Using a Fitness Tracker to Predict Automatically Reinforced Problem Behavior

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Introduction

- Smart watches have become ubiquitous in developed nations due to their falling cost and increased functionality
- Among their many uses, smart watches can serve as fitness trackers that monitor body temperature, heart rate (HR), muscle motion, and other health data (Lu et al., 2016)
- Automatically reinforced problem behaviors associated with heightened states of physical activity (e.g., self-injurious behavior) may correlate with increased HR
- Similarly, elevated HR could be predictive of problem behavior before it occurs
- If a relationship were established between elevated HR and problem behavior, then HR could potentially be used as a cue to take action before the behavior begins

Method

Participants

- A fifteen year old male with autism who has a history of automatically reinforced problem behavior
- A FBA was conducted on the subject to rule out socially mediated reinforcement of problem behavior

Targets

- *Partial Overlap:* The percentage of problem behaviors where the reported time of the problem behavior partially overlapped with an elevated heart rate (HR $>$ 100 bpm)
- *Precedes Onset:* The percentage of problem behaviors where the reported time of the problem behavior was preceded by an elevated heart rate (HR $>$ 100 bpm) by no more than 10 minutes
- 10 minutes was chosen to allow the increase in HR to potentially be connected to the problem behavior because not enough time would have elapsed for a cool-down period to occur
- Problem behavior was defined as self-injurious behavior (i.e., hand biting, striking the face with a closed fist, and head banging) and/or aggression towards others (i.e., attempts to bite, hit, or kick)

Procedures

- An online form was created to collect information about each incidence of the subject's problem behavior from parents, teachers, and other caregivers
- HR information (i.e., bpm vs time) was collected from the Fitbit and downloaded into a spreadsheet
- The time and duration of each problem behavior was plotted to overlay time series data of the subject's HR to look for correlations between the two
- An alpha of 5% (2.5% each tail) was used to establish statistical significance using 10,000 simulations of the binomial distribution for each condition

Results

- Data was collected for a ten week period from March 15 to May 24, 2018, with 32 total problem behaviors recorded
- Below are examples of daily data collection showing heart rate versus time of day in blue
- Incidents of problem behavior are shown as red horizontal lines with the length corresponding to the duration of the episode
- These incidents are also annotated with text giving the onset time of the problem behavior followed by its duration

Ex 1: Partial Overlap, Not Preceding Onset

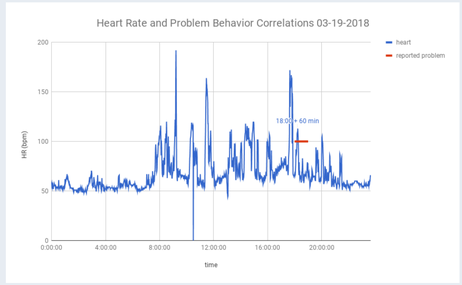

Figure: Data collected on 3/19/2018 shows partial overlap of elevated HR and the reported time of the problem behavior. This was scored as a '1' for Partial Overlap and '0' for Precedes Onset.

Ex 3: Partial Overlap, Preceding Onset

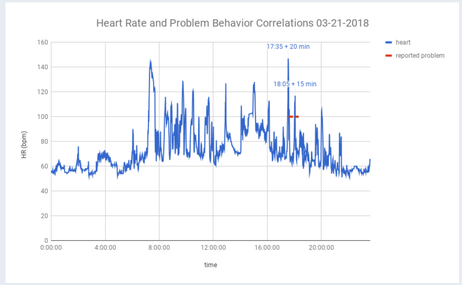

Figure: Data collected on 3/21/2018 shows two incidents with partial overlap and elevated HR preceding the reported onset. This was scored as a '1' for Partial Overlap and '1' for Precedes Onset.

Ex 2: No Overlap, Not Preceding Onset

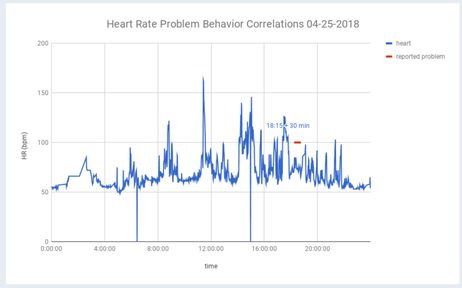

Figure: Data collected on 4/25/2018 demonstrates a problem behavior that is not preceded by an elevated HR nor does it overlap with an elevated HR. This was scored as a '0' for Partial Overlap and '0' for Precedes Onset.

Ex 4: No Overlap, Preceding Onset

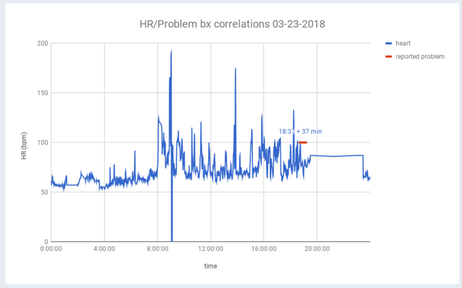

Figure: Data collected on 3/23/2018 shows an elevated HR following the reported onset of problem behavior. This was scored as a '0' for Partial Overlap and '1' for Precedes Onset.

Overlap Probability Mass Function

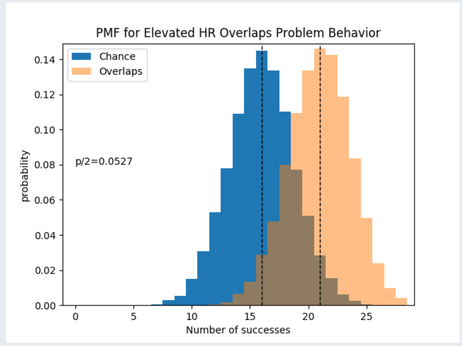

Figure: For 32 incidents, chance would average 16 overlaps. The study found 21 overlaps with a 11% probability of attaining this value by chance.

Precedes Probability Mass Function

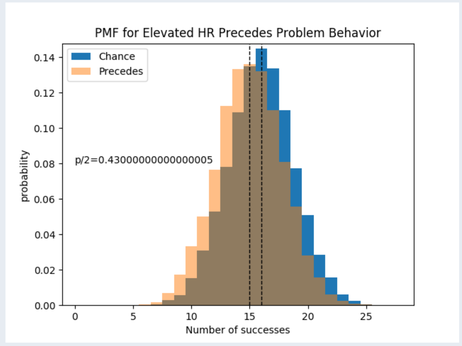

Figure: For 32 incidents, chance would average 16 precedes. The study found 15 precedes with a 86% probability of attaining this value by chance.

Results (continued)

Date	Partial Overlap	Precedes Onset
3/19/2018	1	0
3/21/2018	1	1
...	...	...
5/7/2018	0	0
5/10/2018	0	1
Totals	21/32=65.6%	15/32=46.9%

- The reported time period of a problem behavior overlapped with a HR greater than 100 bpm on 65.6% of episodes. This represents 21 of 32 episodes, a value that would be expected 11% of the time by chance.
- A HR greater than 100 bpm preceded the reported onset of problem behavior on 46.9% of episodes. This represents 21 of 32 episodes, a value that would be expected 86% of the time by chance.

Discussion

- No statistically significant relationship was established for either condition
- A marginally better relationship was established between the partial overlap of elevated HR and reported times of problem behavior
- The study suffered from problems with the Fitbit battery being low during problem behaviors
- The accuracy of the HR monitoring of the Fitbit was contingent upon proper placement on the wrist which could be adjusted by the subject
- There were also problems with the reliability of the reported onset/offset times (i.e., not reporting an accurate onset time due to dealing with the problem behavior itself)
- Allowing for a certain degree of error in reporting the onset time may also improve the relationship
- The HR criteria of 100 bpm and cool down period of 10 minutes are somewhat arbitrary and adjusting these values may yield better results
- Future studies could determine if a self-monitoring intervention could help caregivers implement antecedent strategies to deter potential problem behaviors before they arise

References

Lu, T. et al. (2016), Healthcare Applications of Smart Watches. *Applied Clinical Informatics, 7*(3), 850-869

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- ptsouth97@gmail.com
- https://github.com/ptsouth97/FitnessTracker