Respite

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Introduction

Throughout the course, we have learned about and experienced the subjective benefits of mindfulness. These come in the form of lowered anxiety, improved sleep, longer attention span and increased interoceptive awareness. Mindfulness cannot and should not be reduced to these practical benefits: it is not simply a means to an end, and understanding it as such is a reduction of spiritual practice to wellness intervention. Yet each of these benefits, whether it be sleep or attention related, can also be understood as a tracking mechanism--tangible trait and state changes correlated with increases in mindfulness--so that those engaging in the practice of mindfulness can better understand their progress. Understanding how mindfulness is changing measurably in each of us, as habit and behavior and personality trait, allows for more informed structuring and iterating on daily mindfulness practice.

Mindfulness thus far has proven hugely difficult to operationalize, or make measurable (Quickel, Johnson, and David 2014). Many different scales exist to measure mindfulness, and these are complicated by gulfs between subjective assessment and objective assessment, expert mindfulness and novice mindfulness, different meditative practices, and trait versus state mindfulness. Yet a new paper from Richie Davidson's lab offers a step towards a solution in the form of the first validated behavioral measure of mindfulness--breath counting. In four independent studies with over 400 total participants, they found breath counting correlated with self-reported mindfulness, differentiated long-term meditators from age-matched controls, was associated with more meta-awareness, less mind wandering, better mood, and greater non-attachment. This one skill, breath counting, is a reliable index for so many different facets of mindfulness! Yet it also is a training mechanism: Davidson et al found that 4 weeks of breath counting training improved mindfulness and decreased mind wandering relative to working memory training and no training controls. These findings provide the first evidence for a behavioral measure of mindfulness, and unsurprisingly have their roots in a breath counting practice found as far back as 430 A.D. (Levinson et al. 2014).

We took this study as inspiration for translational neuroscience of mindfulness! Breath counting, if it can be done cheaply and simply, could open up doors to tracking and training mindfulness and its many facets. We built Respite, a mobile app which integrates the elements of the Davidson paper into an iOS app, including 1) breath tracking 2) breath training 3) mindfulness trait assessment MAAS 4) habit forming assessment SRHI 5) integrated scientific explanations. With this app, people can train and track their mindfulness via breath, see how their trait mindfulness personality is changing over time with the MAAS, see how successfully they are forming a mindfulness habit over time with the SRHI, and better understand the science which elucidates a mindfulness

practice. We hope this tool can help people have a clearer picture of their practice and how it changes with time.

System

Hardware

One of the goals of this project is to make this system massively deployable. Therefore, we wanted to use off-the-shelf hardware and nothing more. We chose to use the accelerometer embedded in the iPhone. According to Apple's official documentation, the maximum frequency at which one can request accelerometer updates is hardware-dependent, but is usually at least 100 Hz (which is what we are using).[1] There were no specs for specific iPhone models, but a handy stackoverflow post[2] guided us towards a teardown of the iPhone 6, where Apple's choice for including two accelerometers was described, one accelerometer that can sample at a maximum of 2 kHz, and one at 4 kHz.[3] Therefore, this system should be able to work in any iPhone 6 and newer.

Software

We sampled at a frequency of 100 Hz. To count the number of breaths, we used 4 filtering stages and one peak detector algorithm. First we cleaned up the data removing big jumps between samples. Given that for deep breathing one normally do a breath of at least 5 seconds, the breathing frequency is at most 0.2 Hz. Therefore, the second stage was a low-pass filter with a cut-off frequency of 0.25 Hz. This removed all the unwanted high-frequency noise. The third stage was an envelope-follower with a window size of 50 samples, meaning that the output was the highest value in the last half-second. To smooth-out this signal, we applied a second low-pass filter with the same cut-off frequency of 0.25 Hz. Finally, a peak detector algorithm was used to count the number of breathe-ins and breathe-outs. If a sample was bigger than the previous one, the point was considered positive, else, negative. If 5/9th of a window of 50 was positive, the point was considered a breathe-in, else, breathe-out. 30 or more consecutive points of the same category were considered either a breathe-in or out.

The interaction is as follows: the user fills-in both surveys. Then they go into the breathe count screen, select a session duration, press start, and place the iPhone on their stomach. After the selected time passes, the app emits a sound indicating the end of the session and prompts the user to input the number of breaths they counted. The survey scores and breathe counting accuracy is logged and graphed across time.

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[1] https://developer.apple.com/documentation/coremotion/getting_raw_accelerometer_events
[2] https://stackoverflow.com/questions/37937453/iphone-accelerometer-sampling-frequency
[3] https://www.macrumors.com/2014/09/26/iphone-6-6-plus-two-accelerometers/

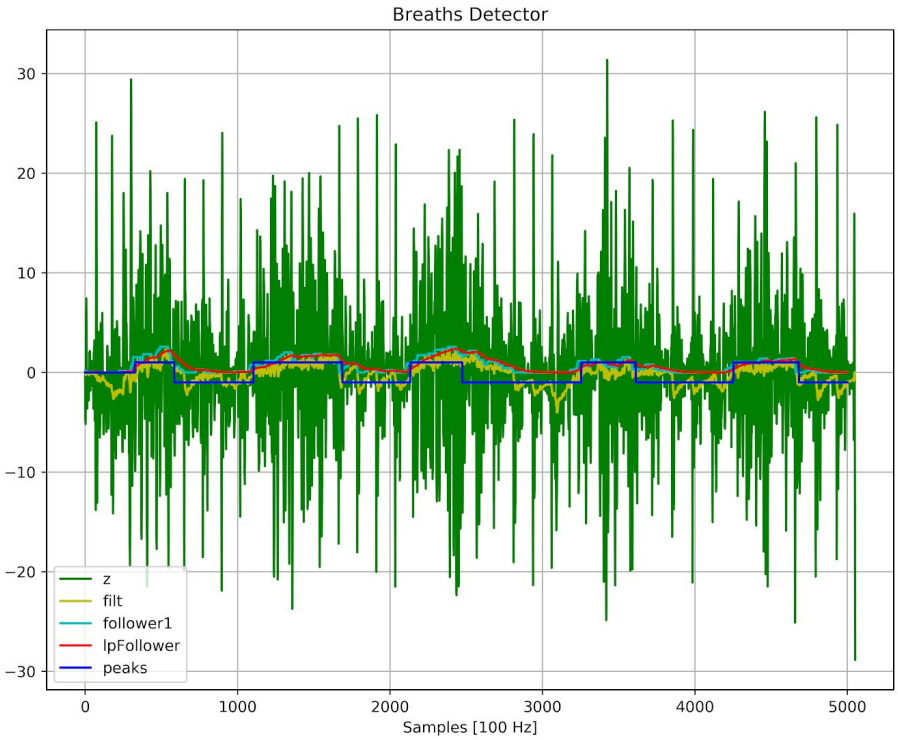

Fig 1. Raw, first low-pass filter, peak-follower, second low-pass filter, and peaks

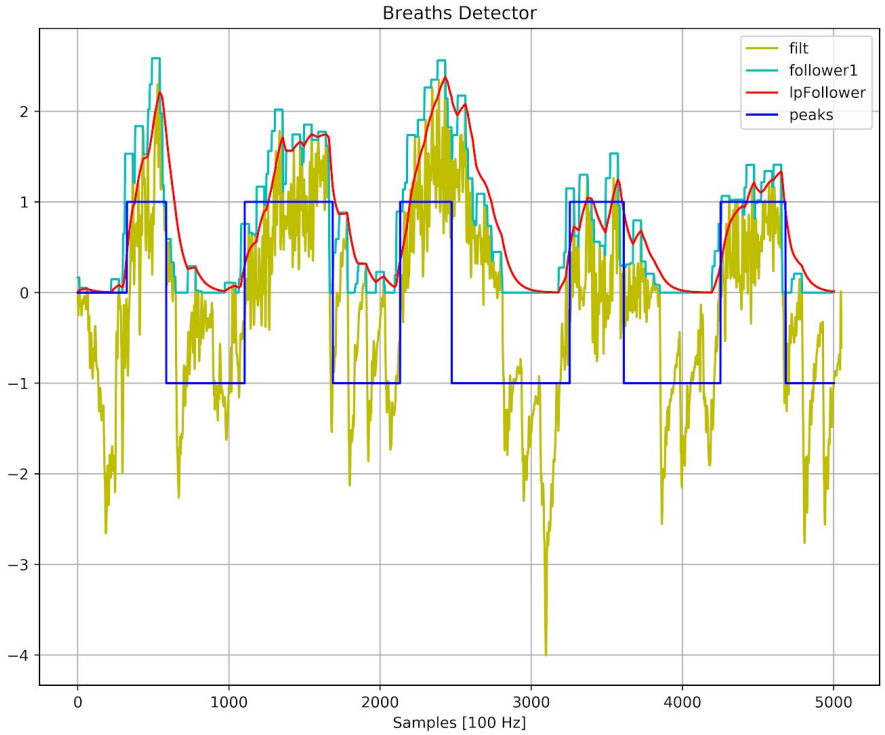

Fig 2. First low-pass filter, peak-follower, second low-pass filter, and peaks

Pilot Experiment

We executed a pilot experiment (n=8) wherein subjects engaged in breath counting and self-assessment of mindfulness traits and habits. Subjects counted breath for 3 minutes while the Respite iOS app counted their breaths. Both scores were compared for deltas, and measured against the ground truth of an observing experimenter counting breaths by sight. This pilot experiment is meant to 1) validate the utility of the Respite iOS app for breath counting within the context of mindfulness tracking and 2) identify any trend relationships between successful breath counting and subjective mindfulness assessments. One subject was eliminated due to experimenter error, namely poor placement of the iPhone during breath counting.

Data

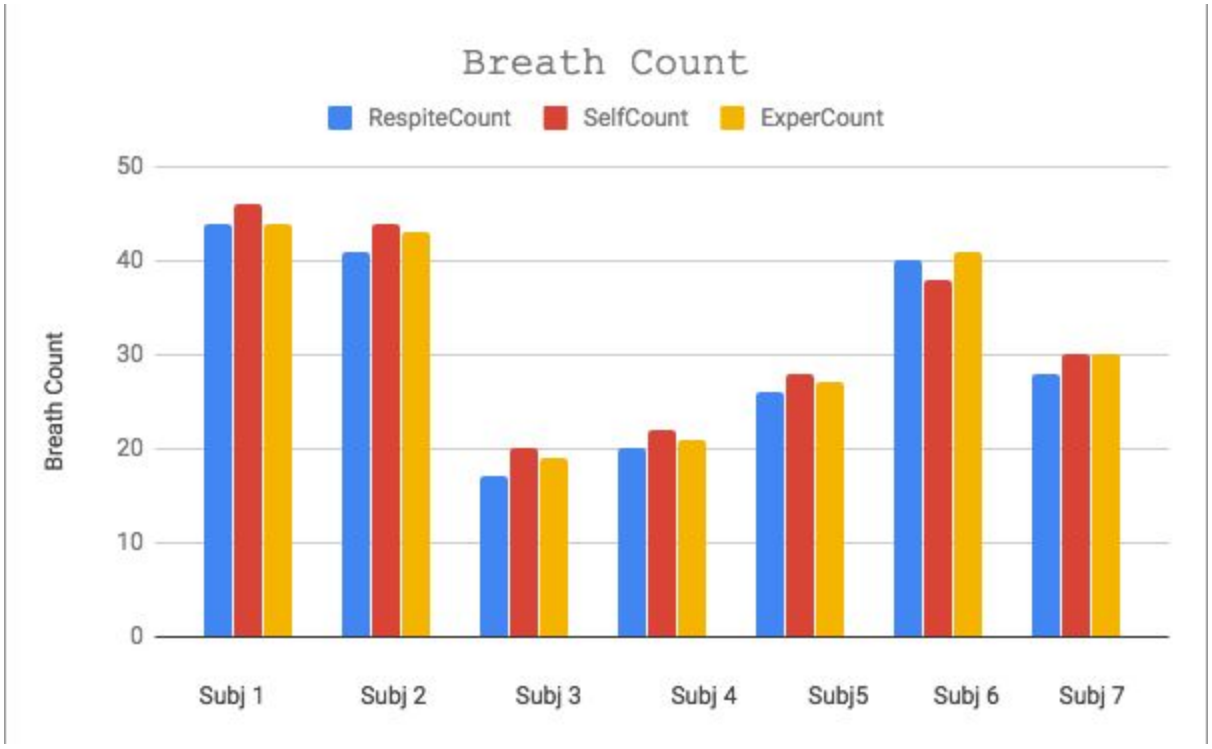

Fig 3. Comparisons of breath counts over 3 minute period by the Respite App, by self-assessment of the subject, and by experimenter (n=7)

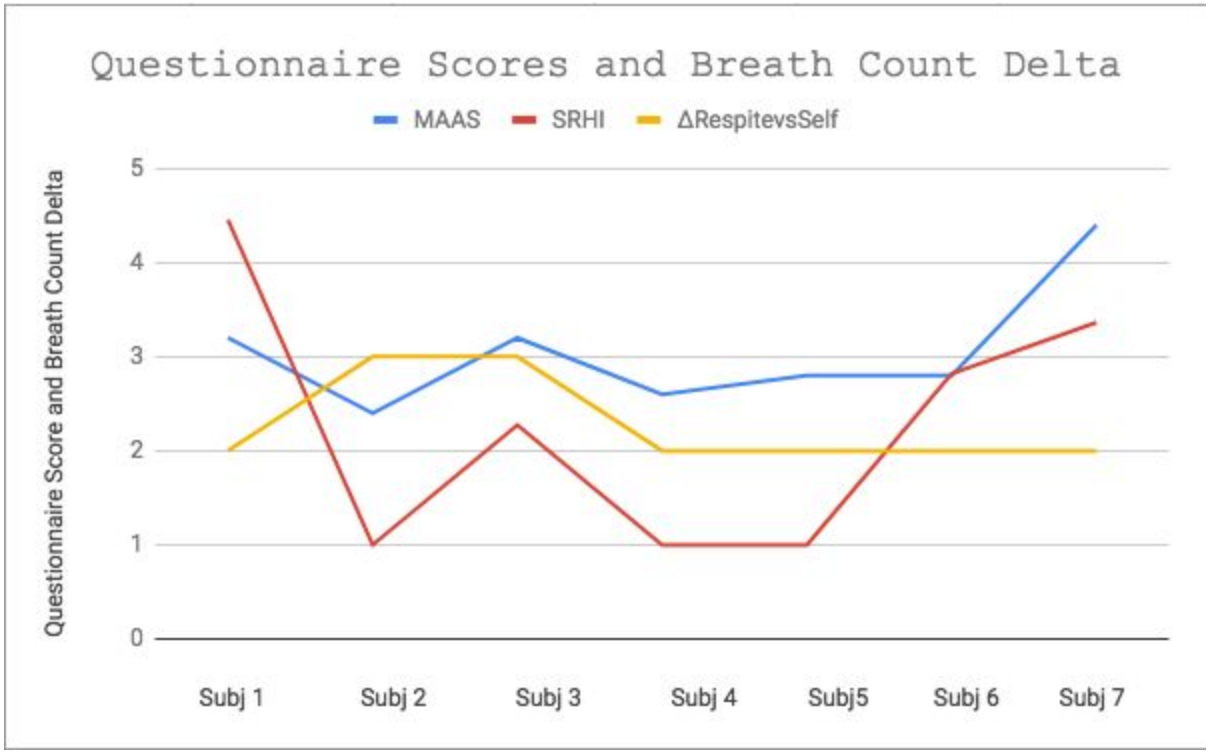

Fig 4. Comparisons of breath counts delta between Respite App and Self-Assessment trend relationships with scores on MAAS and SRHI questionnaires.

Results

With limited subjects (n=7) it is not meaningful to make claims to statistical significance, but there is a clear success in breath tracking with the Respite app, as shown in minimal deltas between RespiteCount and ExperimenterCount in the comparison of breath counts. With respect to trend relationships between delta of Self-Assessment Count and Respite App Count, there are no clear trends emerging yet. This is likely due to the limited time (3 minutes) of breath counting, offering limited opportunity for stimulus independent thought (attentional lapses) and thus a homogenous data sample with limited breath counting errors.

Future Work and Conclusions

We have arranged a meeting with Professor Richie Davidson for July 20th, after sending him information on our Respite iOS demo. We will work with him to improve app aesthetics, training video, and onboard mindfulness assessments. We will execute a breath counting test with a longer count period, and test this data on breath count deltas (likely more varied) against MAAS and SRHI data collected from within the app. We plan on putting the Respite app online, free and open-source, such that his paper can have maximal impact beyond the neuroscience community. A behavioral marker of mindfulness that can be tracked and trained is exciting for the community of

neuroscientists who will read his paper, but should also be a tool available to the public at large who want to navigate their own spiritual and scientific practice.

This project exists within a larger framework of science/spirituality/tech interactions. Our Awareness class exists within the Media Lab, and so a vocabulary infused with scale, technology, impact and objectivity are ever-present. Yet in our discussions on Resisting Reduction, on emotion, and on subconscious knowing with Nainoa, we have come across the friction between many ways of knowing, and the spaces in between. A meditation practice may not be a wholly knowable thing in the scientific sense, and the Awareness class created space for this ambiguity and personal experience. This is part of what made many of us grow over the semester, taking opportunities in discussions and in practice to think beyond strict logical models of productivity and truth. Setting time aside to simply sit still, and then finding it hugely useful, will complicate traditional models of productivity espoused at MIT!

As we move forward with this project, and intersect with principles of objectivity in science and generalizability in technology, these central themes and questions must form a key part of our design process. What is the best way to work with subtle spiritual practices, that are by nature irreducible? And what if those practices have concrete cognitive and physiological benefits, which should be spread for the greater good? And how can technologists interact effectively with those scientists and spiritual practitioners each seeking to understand a practice in different lights? And what are the ethics of condensation of something as subtle as a mindfulness practice into an app, digestible and yet incomplete? These are all questions which we are interested in framing and reframing as we work between many modes of self-understanding, as we did during together over the semester, and aim to be effective translators.

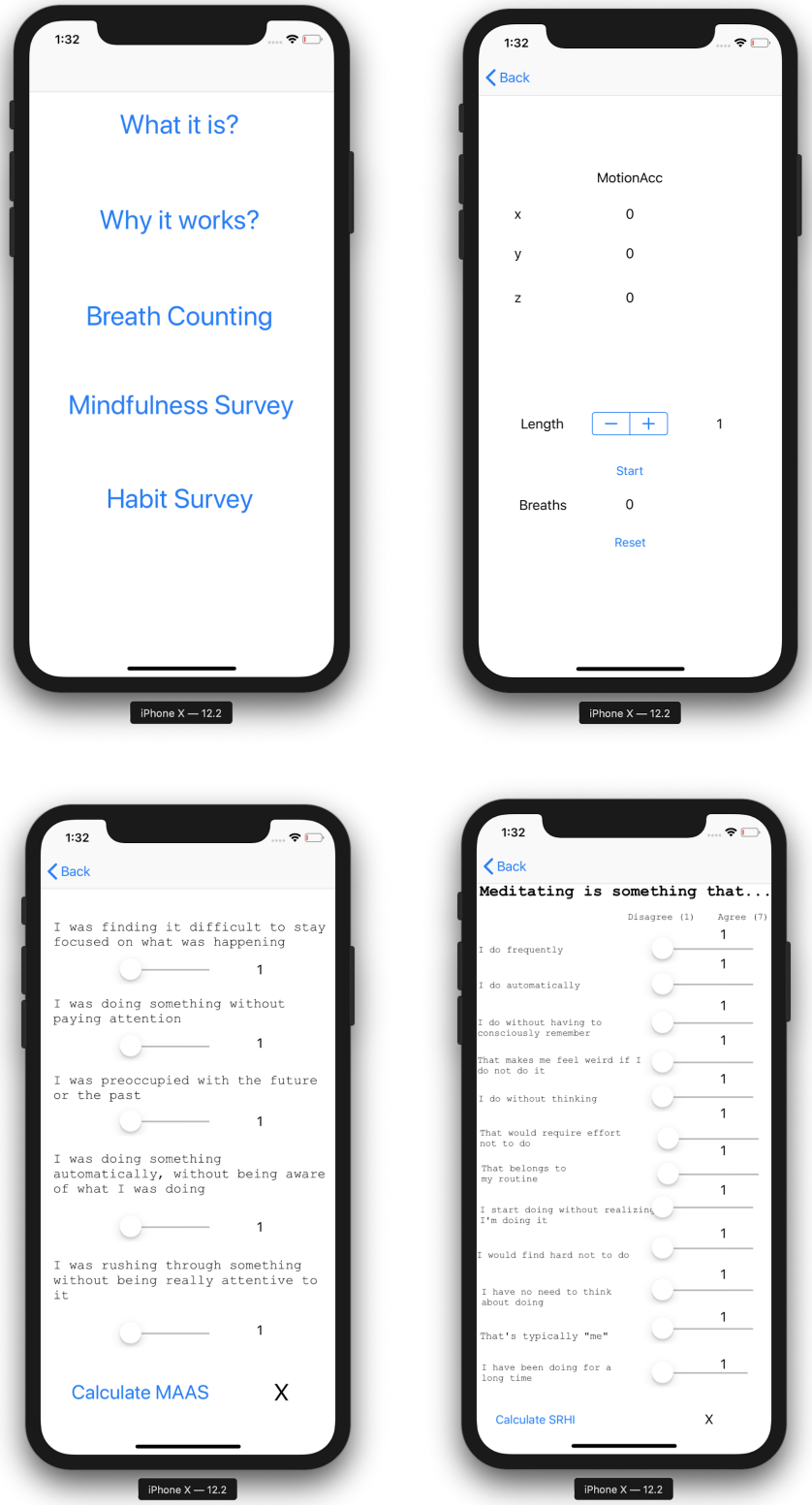

Fig 5. From top-left to bottom-right: Menu, breathing experience, MAAS, and SRHI.

Levinson, Daniel B., Eli L. Stoll, Sonam D. Kindy, Hillary L. Merry, and Richard J. Davidson. 2014. "A Mind You Can Count on: Validating Breath Counting as a Behavioral Measure of Mindfulness." *Frontiers in Psychology* 5 (October): 1202.

Quickel, Emalee J. W., Susan K. Johnson, and Zhanna L. David. 2014. "Trait Mindfulness and Cognitive Task Performance: Examining the Attentional Construct of Mindfulness." *SAGE Open* 4 (4). https://doi.org/10.1177/2158244014560557.