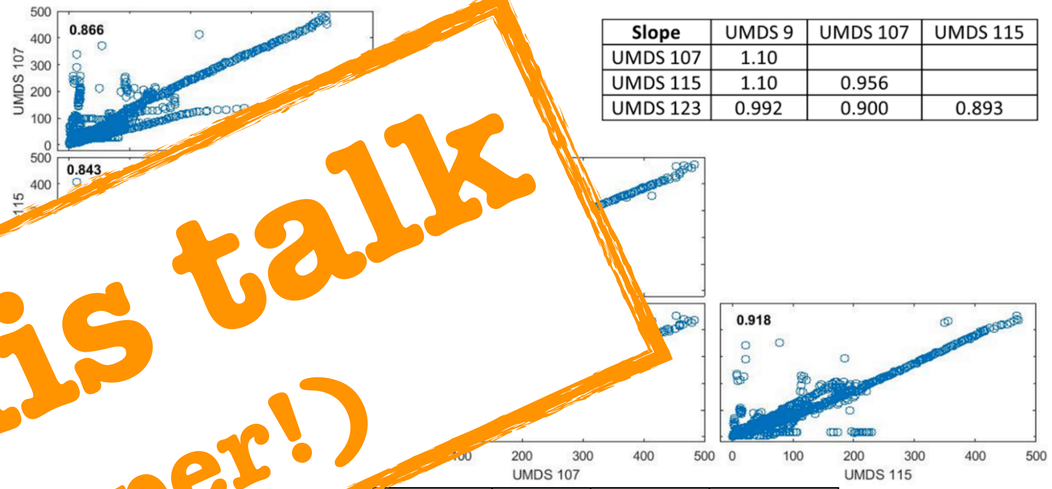
Sun Aug 13
9:00 PM
Sun Aug 13
12:00 AM
Mon Aug 14
3:00 AM
Mon Aug 14
Started electric wood smoker

Lundrigan et al. EpiFi: An In-Home Sensor Network Architecture for Epidemiological Studies, 2017



Hegde et al. Household Indoor Particulate Matter Measurement Using a Network of Low-Cost Sensors *(in submission)*



Slope	UMDS 9	UMDS 107	UMDS 115
UMDS 107	1.10		
UMDS 115	1.10	0.956	
UMDS 123	0.992	0.900	0.893

	Sensors	Average ($\mu g/m^3$)	Maximum ($\mu g/m^3$)	S.D ($\mu g/m^3$)
Outside	UMDS 124	12.0	45.8	14.7
Living Room [2]	UMDS 116	23.8	342	30.0
Front Door	UMDS 121	20.4	262	26.0
Bathroom	UMDS 114	18.0	480	26.6
Bedroom	UMDS 117	22.0	232	21.3

Not in this talk
(See the paper!)

Takeaways

Time series data is not enough

Annotated data is essential for sensemaking

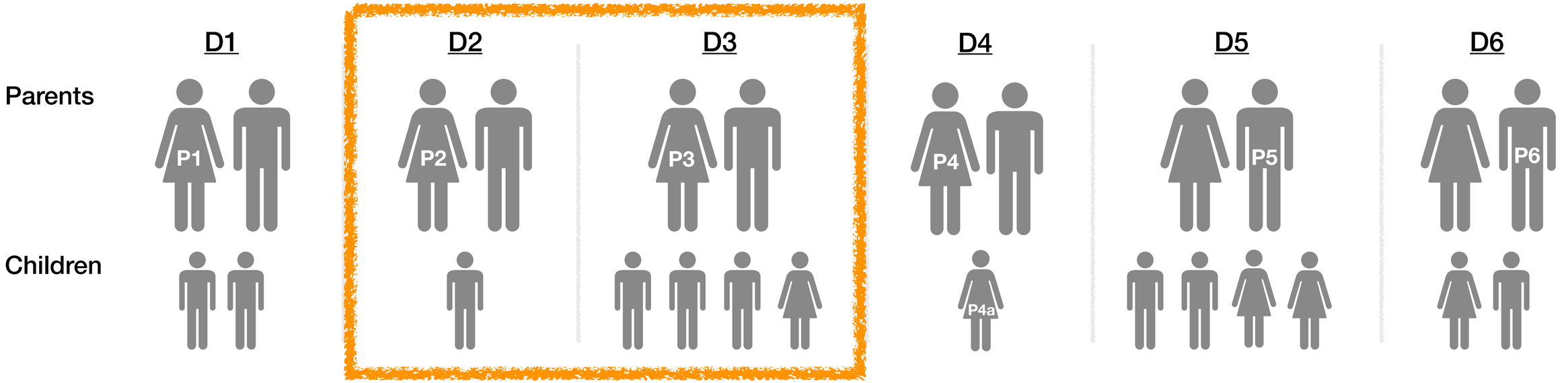
Text alerts keep people engaged

“We detected a PM spike in the bedroom at 10:56 AM. Any idea what caused it?”

How would they use MAAV?

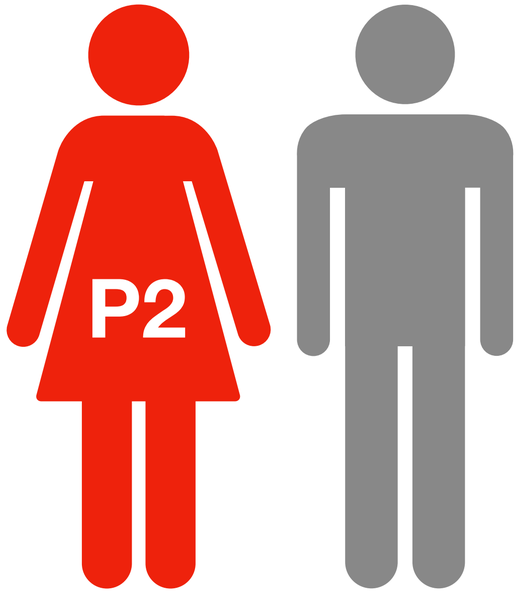
How does engagement change over time?

How does this inform design?



P2 - Strategic Cleaner

Parents



Children

Severe Asthma

P2 Routines

1.0 k
800
600
400
200
0
22:00
23:00
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
bedtime routine
sleeping
morning routine
vacuuming

“When the friend came over that was super allergic, he just knows, he takes Benadryl and stuff before he comes over and this last week -- soon as he walked in the door -- he was like, "Crap! I forgot to my Benadryl!"

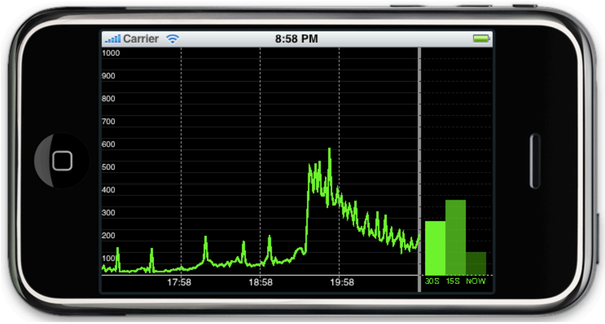
And he ended up not needing any that whole night, and I had vacuumed first thing in the morning instead of mid afternoon, before he came over. He was like "Gosh, that's weird! I went home, I didn't have any reactions..."

I was like "Oh...I didn't clean an hour before you came over. I did it longer before than that...maybe I'll have to keep trying that.”

Complementing and Extending Past Work

InAir Series

Kim et al., 2009 - 2013

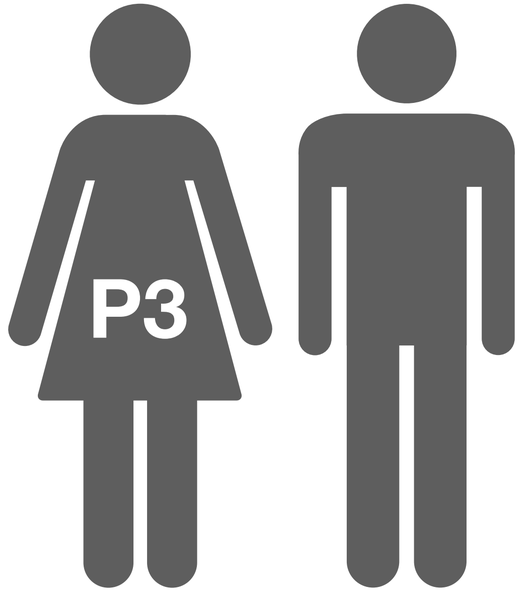


"…users often struggled to connect a change in the level with the cause… [resulting] in feelings of powerlessness and frustration."

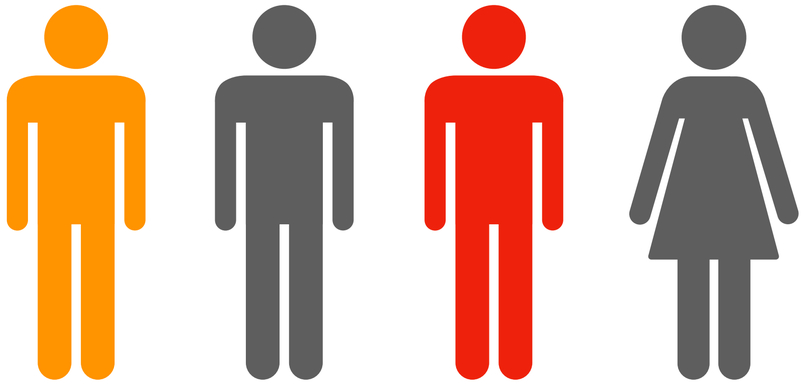
Kim & Paulos, 2010

P3 - Self Experimenter

Parents



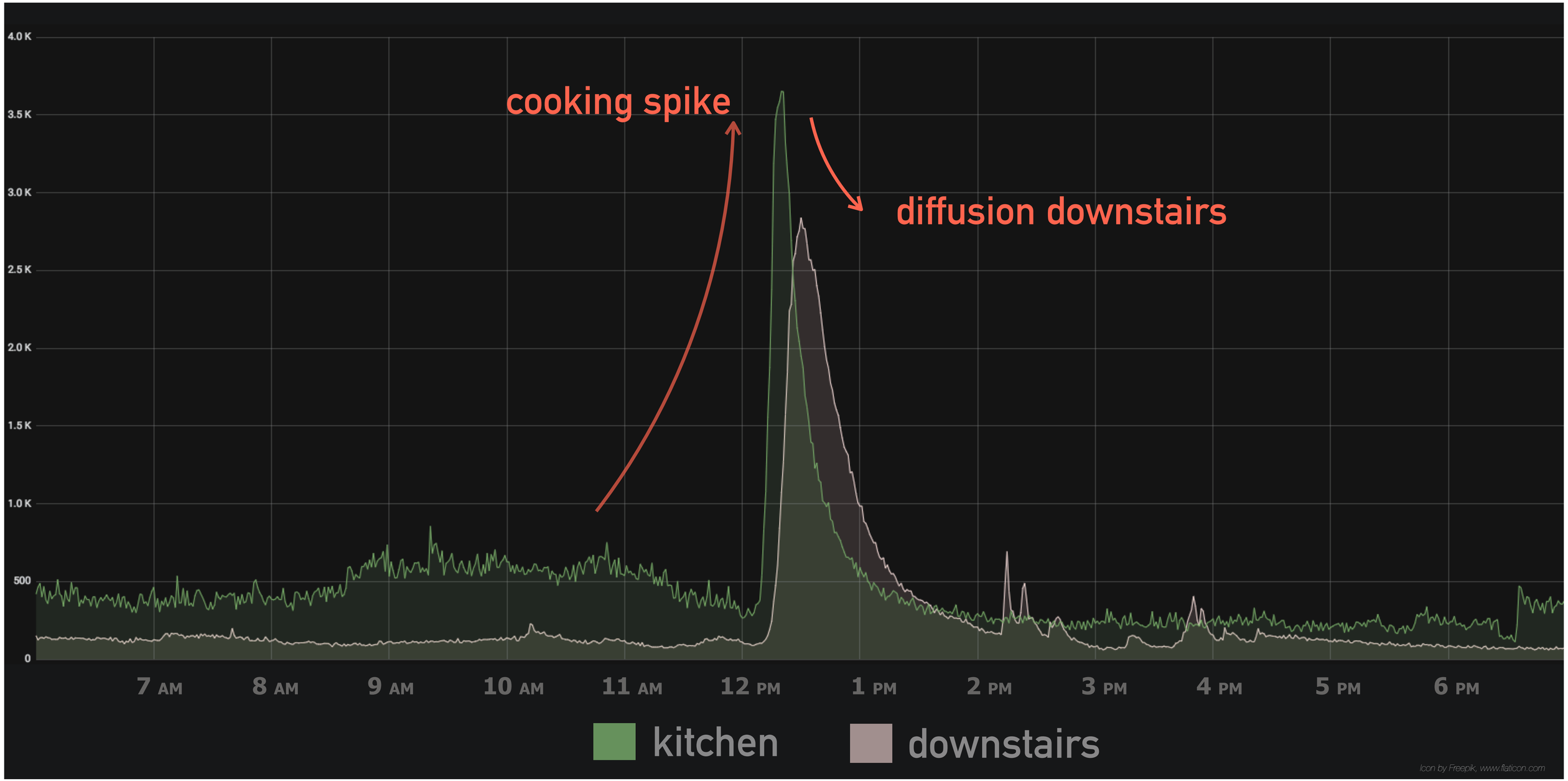
Children



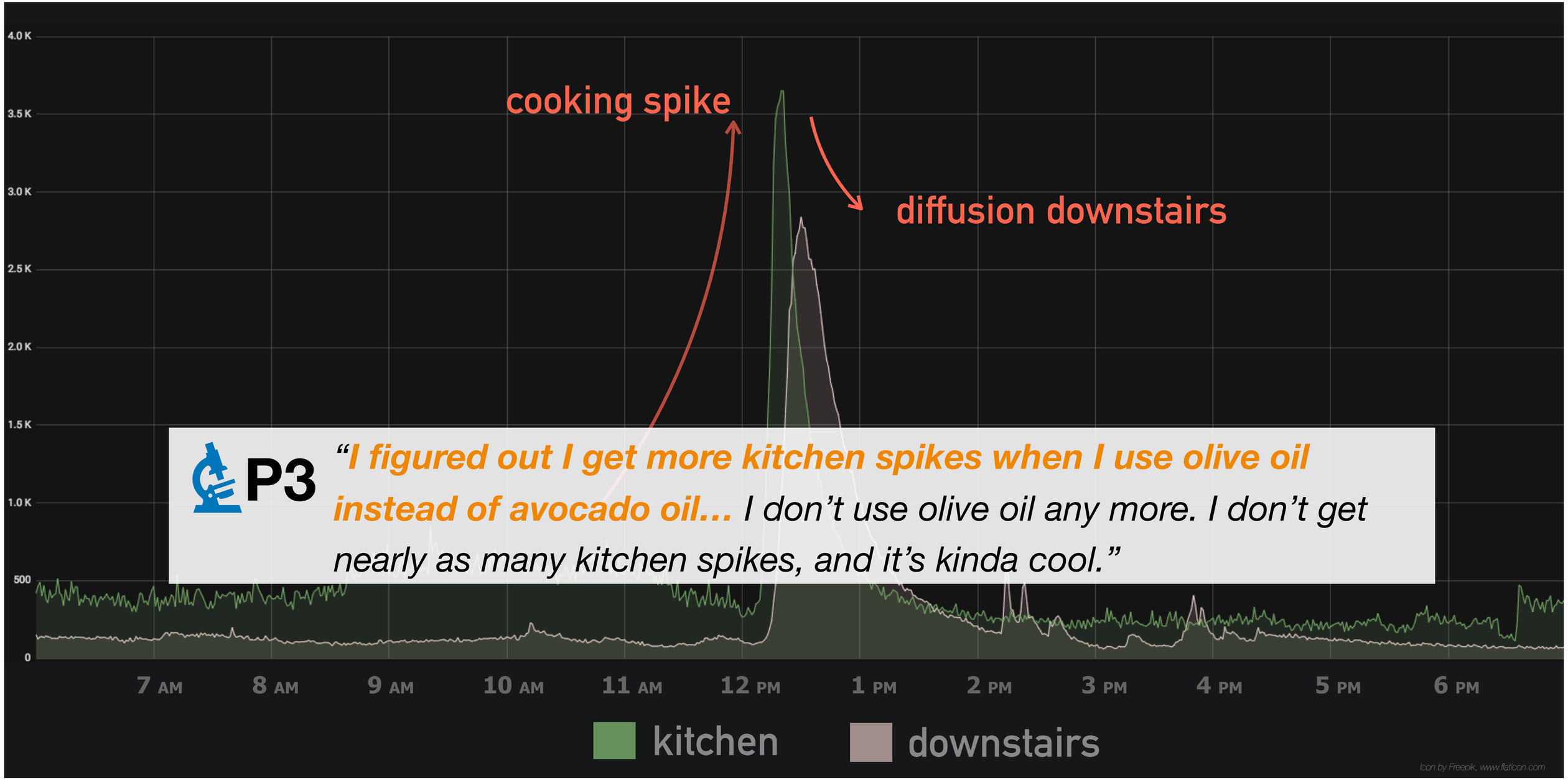
Mild Asthma

Severe Asthma

Unprompted Self Experimentation



Unprompted Self Experimentation



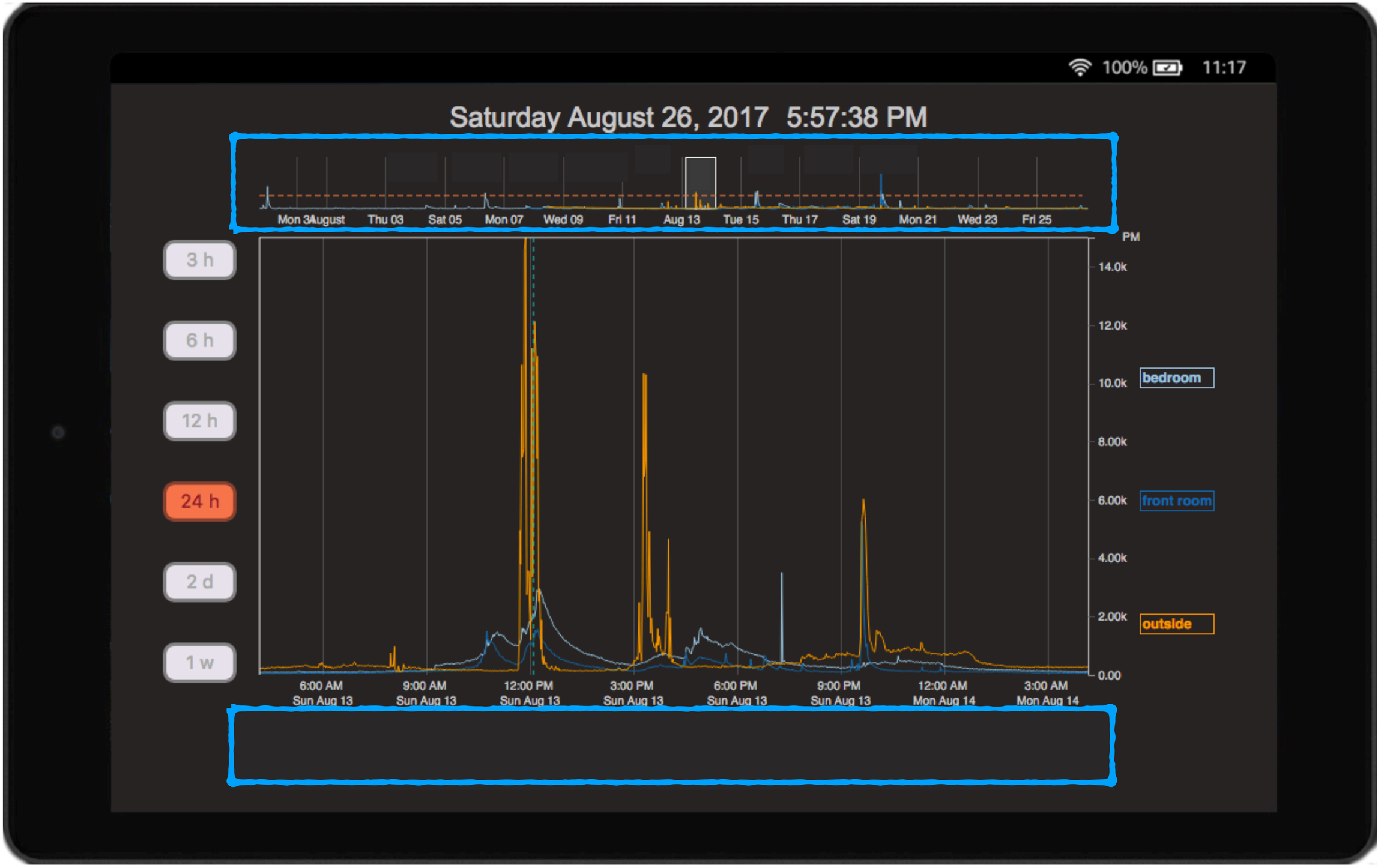
P3 *"**I figured out I get more kitchen spikes when I use olive oil instead of avocado oil…** I don't use olive oil any more. I don't get nearly as many kitchen spikes, and it's kinda cool."*

The Importance of Annotating Your Data

"…personal data generated through [a] networked sensing system is opaque *when considered in isolation. This means that* ***fine grain understandings of interaction cannot be 'read off' the data alone.***"

"*This has to be the cats*" - Personal Data Legibility in Networked Sensing Systems

Tolmie et al, 2016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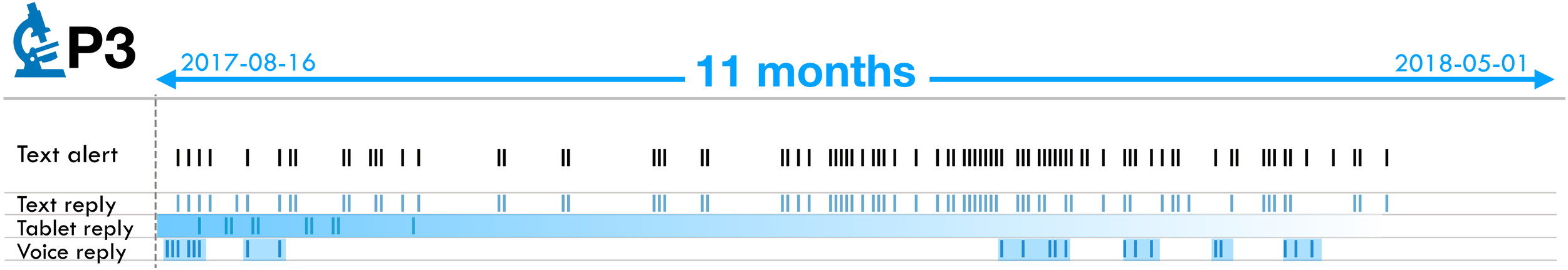
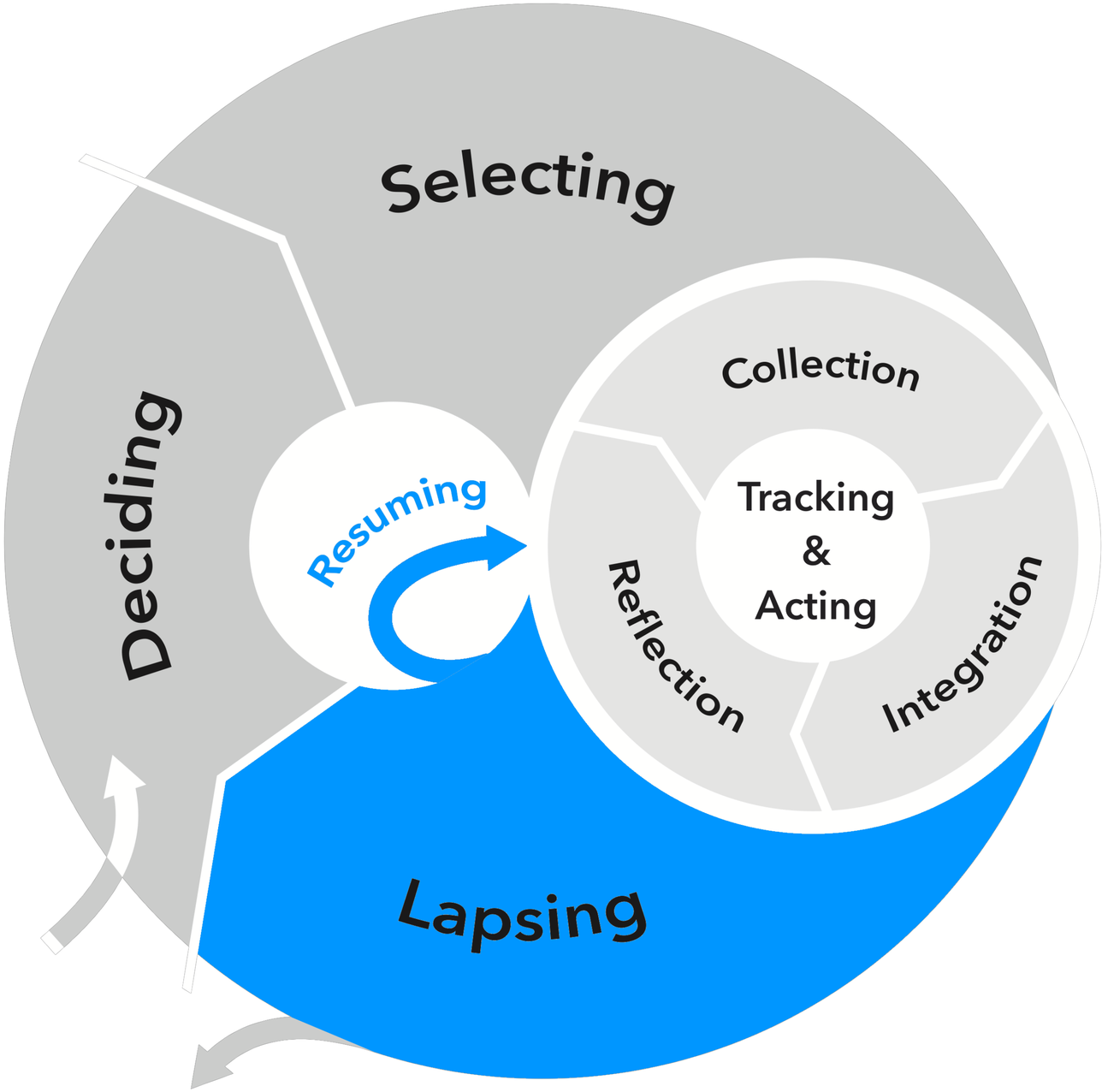
3:00 AM Mon Aug 14

Long Term Use

P3



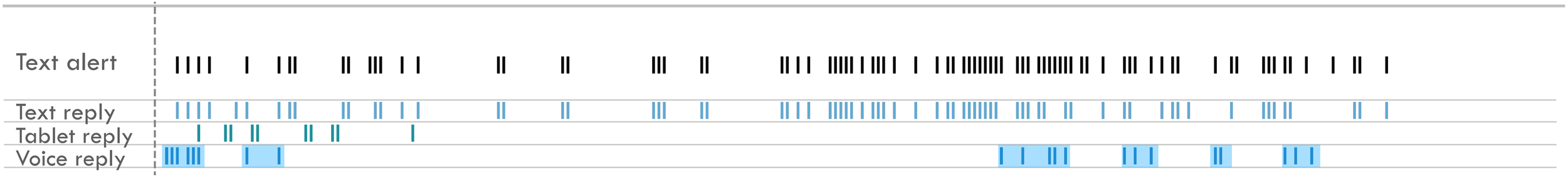
“I had a lot of fun trying to figure out why [the monitor] would go off at various times in the kitchen, so I did a lot of experimenting early on, but once I had my questions answered, it was good.”

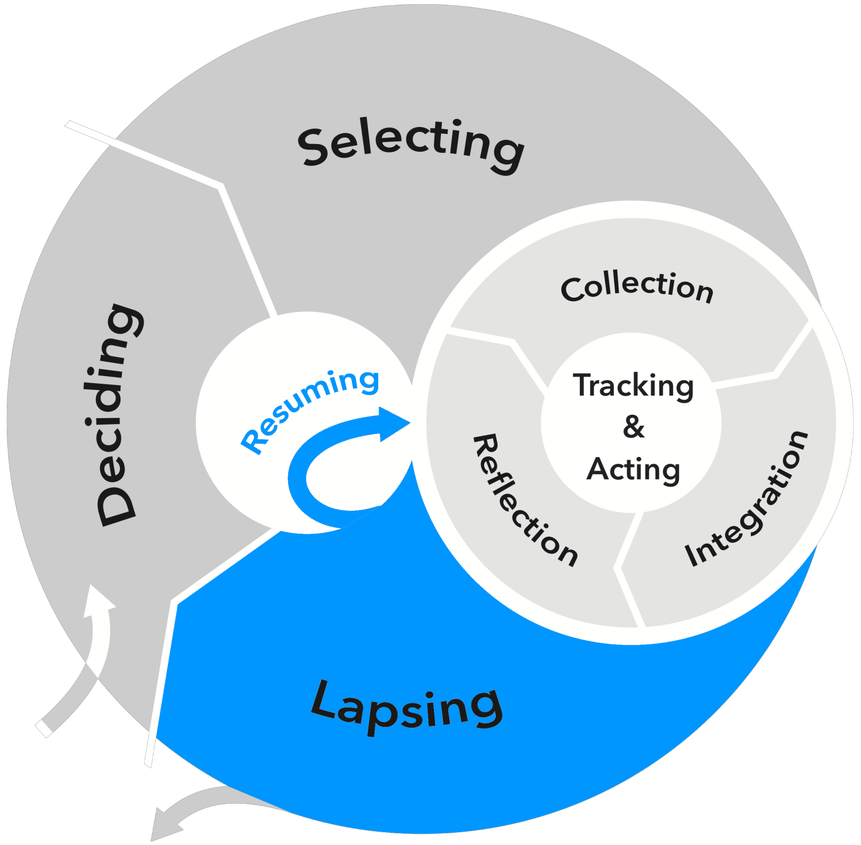


From “A Lived Informatics Model of Personal Informatics”, Epstein et al., 2015. Used with permission.

P3

2017-08-16 — 11 months — 2018-05-01





From "A Lived Informatics Model of Personal Informatics", Epstein et al., 2015. Used with permission.

So What?

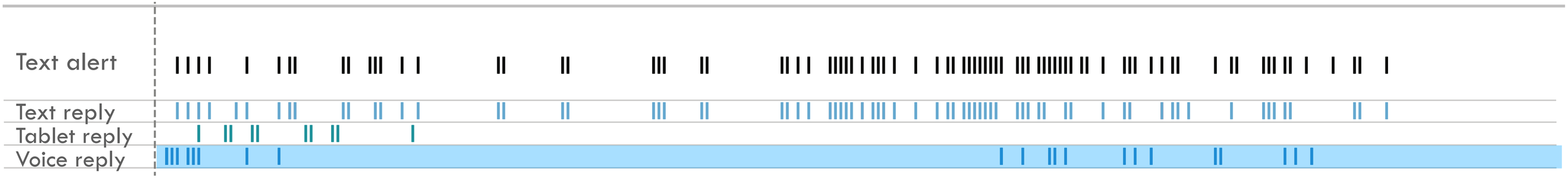
How would people use it?

How does engagement change over time?

How does this inform design?

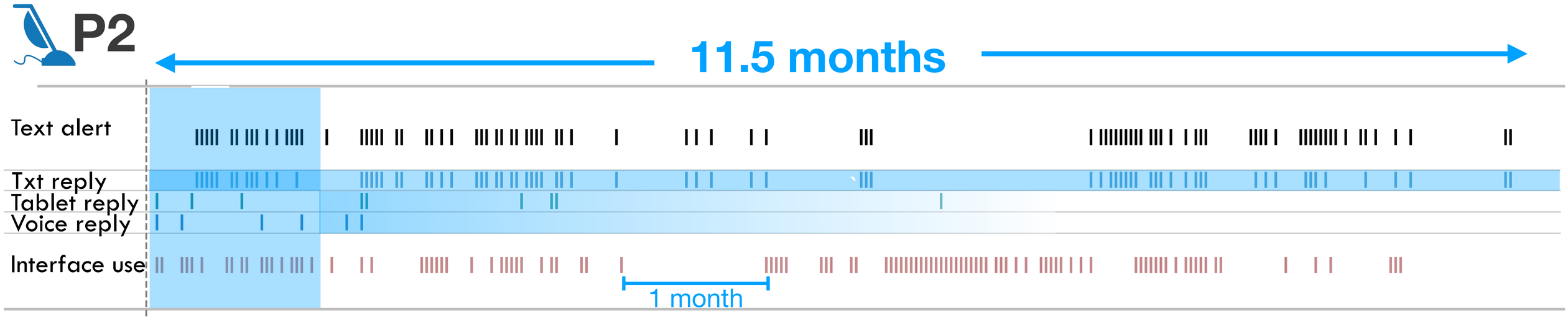
How would people use it?

P3

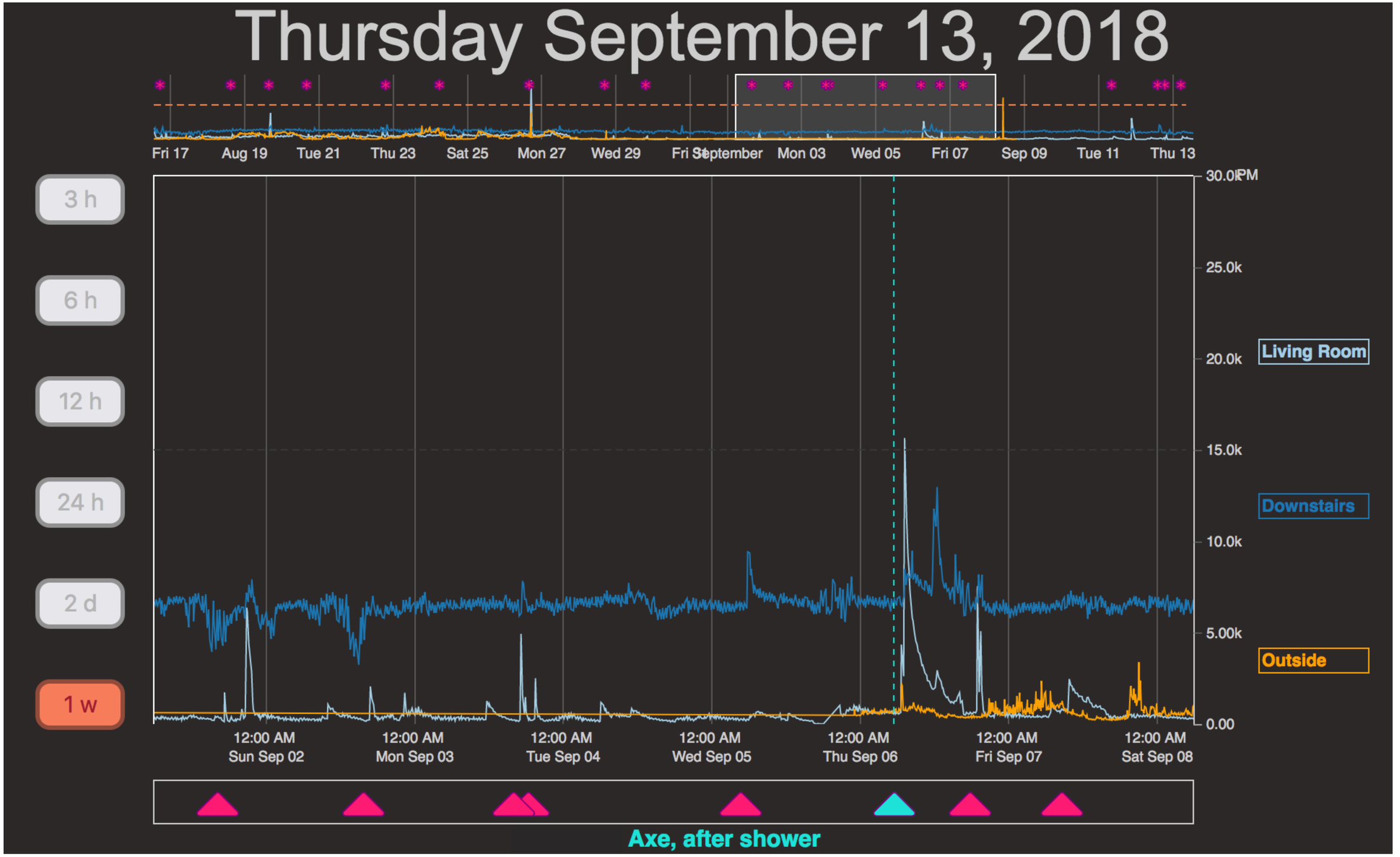


P1

How does engagement change over time?



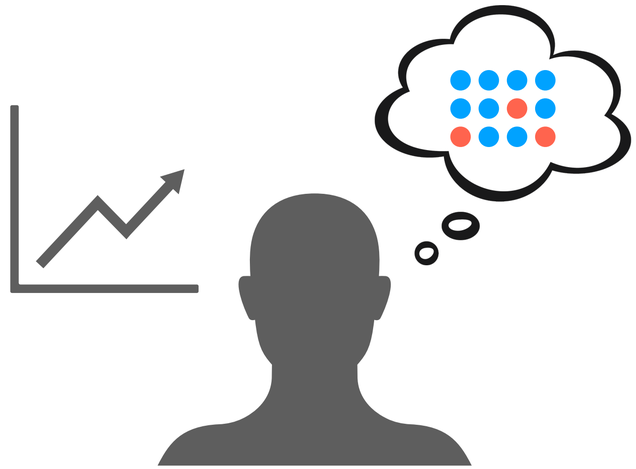
“If it sucks enough for you to message me, that’s going to indicate that something is up.”


Thursday September 13, 2018
Fri 17
Aug 19
Tue 21
Thu 23
Sat 25
Mon 27
Wed 29
Fri September
Mon 03
Wed 05
Fri 07
Sep 09
Tue 11
Thu 13
3 h
6 h
12 h
24 h
2 d
1 w
30.0k PM
25.0k
20.0k
15.0k
10.0k
5.00k
0.00
Living Room
Downstairs
Outside
12:00 AM Sun Sep 02
12:00 AM Mon Sep 03
12:00 AM Tue Sep 04
12:00 AM Wed Sep 05
12:00 AM Thu Sep 06
12:00 AM Fri Sep 07
12:00 AM Sat Sep 08
Axe, after shower

How Does this Inform Design?

Time series views are not enough

Annotated data is essential for sensemaking



Notifications keep people engaged

Managing In-home Environments through Sensing, Annotating, and Visualizing Air Quality Data

Jimmy Moore, et al. jimmy@cs.utah.edu

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visualization design lab

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https://bit.do/maav2018

- Time series views are not enough
- Annotation is essential for sense making
- Notifications keep people engaged

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