Unity field trip!

April 9 or 23 at 4pm in SF?

Or possibly April 2 or 30 at 4pm

Exploring Application Areas of Physiological Sensing (and Synchrony)

Collective Intelligence (CI)

Collective Intelligence is a group’s shared intelligence that comes from collaboration and collective efforts.

Evidence for a Collective Intelligence Factor in the Performance of Human Groups

http://science.sciencemag.org/content/330/6004/686

Woolley, Anita Williams; Chabris, Christopher F.; Pentland, Alex; Hashmi, Nada; Malone, Thomas W. (2010-10-29). "Evidence for a Collective Intelligence Factor in the Performance of Human Groups". *Science*. **330** (6004): 686–688.

Found evidence for general collective intelligence (c) working with 699 people working in groups of two to five on a wide variety of tasks.

Tasks included solving visual puzzles, brainstorming, making collective moral judgments, and negotiating over limited resources.

Average and maximum individual intelligence not correlated to group intelligence

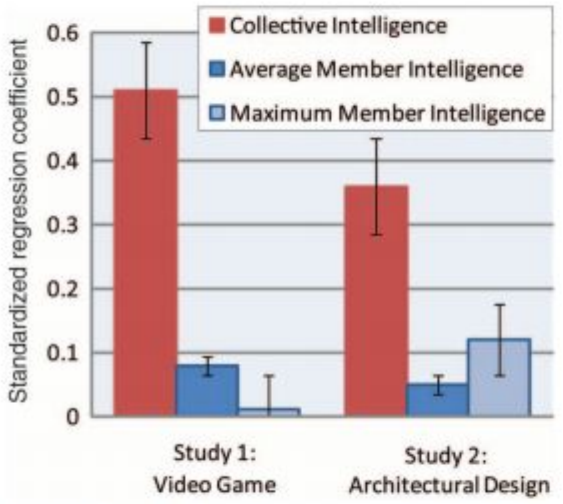


Fig. 1. Standardized regression coefficients for collective intelligence (*c*) and average individual member intelligence when both are regressed together on criterion task performance in Studies 1 and 2 (controlling for group size in Study 2). Coefficient for maximum member intelligence is also shown for comparison, calculated in a separate regression because it is too highly correlated with individual member intelligence to incorporate both in a single analysis (r = 0.73 and 0.62 in Studies 1 and 2, respectively). Error bars, mean ± SE.

They examined a number of group and individual factors that might be good predictors of c. They found that many of the factors one might have expected to predict group performance—such as group cohesion, motivation, and satisfaction—did not.

However, three factors were significantly correlated with c.

1. There was a significant correlation between c and the average social sensitivity of group members, as measured by the “Reading the Mind in the Eyes” test (15) ($r = 0.26$, $P = 0.002$).

2. c was negatively correlated with the variance in the number of speaking turns by group members, as measured by the sociometric badges worn by a subset of the groups (16) ($r = –0.41$, $P = 0.01$). In other words, groups where a few people dominated the conversation were less collectively intelligent than those with a more equal distribution of conversational turn-taking

3. c was positively and significantly correlated with the proportion of females in the group ($r = 0.23$, $P = 0.007$). However, this result appears to be largely mediated by social sensitivity (Sobelz = 1.93, $P = 0.03$), because (consistent with previous research) women in their sample scored better on the social sensitivity measure than men [$t(441) = 3.42$, $P = 0.001$].

In summary: group intelligence is positively correlated with:

1. the average social sensitivity of group members

2. the equality in distribution of conversational turn-taking

3. the proportion of females in the group (which the authors found to be related to the first point)

Backed up by other studies such as:

“Groups where a few people dominated the conversation were less collectively intelligent than those with a more equal distribution of conversational turn taking”

Engel, D.; Woolley, A. W.; Jing, L. X.; Chabris, C. F. & Malone, T. W. (2014). "Reading the Mind in the Eyes or reading between the lines? Theory of Mind predicts collective intelligence equally well online and face-to-face". *PLoS ONE*. **9** (12): e115212.

Deep Structures of Collaboration: Physiological Correlates of Collective Intelligence and Group Satisfaction

Chikersal, P., Tomprou, M., Kim, Y.J., Woolley, A.W. and Dabbish, L., 2017, February. Deep structures of collaboration: physiological correlates of collective intelligence and group satisfaction. In *Proceedings of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing*(pp. 873-888). ACM.

How does physiological synchrony, which is thought to be an indicator of coordination and rapport, relate to collective intelligence?

Investigate:

Electrodermal activity (EDA)

Heart rate

Facial expressions

Physiological Synchrony

Behavioral synchrony promotes affiliation, rapoort and cooperation.

Physiological synchrony is less consciously controllable.

e.g.Trust found to have a positive effect on heart rate synchrony (Mitkidis et al. 2015)

Panagiotis Mitkidis, John J. McGraw, Andreas Roepstorff, and Sebastian Wallot. 2015. Building trust: Heart rate synchrony and arousal during joint action increased by public goods game. Physiology & behavior 149: 101–106.

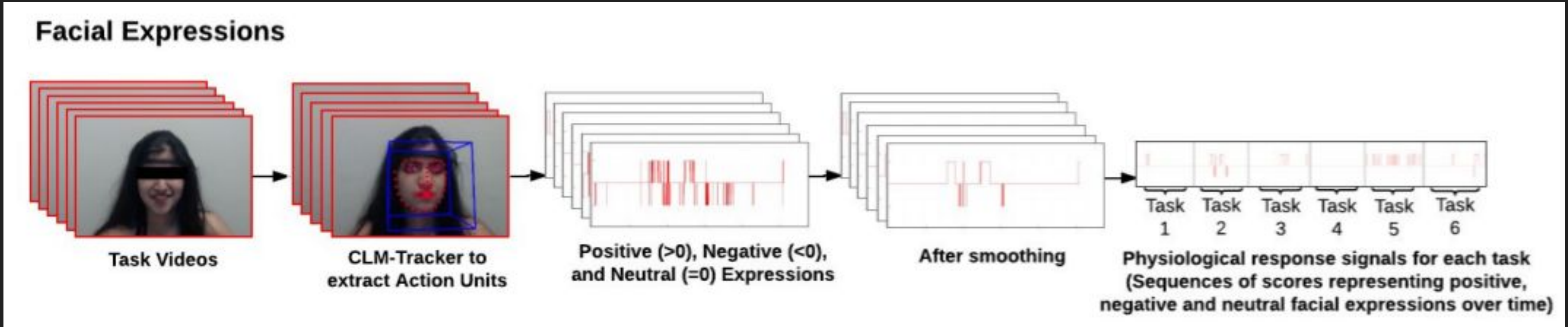
Hypotheses

Hypothesis 1. Physiological synchrony is positively related with (a) collective intelligence and (b) group satisfaction.

Hypothesis 2. Group average social perceptiveness will affect (a) collective intelligence and (b) group satisfaction via effects on physiological synchrony.

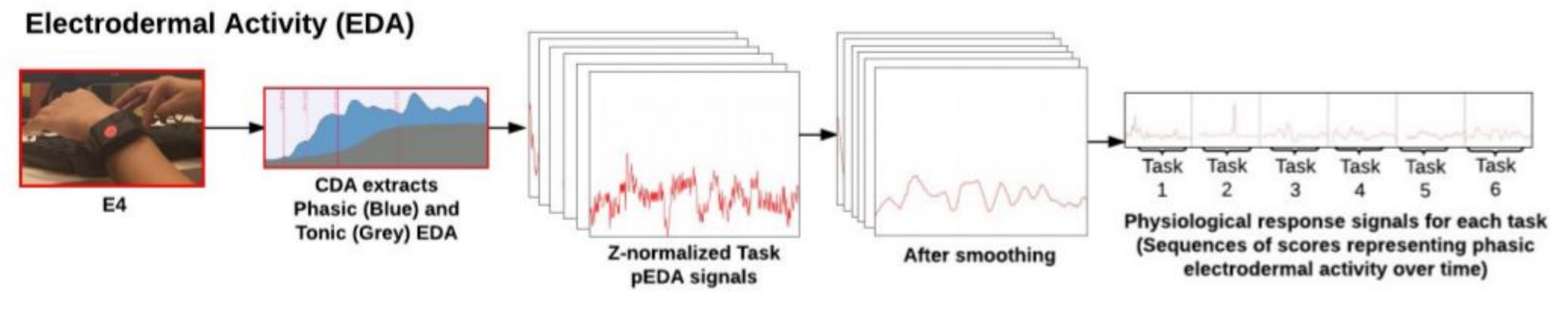
Hypothesis 3. Group composition (sex diversity, age diversity (or distance), and ethnic diversity) will affect (a) collective intelligence and (b) group satisfaction via effects on physiological synchrony.

Facial expressions



Identified positive (AU 12 with or without AU 6) and negative (AU 15 and AU 1 or AU4).

EDA

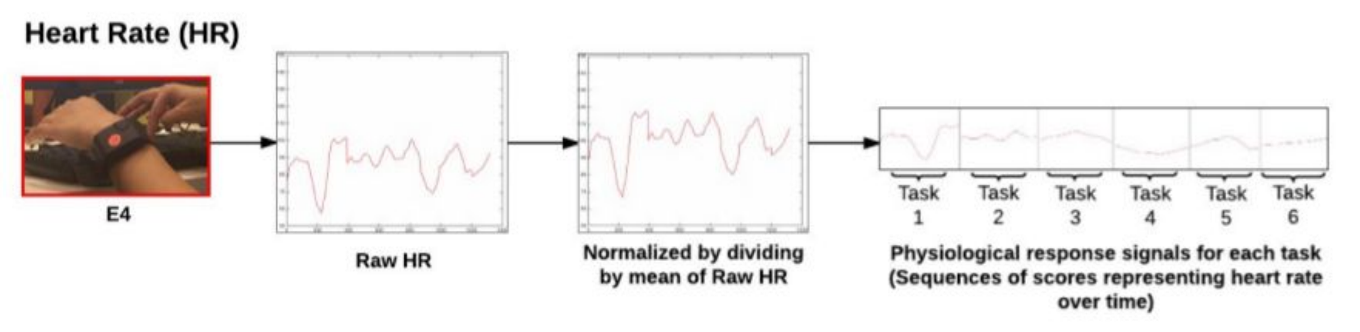


Separate phasic and tonic signals:

Simple moving average filter (5 second window with 20 data points per window).

Normalized using z-scores (number of standard deviations from the mean a datapoint is).

Heart Rate



Different people have different resting heart rates. So, in order to compare heart rates between participants they normalized it by dividing by its mean and multiplying by 100.

(no smooting needed as HR averaged/smoothed over a moving window of 1 min)

Used Dynamic Time Warping -> algorithm to measure similarities betwen two time sequences that differ in length and speed.

The algorithm warps the time axes of two different signals to find points between the signals that seem to match.

A locality constraint is the maximum distance allowed between two such points -> for physiological synchrony this is needed. An arbitrary one of 5 seconds was chosen.

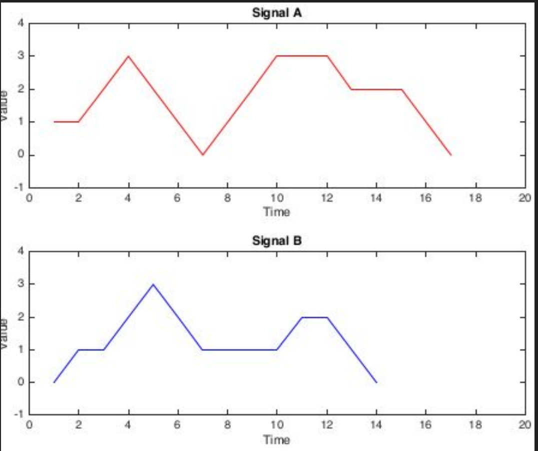


Figure 2. Examples of signals A and B of different lengths and varying time and speed

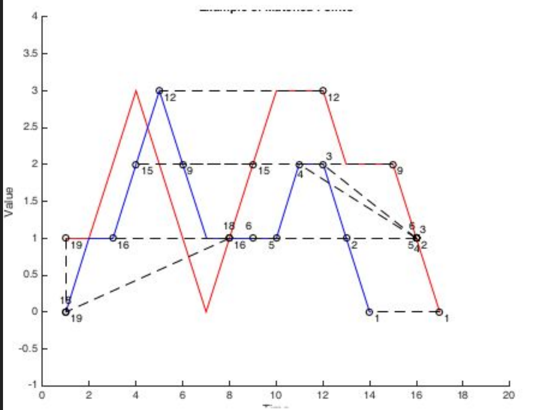


Figure 3. Signals A and B matched using DTW. Only some of the corresponding points matched between the two signals are shown for readability purposes.

	Mean	S.D.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1. Age distance	9.240	10.044	1									
2. Number of females	1.010	0.813	.214	1								
3. Ethnicity similarity	1.42	0.498	-.019	-.271*	1							
4. Education distance	1.51	1.135	.342**	.083	.131	1						
5. RME	26.350	2.943	-.198	-.240	-.085	.050	1					
6. CI	-0.016	0.630	-.223	.101	-.295*	-.041	.390**	1				
7. Group satisfaction	4.120	0.425	.115	-.050	.266*	-.006	.020	-.140	1			
8. DTW_EDA	3674.8	411.553	.114	.211	-.085	.071	.077	-.064	.325*	1		
9. DTW_HR	15571.0	5935.2	.207	.047	-.225	.072	-.053	-.140	-.002	-.340*	1	
10. DTW_FACE	7772.1	3931.1	-.255	.168	-.068	.152	.222	.304*	-.093	-.057	-.200	1

**** p <.01, * p <.05, N = 60 (in subjective measures), N = 52 (in facial expressions) , N = 53 (in EDA and HR)**

Number of females is coded as 0 (male only), 1 (mixed sex), 2 (female only), ethnicity similarity coded as 1 (dissimilar), 2 (similar). CI = Collect intelligence (z-score), RME= Read the Mind through the Eyes, DTW = Dynamic Time Warping (measure of similarity or synchrony in dyads), EDA= electrodermal activity, HR= heart rate, FACE = facial expressions.

Table 1. Correlation coefficient for synchrony strength in facial expressions, electrodermal activity and heart rate with collective intelligence, group satisfaction and RME.

Hypothesis 1

They found a significant,positive relationship between synchrony in facial expressions and CI ($r = .30$, $p = .01$).

By contrast, CI was neither significantly correlated with synchrony in pEDA nor with synchrony in heart rate.

[Group satisfaction was positively associated with high levels of pEDA synchrony ($r = .33$, $p =.04$). There was no relationship between CI and group satisfaction, consistent with prior studies [95, 27, 28, 96].]

Hypothesis 2

Results seem to suggest that social perceptiveness (which has a positive effect on CI) is *in part* explained by synchrony in facial expressions.

The kappa squared effect size measure has been questioned and may not be entirely accurate https://www.ncbi.nlm.nih.gov/pubmed/25664380

Hypothesis 3

Ethnic diversity had a positive indirect effect on CI (with and without synchrony in facial expressions).

Group satisfaction -> if ethically diverse *and* synchonrized with EDA

-> number of females *and* synchronized pEDA

Synchrony in facial expressions (indicative of shared experience) was associated with CI.

Synchrony of in electrodermal activity (EDA) (indicative of shared arousal) was somewhat associated with group satisfaction.

What happened to Heart Rate?

Empatica E4 wristband (which you will be using in Lab 4!)

Paper did not discuss how much participants moved - *very sensitive to movement*

Will stop recording if movement so there are no motion artifacts.

Group Discussion - Intervention Design

What kinds of interventions could we design to increase group intelligence using physiological synchrony?

(paper suggests:
increasing temperature of room or ambient noise to effect arousal levels
or encouragement to match group members' facial expressions or consciously change one's own facial expressions)

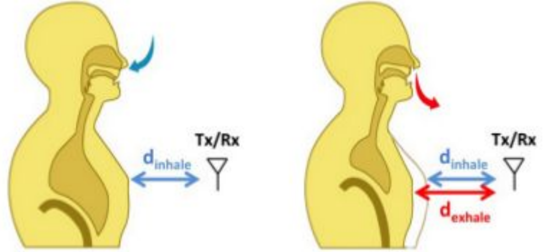
What about linking back to the three main positive correlations with group intelligence:
1. the average social sensitivity of group members
2. the equality in distribution of conversational turn-taking
3. the proportion of females in the group (which the authors found to be related to the first point)

Smart Homes that Monitor Breathing and Heart Rate

Adib, F., Mao, H., Kabelac, Z., Katabi, D. and Miller, R.C., 2015, April. Smart homes that monitor breathing and heart rate. In *Proceedings of the 33rd annual ACM conference on human factors in computing systems* (pp. 837-846). ACM.

Vital-Radio is a wireless sensing technology that monitors breathing and heart rate without body contact. Vital-Radio exploits the fact that wireless signals are affected by motion in the environment, including chest movements due to inhaling and exhaling and skin vibrations due to heartbeats.

Adib et al. 2015 demonstrate that it can track users' breathing and heart rates with a median accuracy of 99%, even when users are 8 meters away from the device, or in a different room. Furthermore, it can monitor the vital signs of multiple people simultaneously. We envision that Vital-Radio can enable smart homes that monitor people's vital signs without body instrumentation, and actively contribute to their inhabitants' well-being.



(a) **Inhale Motion** (b) **Exhale Motion**

Figure 1—Chest Motion Changes the Signal Reflection Time. (a) shows that when the person inhales, his chest expands and becomes closer to the antenna, hence decreasing the time it takes the signal to reflect back to the device. (b) shows that when the person exhales, his chest contracts and moves away from the antenna, hence the distance between the chest and the antenna increases, causing an increase in the reflection time.

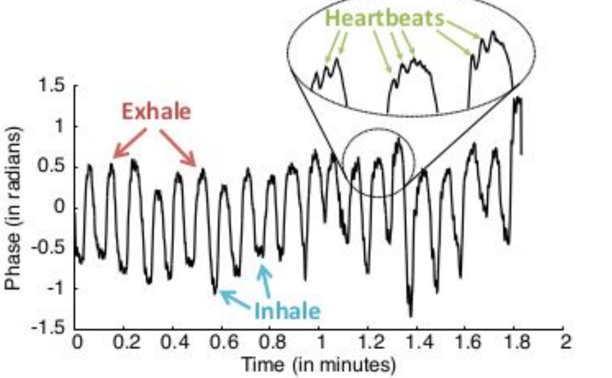
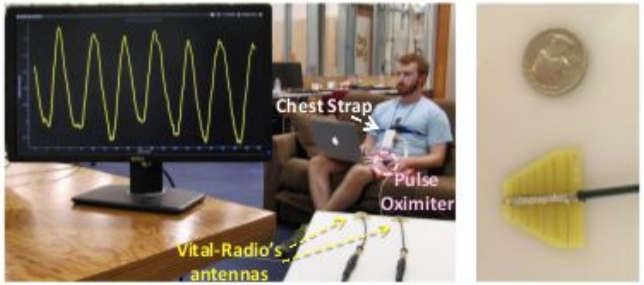


Figure 3—Phase variation due to vital signs. The figure shows the variations in phase due to breathing and heartbeats, where peaks and valleys in the phase correspond to exhale and inhale motions respectively; also, zooming in on the signal allows us to observe the heartbeats modulated on top of the breathing motion.



(a) **Setup.** (b) **Antennas.**

Figure 7—Experimental Setup. (a) shows a user sitting about 2.5m away from Vital-Radio's antennas; the user also wears a chest strap and a pulse oximeter, which are connected to the Alice PDx for obtaining ground truth measurements. (b) shows one of Vital-Radio's antennas placed next to a quarter.

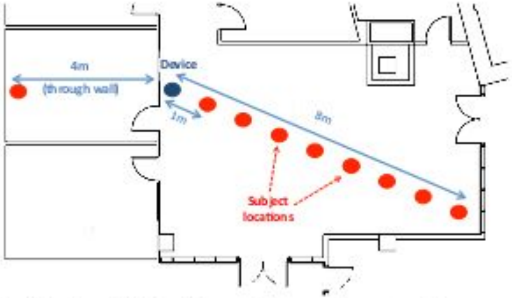


Figure 8—Testbed. The figure shows a layout of our experimental setup, marking the location of Vital-Radio in navy blue, and the different locations where our monitored subjects sat down in red.

Synkin: A Game for Intentionally Synchronizing Biosignals

Wikström, V., Makkonen, T. and Saarikivi, K., 2017, May. SynKin: A Game for Intentionally Synchronizing Biosignals. In *Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems* (pp. 3005-3011). ACM.