Heart Rate Variability, Bio-Markers and Non-Cognitive Skills

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Overview of Talk

- Motivation
- Description of the current study
- Overview of initial results
  - Factor Models of Discounting Related Variables
  - Determinants of Financial Discounting

Motivation – 1

- Time Preference a key variable in economics (Frederick et al 2002; Berns et al., 2007; Wittman et al., 2008)
- Recent papers examining neuro and psychometric analogues to time preferences (McClure et al 2004; Borghans et al 2008)
- Plausability of different accounts needs to be examined further

Motivation – 2

- “Despite the well-established finding that impulsive individuals discount delayed rewards more strongly than do more self-controlled individuals, the underlying cognitive and affective processes that account for this phenomenon are poorly understood”- Wittman et al., 2008

Psychometric Analogues

- Conscientiousness &“big five” components
- Emotional Regulation
- Future Orientation
- Cognitive Reappraisal
- Self-awareness
- Self-Control

Motivation – 3

- Biological Analogues
  - Neural Substrates
    - Glucose Depletion
    - HPA-axis and Cortisol Activation
  - Parasympthatetic and Sympathetic Nervous System Activation
    - Heart Rate
    - Heart Rate Variability

Overview of Initial Study

- Day Reconstruction Study including psychometric battery, bio-markers, and monetary choice task
- 200 students
- Recruited via research credits and monetary incentives

Study Phases

- Phase I: Baseline Medical Tests
- Phase II: Real-Time Bio-Tracking
- Phase III: Day Reconstruction Method
- Phase IV: Demographics/Questionnaires

Medical Tests Employed

- Systolic and diasystolic blood pressure Professional Blood Pressure Monitor
- Forced Expiratory Volume and Peak Flow
- Body Fat and Body Mass Index
- Blood Glucose Levels using pin prick test

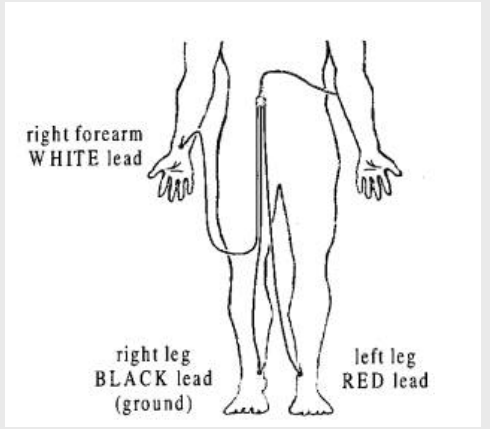
Real-time Biotracking

- Cornell Job Study (Schnall 1998) - measured change in ambulatory blood pressure (ABP) in employees as related to job strain (both perceived and reported by supervisors)
- In combination with DRM, physiological feedback (blood pressure, heart rate, galvanic skin response, etc.) can be used to confirm or augment participant reports of affective experience

Real-time Biotracking: HRV

- Heart Rate assessed using non-invasive chest belt sports monitor which can record 200,000 heart beats
- Has demonstrated reliability equal to Biopac 1000 Hz sampling system at the millisecond level (r=1.00),

  t(1, 2206)=-.34, p=.74
- This data can be used to calculate accurate Heart Rate Variability (HRV)



Real-time Biotracking: HRV

- Heart rate variability analysis is emerging as an objective measure of self-regulatory strength and activity (e.g. Segerstrom et al., 2007; Appelhans et al., 2006).
- Measures variability in the beat-to-beat interval of the heart.
- Low HRV is associated with a range of clinical (obesity, hypertension) and psychiatric (anxiety, depression) conditions as well as psychological processes and psychosocial factors.
- High HRV is an index of the efficient allocation of attentional and cognitive resources needed for optimal adaptive functioning in an environment in which behavioural inhibition and delayed responding are essential

A2

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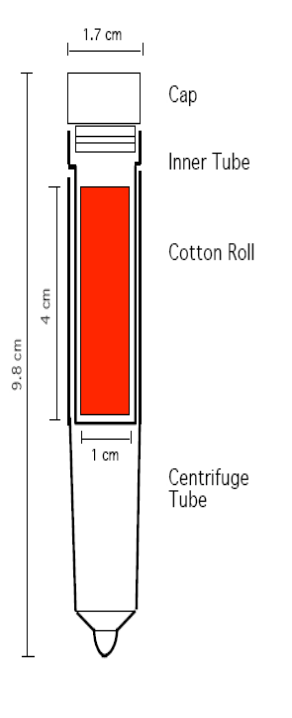
Functional neural architecture of HRV

- Thayer (2007)- neural structures involved in cognitive, affective, and autonomic regulation are related to HRV and cognitive performance
- CNS concomitants: Pre-frontal cortex and anterior cingulate relate closely to HRV (SNS modulation of HR) indicating a link to inhibition and monitoring systems (Critchley et al., 2003)
- Vagal system inhibits SNS input associated with Fight/Flight response
- Evidence for a tonic ‘depletion’ effect on HRV, similar to that demonstrated in EEG (Inzlicht et al., 2007)

Real-time Biotracking: Cortisol

- Saliva samples at three points of the day. Chew cotton roll.
- Self-sample immediately before upon awakening (before getting out of bed), 30 min after waking, and before going to bed
- This is because cortisol levels are high in the morning, rise 50-60% in first half hour or so after waking and decrease continually after this point steeply at first then gradually until going to bed



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Real-time Biotracking: Cortisol

- High salivary cortisol levels on average across the day have been found to relate to measures of distress (e.g. depression, stress)
- Different diurnal rhythms of cortisol have been found to relate to psychosocial risk factors (depression, stress)-associated with flatter rhythms (small differences between morning and evening levels), and psychosocial resources (social support, coping mechanisms)-associated with steeper diurnal patterns (a decline in levels from morning to evening)
- Steeper patterns across the day predict health and well-being

Real-Time Biotracking: Glucose

- Glucose hypothesised to be a “fuel” for frontal lobe functioning and hence capacity for self-control (e.g. Baumeister)
- Effortful control of attention ‘depletes’ both regulatory resources and blood glucose levels
- Ability to metabolise glucose and maintain stable levels should then be related to lower time preferences and other psychological metrics of self-control
- Experimental evidence shows glucose to improve memory in low & high functioning groups (e.g. Karol, 2002)
- Dietary interventions to improve glucose regulation (e.g. Panax ginseng (G115), beta-D-glucan)

Day Reconstruction Method (DRM)

- At the end of a day, participants construct a diary composed of a sequence of “episodes” starting from when they got up to when they went to bed
- They describe each episode by answering questions about the situation (e.g., who were you with?) and their affective state at the time
- Benefits:
  - Less participant burden than ESM
  - Does not disrupt normal activities
  - Assesses contiguous episodes over a full day rather than a sampling of moments
  - Provides both time-budget information and affective components

The DRM measure

- Participants describe occurrences as a set of “episodes” and rate each episode for affective components

- What were you doing? (check all that apply)

- __ commuting __ working __ shopping __ preparing food
- __ doing housework __ taking care of your children__ eating
- __ pray/worship/meditate __ socializing __ watching TV
- __ nap/resting __ computer/internet/email__ relaxing
- __ on the phone__ intimate relations __ exercising
- __ other (please specify_____)

The DRM measure (2)

- How did you feel during this episode?
- *Please rate each feeling on the scale given. A rating of 0 means that you did not experience that feeling at all. A rating of 6 means that this feeling was a very important part of the experience. Please circle the number between 0 and 6 that best describes how you felt.*

	Not at all						Very much
Happy	0	1	2	3	4	5	6
Frustrated/annoyed	0	1	2	3	4	5	6
Energetic/enthusiastic.	0	1	2	3	4	5	6
Depressed/sad	0	1	2	3	4	5	6
Alert/attentive.	0	1	2	3	4	5	6
Nervous/tense	0	1	2	3	4	5	6
Relaxed/calm.	0	1	2	3	4	5	6
Tired.	0	1	2	3	4	5	6
Stressed.	0	1	2	3	4	5	6
Hungry*..	0	1	2	3	4	5	6

*for obesity study

A Web-Based Approach

- Facilitates rapid collection and analysis
- Allows for randomisation to check for question-wording and ordering effects
- Allows for routing based on previous answers
- Data protection and data management issues

Overview of Demographics/Questionnaires

- **Demographic and personal information**
- **Time preferences and personality**
- **Subjective well-being and health**
- **Emotional Awareness and Emotional Regulation**
- **Emotional Eating**

Demographic and personal information

- Gender
- Age
- Relationship status
- Accommodation type
- Postgraduate/Undergraduate
- Number in Family
- Parent education, income, occupation
- Religiosity

Time preferences and personality

- Consideration of Future Consequences
  - “I consider how things might be in the future, and try to influence those things with my day to day behavior.”
- Elaboration of Potential Outcomes
- Self-control Scale
  - “I am good at resisting temptation.”
- The Big Five
  - Openness, Conscientiousness, Extraversion, Agreeableness, Neuroticism
  - “Extraverted, enthusiastic” rate agreement and disagreement with applicability to self

Emotional Awareness and Emotional Regulation

- **Emotional awareness deficiency**
- *Cognitive and Affective Mindfulness Questionnaire-Revised:* Assesses attention, awareness, present-focus, and acceptance/ nonjudgement facets of the mindfulness construct (Feldman et al., 2007).

- **Emotional regulation strategies**
- Different strategies are associated with different levels of well-being
- Suppression is associated with lower well-being
- “I control my emotions by not expressing them”
- Reappraisal is associated with greater well-being
- “I control my emotions by changing the way I think about the situation I’m in”

Economic Discounting

- Loewenstein & O'Donoghue (WP: 2007) and others infer the presence of multiple selves that represent the same object in different ways and also have differing utilities for the outcomes resulting in time discounting
- Inhibition/Approach, Planner/Doer, Reflective/Impulsive, Cognitive/Affective approaches reference dual-system with psychophysiological correlates including HRV and glucose variability

Measure of Economic Discounting

- Kirby (1999)
- Monetary Choice
  - 27 Questions
  - Small, Medium and Large Rewards
  - Nine Different Discount Values
  - Told that possibility exists of winning one of the choices
  - Various methods of construct discounting and choice inconsistency measures

Table 1: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max	Corr
Age	198	24.39	6.27	19	50	
Cognitive Reappraisal	198	27.10101	6.248646	10	41	-0.0983
Suppression	198	12.65152	4.731874	4	26	0.0628
Extraversion	198	9.489899	2.73117	3	14	-0.2173
Nervousness	198	6.949495	2.900634	2	14	-0.1143
Openness	198	10.92929	2.201765	5	14	0.0099
Conscientiousness	198	9.484848	2.777223	2	14	0.0682
Agreeableness	198	9.888889	2.117795	2	14	0.1215
Mindful	185	65.55135	8.342454	46	83	0.0371
Cognitive Affective Mindfulness Scale	198	31.28788	5.343334	18	44	0.1563
Self-Control Scale	198	39.55556	8.448377	18	59	0.1098
Consideration of Future Consequences	198	42.38384	6.984693	24	57	0.1315
Positive Elaboration	198	14.08586	4.067664	3	21	0.0978
Negative Elaboration	198	15.64141	6.064602	4	28	-0.0543
Elaboration	198	28.66667	6.446972	12	42	0.023
WHO-Five	198	13.03535	4.857749	0	23	-0.0516
Experiential Avoidance	197	34.05584	6.384926	15	51	-0.2079
White Bear Suppression	198	41.52525	12.60396	15	70	-0.0639

Table 2: Descriptive Statistics on Biological Variables and Observed Correlation

Variable	Obs	Mean	Std. Dev.	Min	Max	Patience
glucose	203	5.195074	0.702595	3.2	8.3	-0.06
mean_rr	189	727.664	102.2002	505.21	1137.15	0.07
std_rr	189	142.1417	41.64191	66.65	343.73	0.12
bp_dia	204	68.40686	9.670745	47	103	-0.09
bp_sys	204	122.5343	13.71001	85	159	-0.10
body_fat1	203	28.84089	8.437619	0	47.3	-0.08

Table 3: Regression on Factor Scores Following Varimax Rotation

Variable	Factor1	Factor2	Factor3	Factor4
reappraisal	0.01438	0.05242	-0.06772	-0.11818
bp_sys	-0.01667	-0.03251	0.07577	0.34335
bp_dia	-0.00891	0.04637	-0.08991	0.39982
supression	-0.0699	0.03265	0.05677	-0.11018
extraversion	0.06853	-0.05709	-0.05006	-0.02947
nervousness	-0.13991	0.02637	-0.0769	0.15994
openness	0.02786	-0.0461	-0.03986	0.05166
conscietio~s	0.00541	0.24398	0.02682	0.0146
agreeablen~s	0.03475	0.03352	-0.05734	0.02863
mindful	0.08331	0.01218	0.00405	0.16155
cams	0.20596	0.18952	0.04216	0.09314
scs	-0.00039	0.35097	0.0666	-0.01533
cfc	-0.02386	0.17334	-0.02081	0.04941
poselab	0.16966	-0.03892	-0.11145	-0.07375
negelab	-0.17286	0.09031	-0.08166	-0.02737
elab	-0.03105	0.18786	-0.04275	-0.02043
who5	0.13946	-0.01681	0.0198	-0.08167
experavoid	-0.19151	-0.08894	0.00989	-0.02111
whitebear	-0.09969	-0.01523	-0.00732	-0.06241
mean_rr	-0.00128	0.00622	0.43678	0.02991
std_rr	0.01755	0.01312	0.36953	-0.04824

Table 4: Determinants of Financial Discounting

	(1)	(2)	(3)
COEFFICIENT	Consistent	Patient	Discount
gender	0.120	0.303	-0.007
	(0.112)	(0.948)	(0.010)
age	-0.004	-0.086	0.000
	(0.008)	(0.063)	(0.001)
f1	-0.001	0.471	-0.001
	(0.054)	(0.449)	(0.004)
f2	-0.043	0.923**	-0.011*
	(0.054)	(0.440)	(0.006)
f3	0.052	0.499	-0.008*
	(0.053)	(0.426)	(0.004)
f4	-0.016	-0.108	0.010
	(0.070)	(0.489)	(0.008)
Constant	0.453*	42.126***	0.044*
	(0.264)	(2.208)	(0.025)
Observations	106	105	105
R-squared	0.02	0.07	0.10

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Conclusions (Tentative)