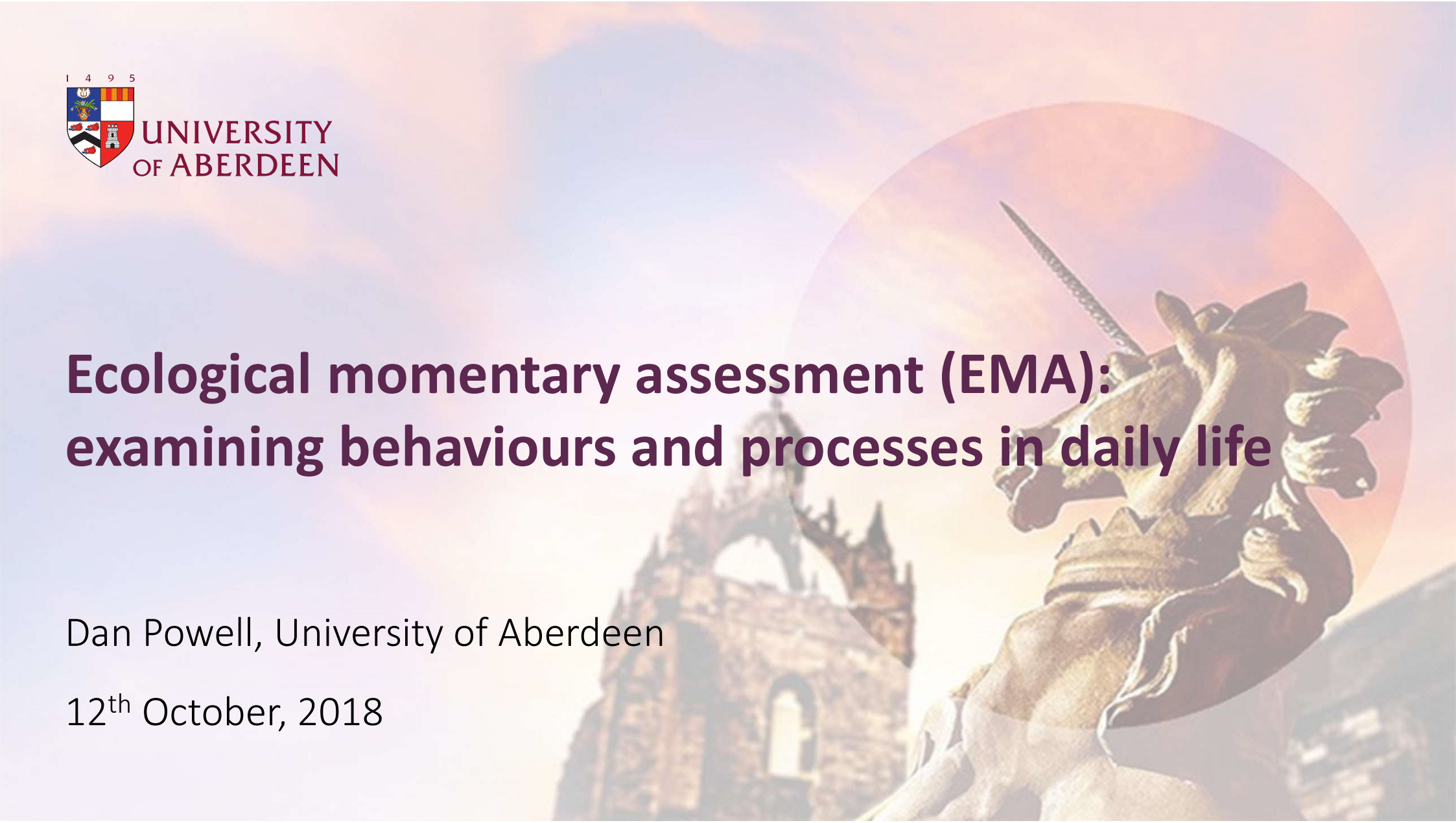


Ecological momentary assessment (EMA): examining behaviours and processes in daily life

Dan Powell, University of Aberdeen

12th October, 2018

Why use EMA? Paradigmatic Rationale

Thinking Within-Person versus Between-Person

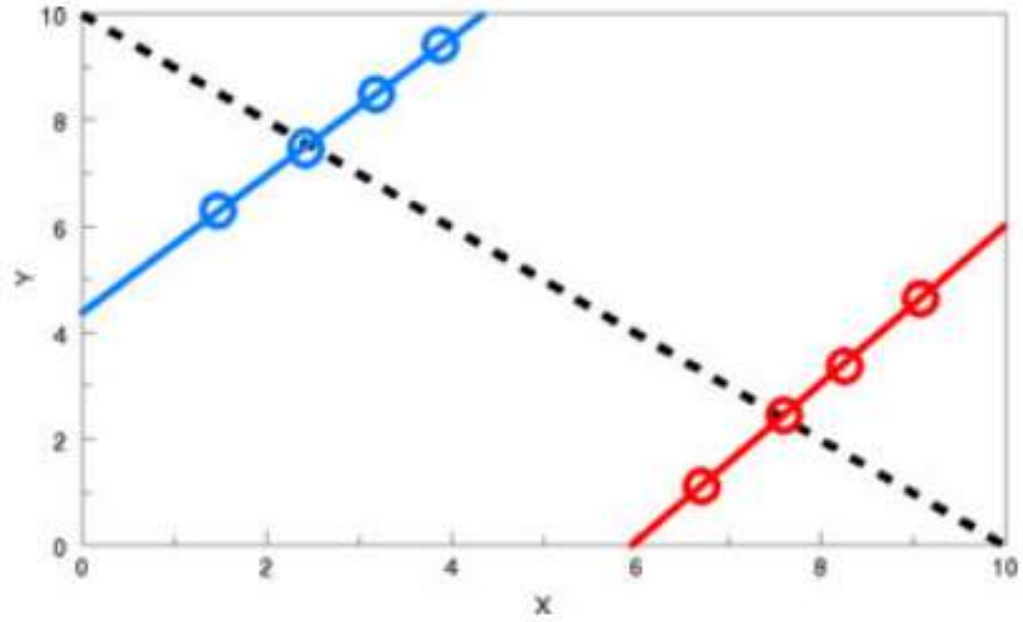
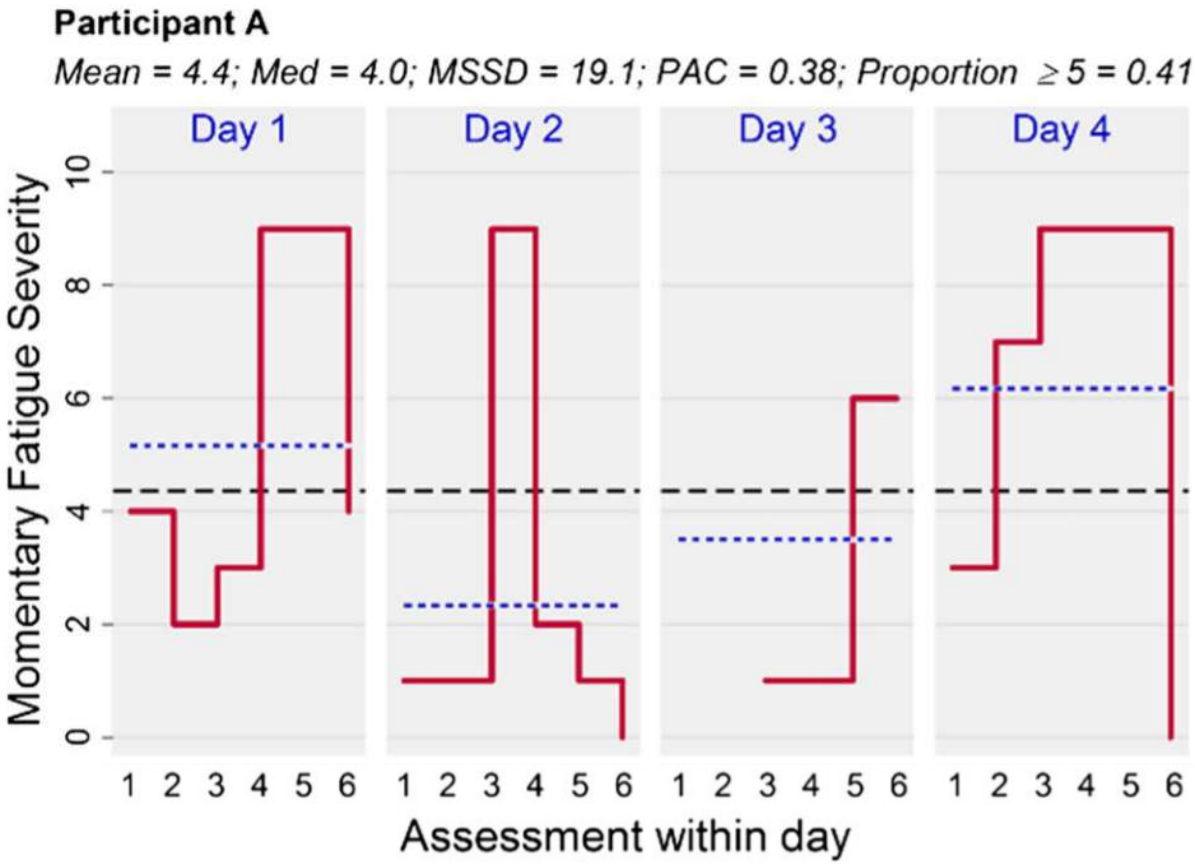


Figure 1. Illustration of a possible result of testing the relationship between variables *x* and *y* where the between-result (dotted line) is negative, but the result for individuals studied over days or locations (illustrated by continuous lines for two people) is positive.

Johnston & Johnston (2013) *British Journal of Health Psychology.*



$$x_{it} = M_i + e_{it}$$

x_{it} = score for individual i at time t.

M_i = mean score for individual i
e_{it} = deviation from mean for individual i at time t

Powell, Liossi, Schlotz, & Moss-Morris (2017). Tracking daily fatigue fluctuations in multiple sclerosis: ecological momentary assessment provides unique insights. *Journal of Behavioral Medicine, 40(5)*, 772-783.

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Practicalities: centring your predictors

		Person mean of all Score_S for individual	Overall mean of all PersonMean_S in sample	Score_S – PersonMean_S	PersonMean_S – GrandMean_S
ID	**Score_S**	**PersonMean_S**	**GrandMean_S**	**Within_S**	**Between_S**
1	7	4	5	3	-1
1	3	4	5	-1	-1
1	1	4	5	-3	-1
1	5	4	5	1	-1
2	9	6	5	3	1
2	2	6	5	-4	1
2	6	6	5	0	1
2	7	6	5	1	1

See Curran & Bauer (2011)

SNAPSHOT project

SNAcking, **P**hysical activity, **S**elf-regulation, and **H**eartrate **O**ver **T**ime

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SNAPSHOT project

SNAcking, **P**hysical activity, **S**elf-regulation, and **H**eartrate **O**ver **T**ime

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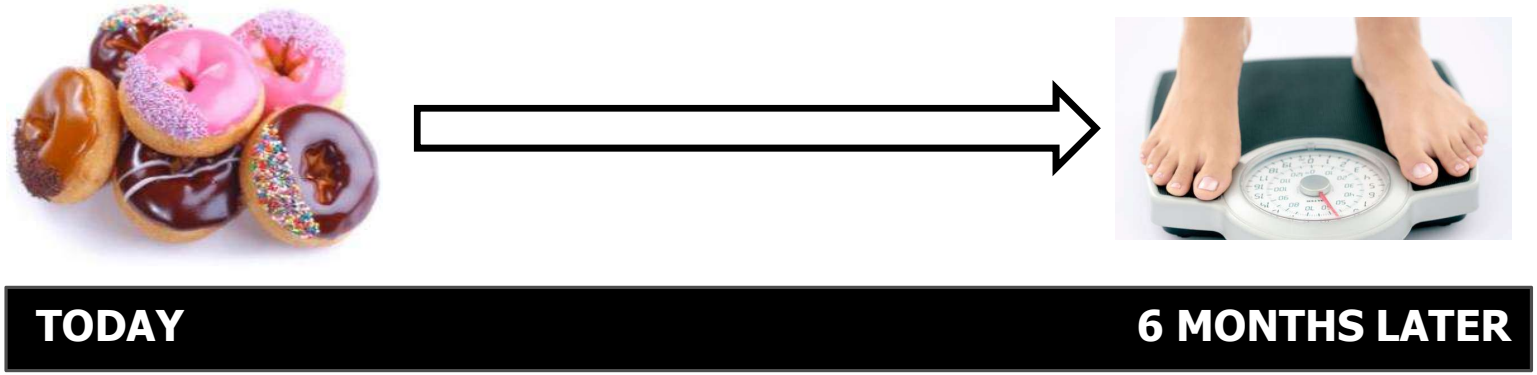
Health behaviours and self-control

Unhealthy behaviours often have significant long-term costs but immediate benefits

(Hall & Fong, 2007; 2015)



Executive function & health behaviour

Exerting self-control over behaviour in the face of temptation places heavy demand on top-down cognitive processes known as the *executive functions*

Three core facets:

- Inhibitory Control
- Working Memory
- Set Shifting

Behavioural Theories and EF

Several theories of health behaviour and conceptual models of self-regulation posit EF as an important determinant of health-relevant behaviour

For example:

- Temporal Self-Regulation Theory (Hall & Fong, 2007, 2013)
- Reflective Impulsive Theory (Strack & Deutsch, 2004; Strack et al., 2014)
- Models of self-control (Baumeister & Vohs, 2007; Inzlicht & Schmeichel, 2012)

Which EF facet?

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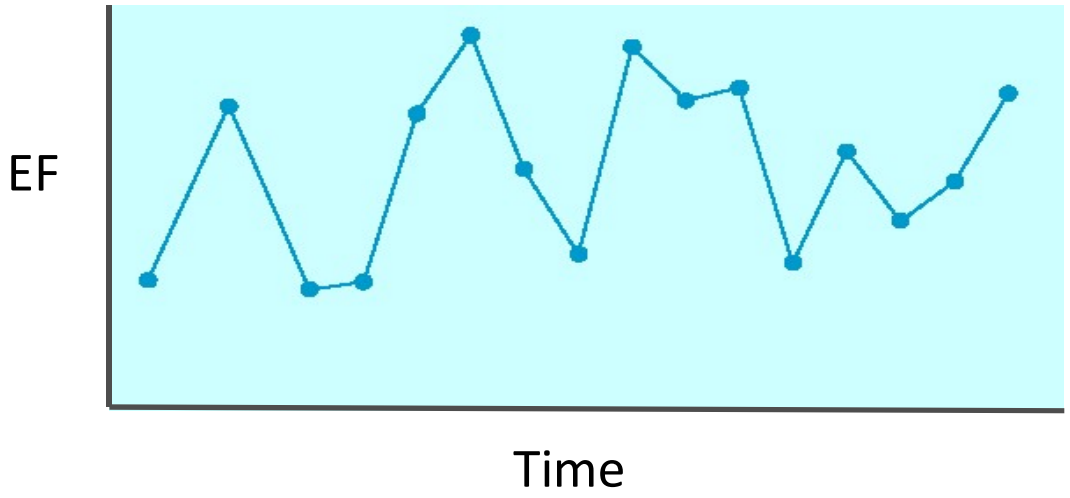
Inhibitory control seems most relevant to unhealthy eating and obesity

- Poor performance on cognitive tests assessing inhibitory control (e.g. Go/No-Go) associated with weaker control of food intake in the lab; particularly of high-fat foods (Allom & Mullan, 2014; Hall, 2012; Hall, Lowe & Vincent, 2014; Limbers & Young, 2015)
- Obese adults and children show marked inhibitory deficits relative to controls (Lavagnino et al., 2016) – impaired inhibition a "critical feature" of obesity
- Other facets (e.g. planning skills, updating) related with initiation of healthy eating behaviours such as fruits and vegetables (Allom & Mullan, 2014; Limbers & Young, 2015)

Studies are focussed on individual differences

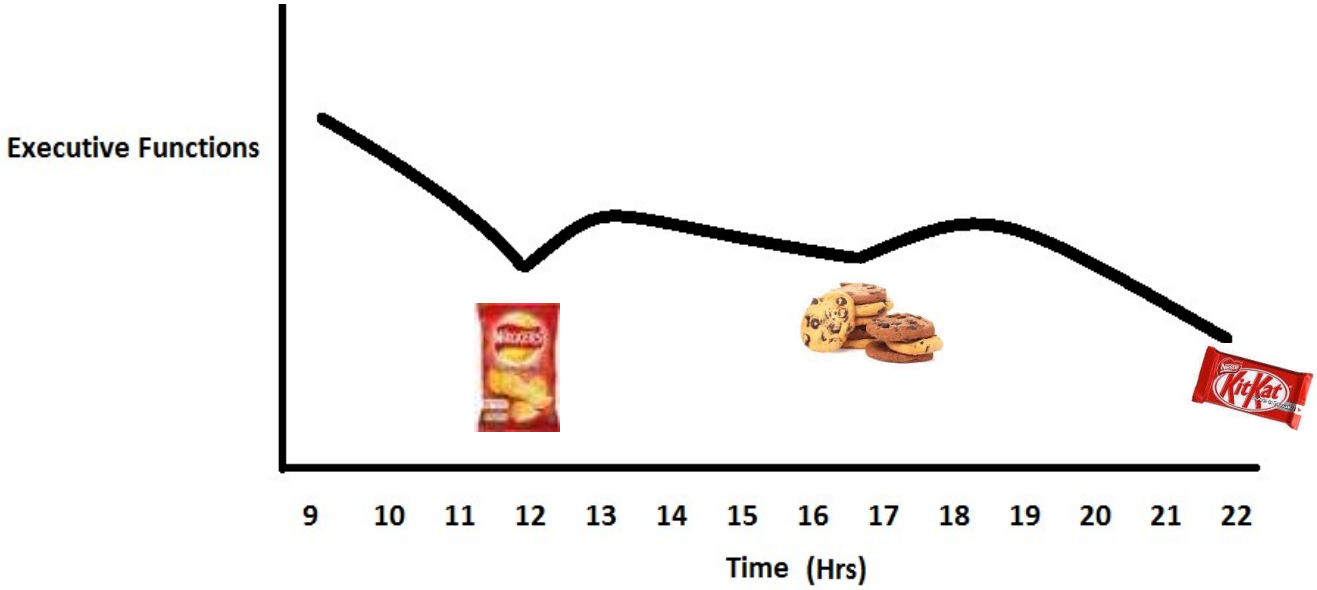


.....but all models imply within-person variability!

EF at any given time important to whether impulsive action occurs or not

Main Hypothesis

Within-person: when EF is poorer than usual, initiation and consumption of energy-dense snacks will be higher than usual



Methodological Challenge

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How to assess objective fluctuations in inhibitory control efficiency “in the wild”?

Methodological Challenge: Solution

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In collaboration with CamnTech, we developed a Go/No-Go Test to deploy via PRO-Diary devices

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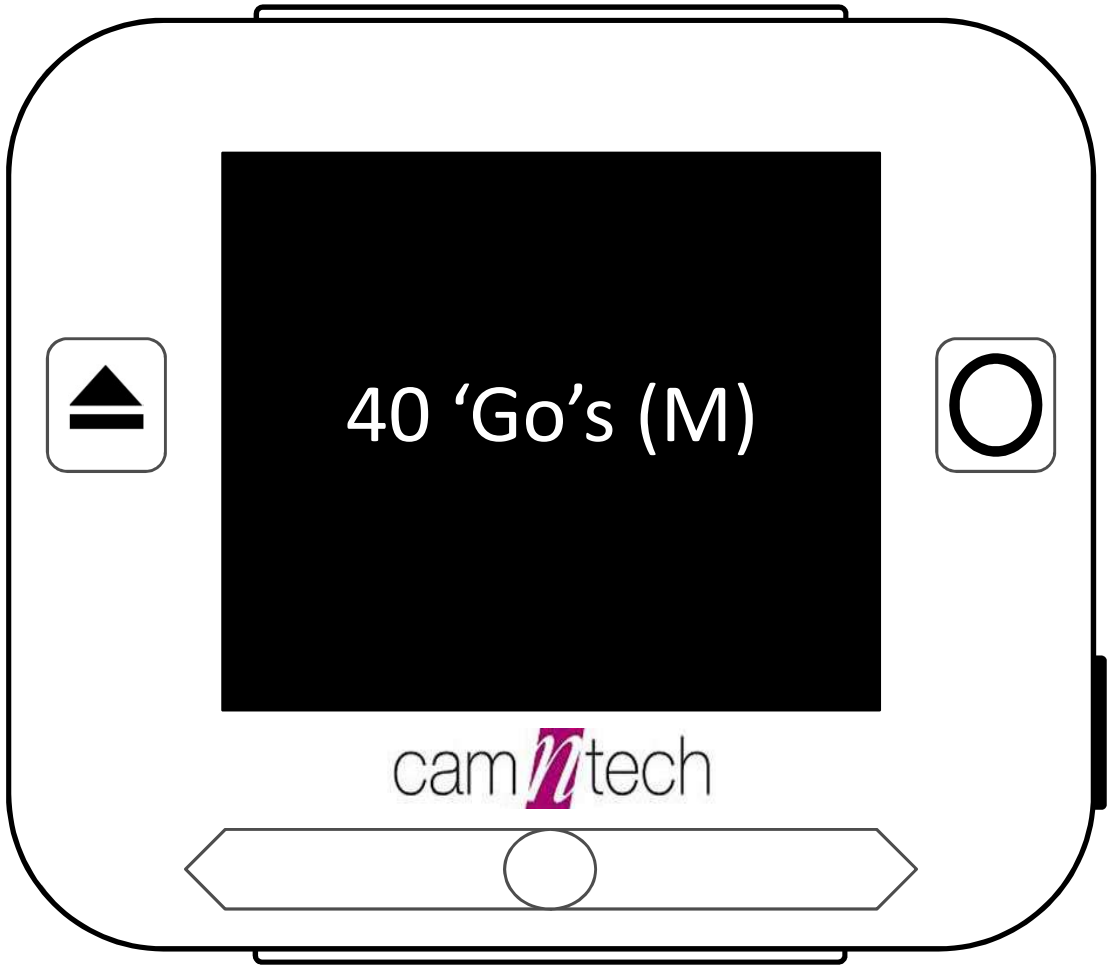
Go/No-Go Test

Testing inhibitory control efficiency

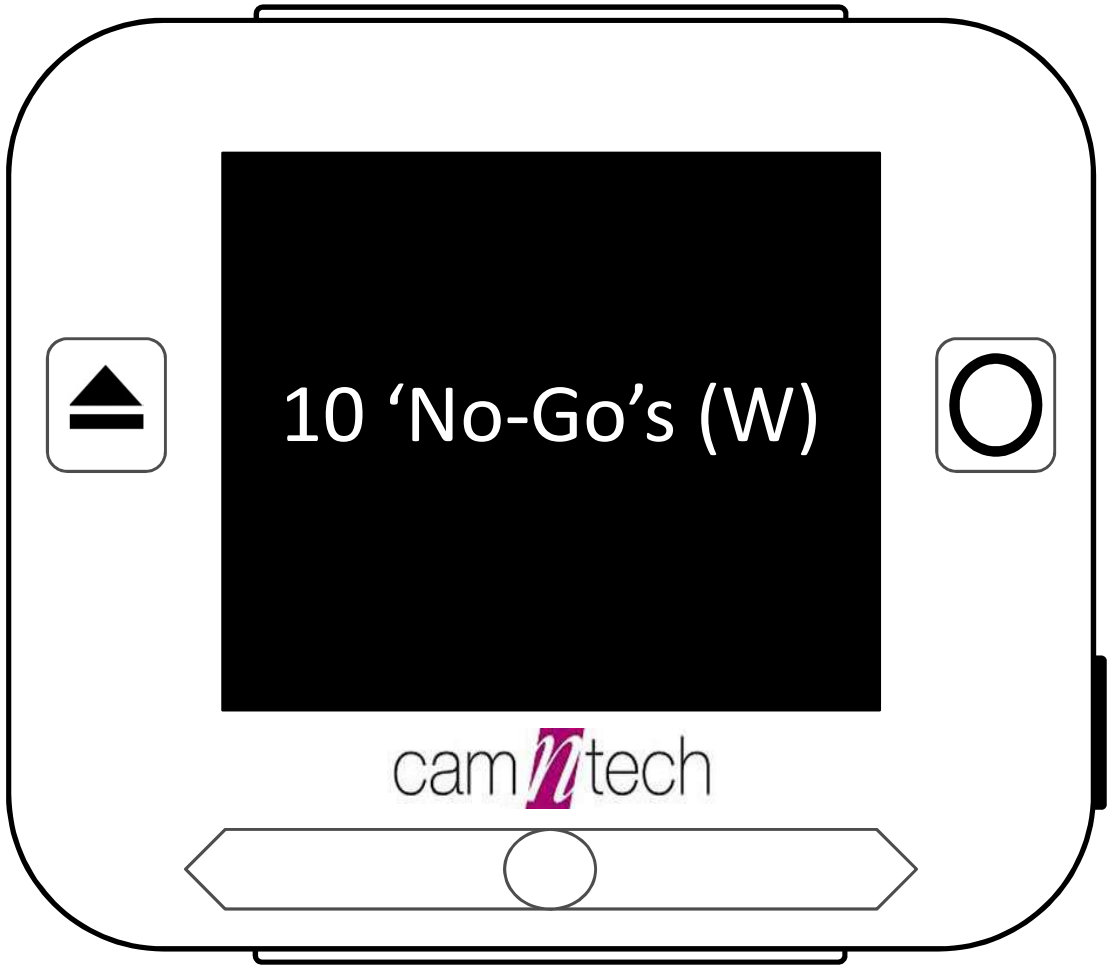
Go/No-Go task

Go/No-Go task

Go/No-Go task

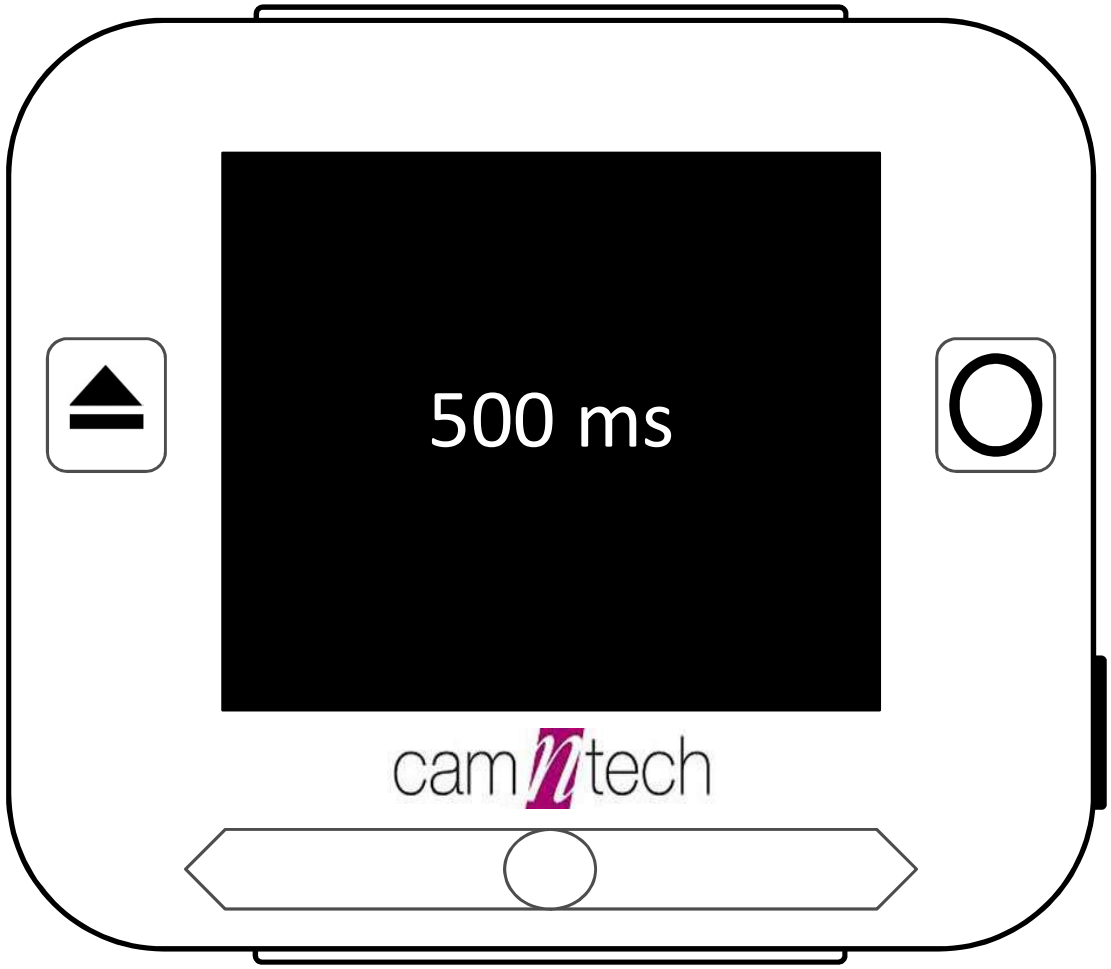


Go/No-Go task

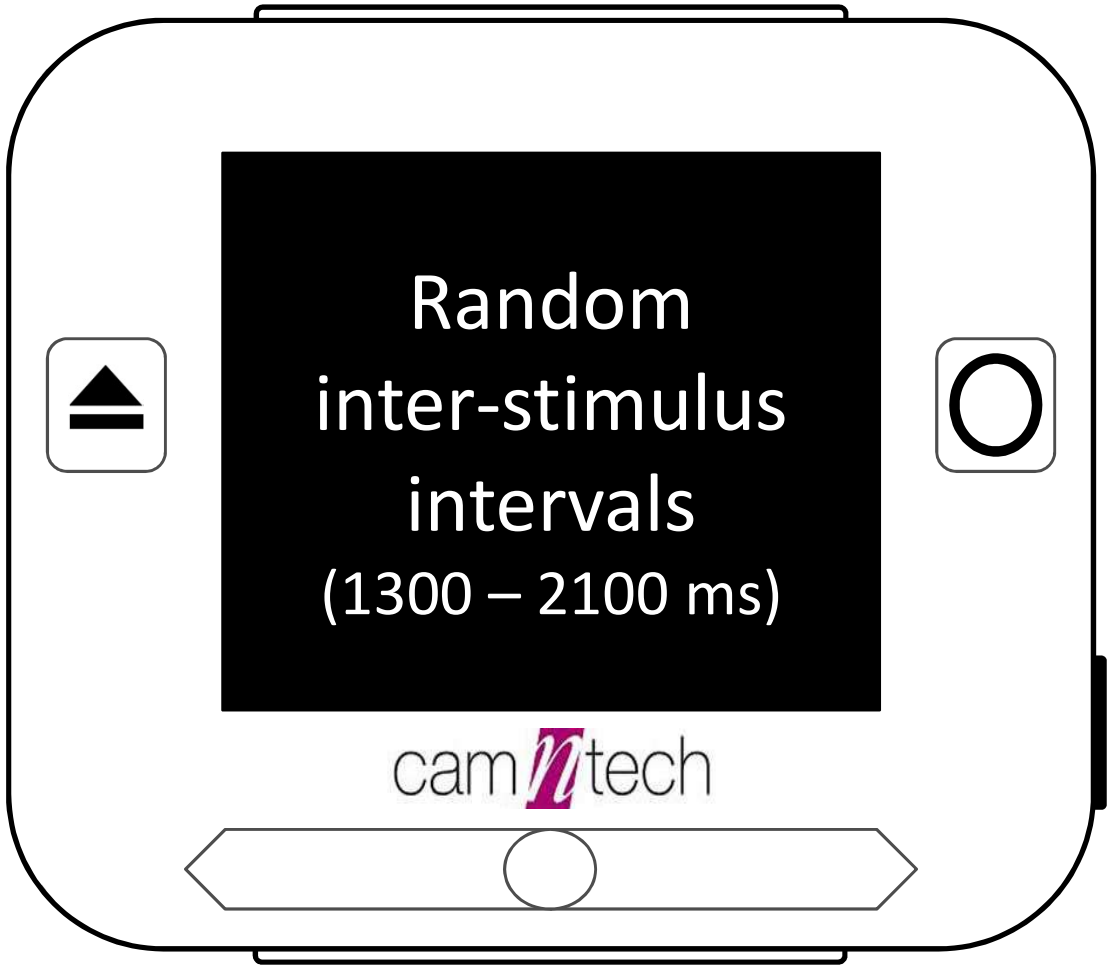


Go/No-Go task

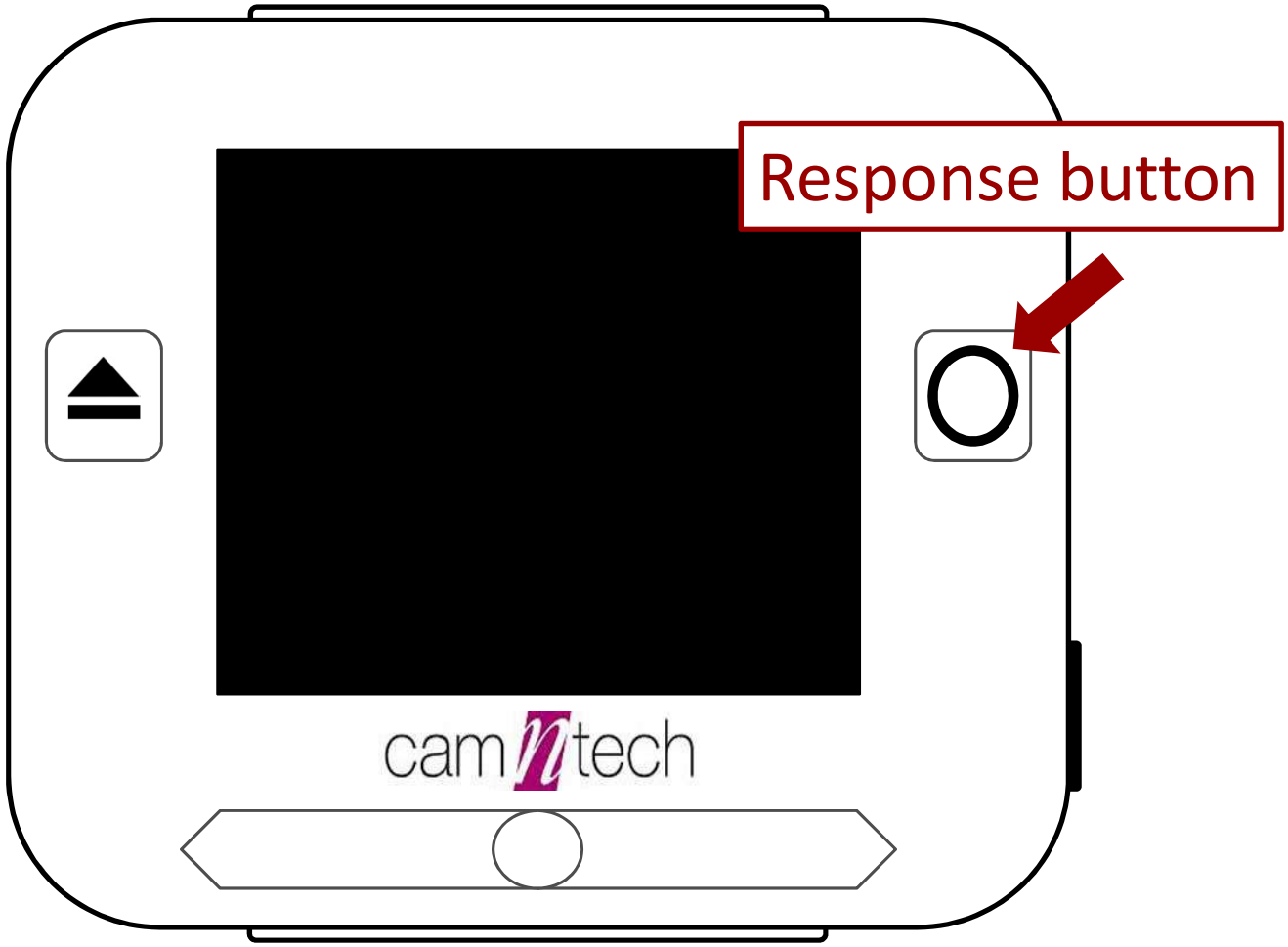
Go/No-Go task



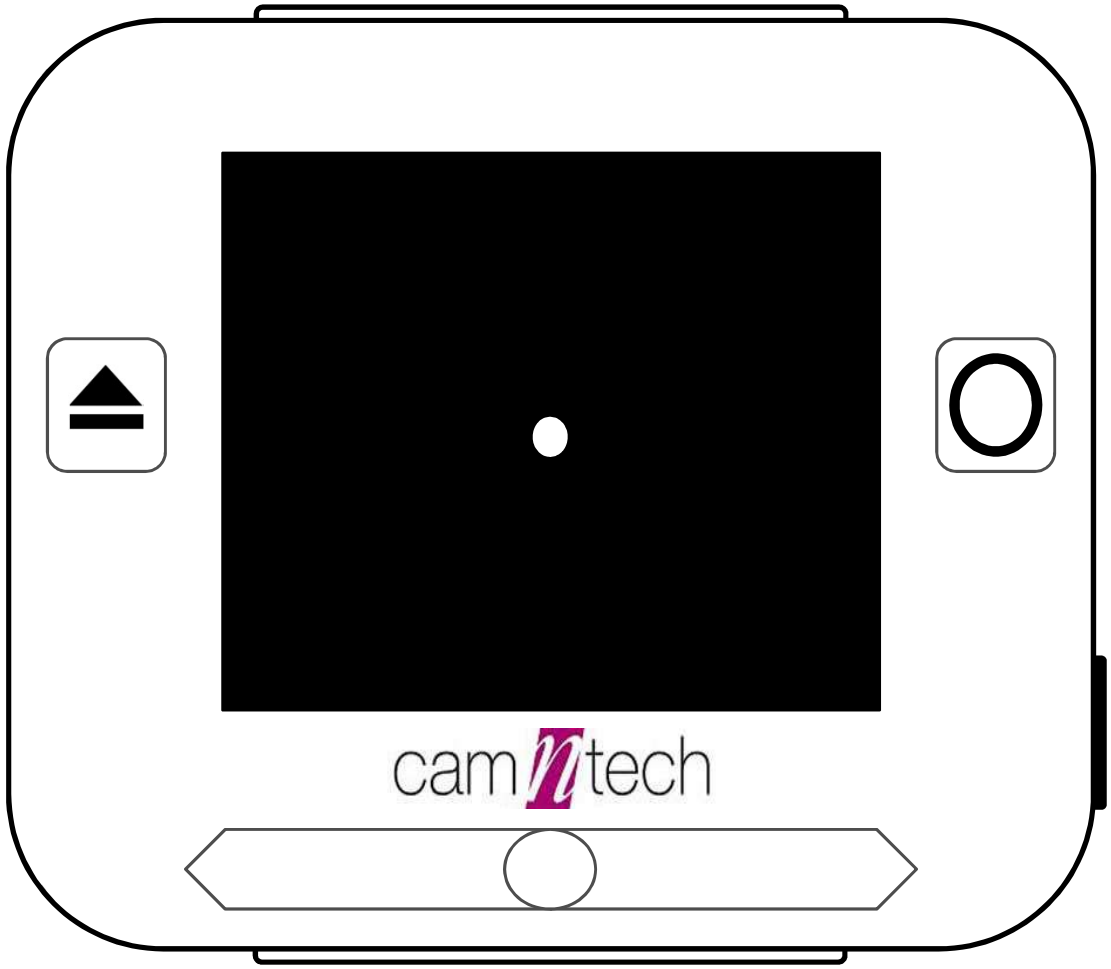
Go/No-Go task



Go/No-Go task



Go/No-Go task



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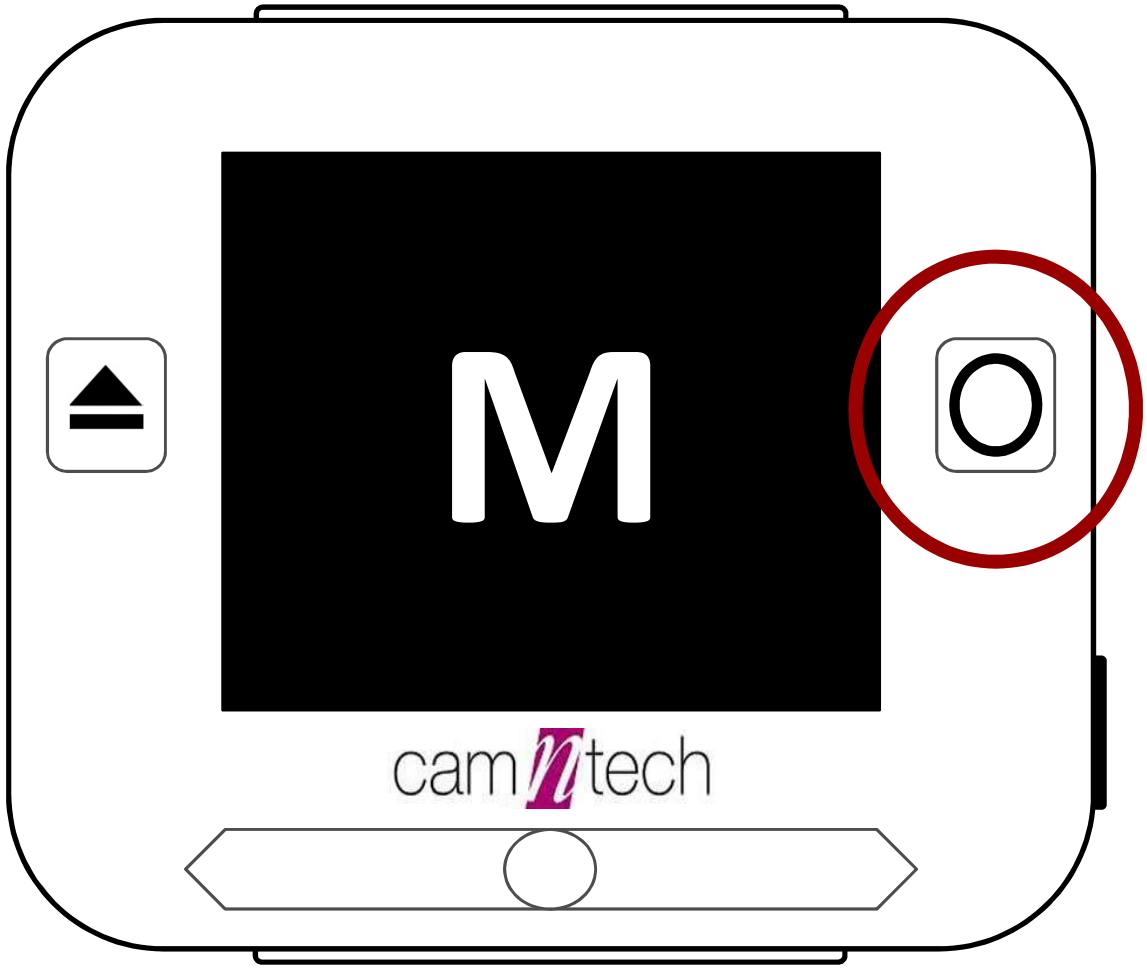
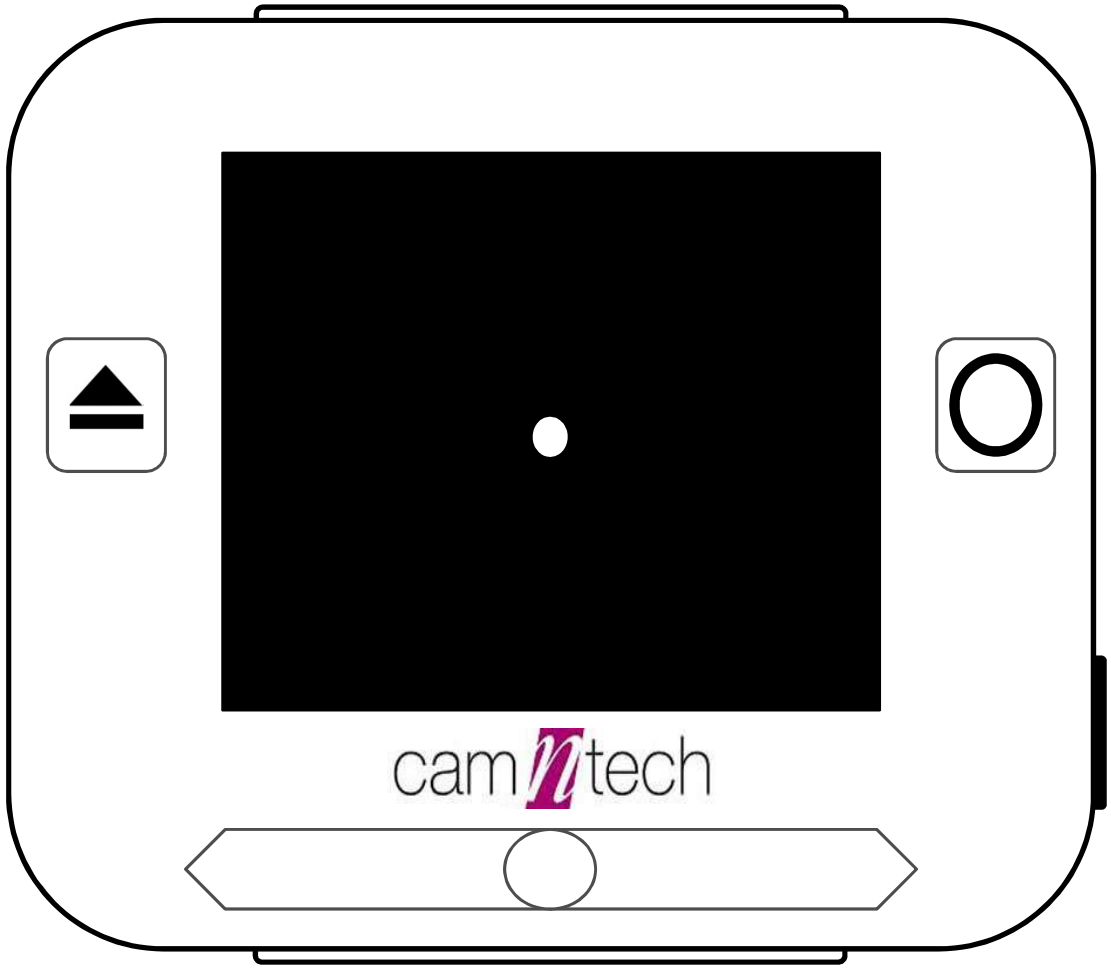


Go/No-Go task



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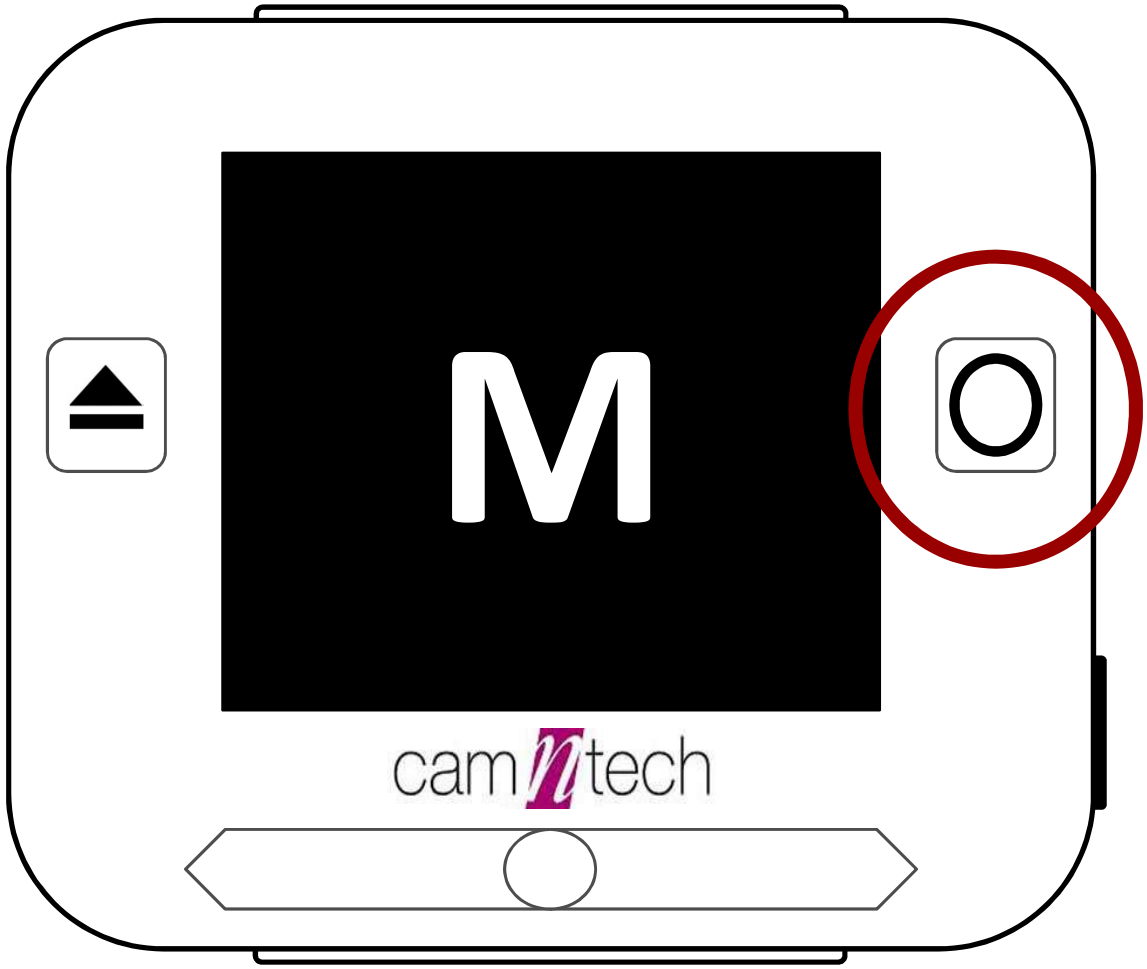

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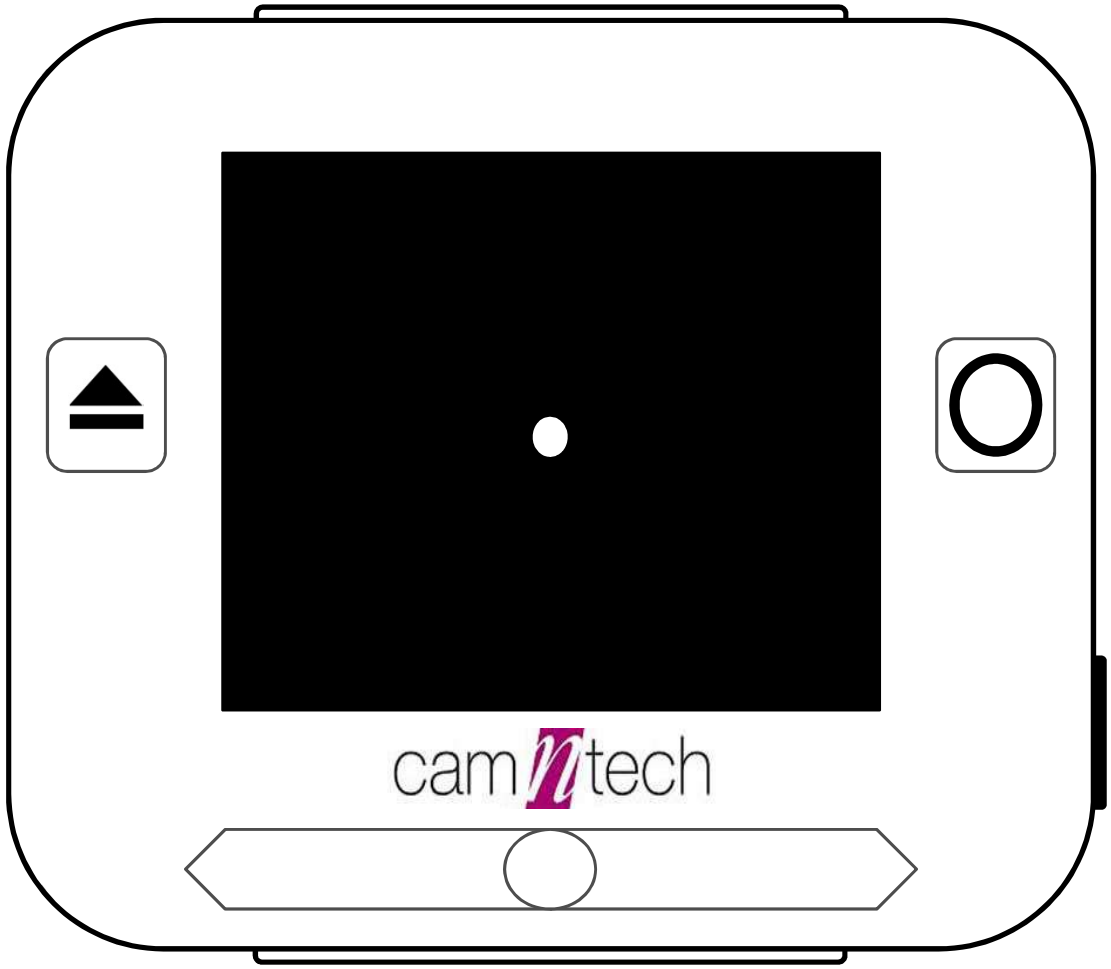

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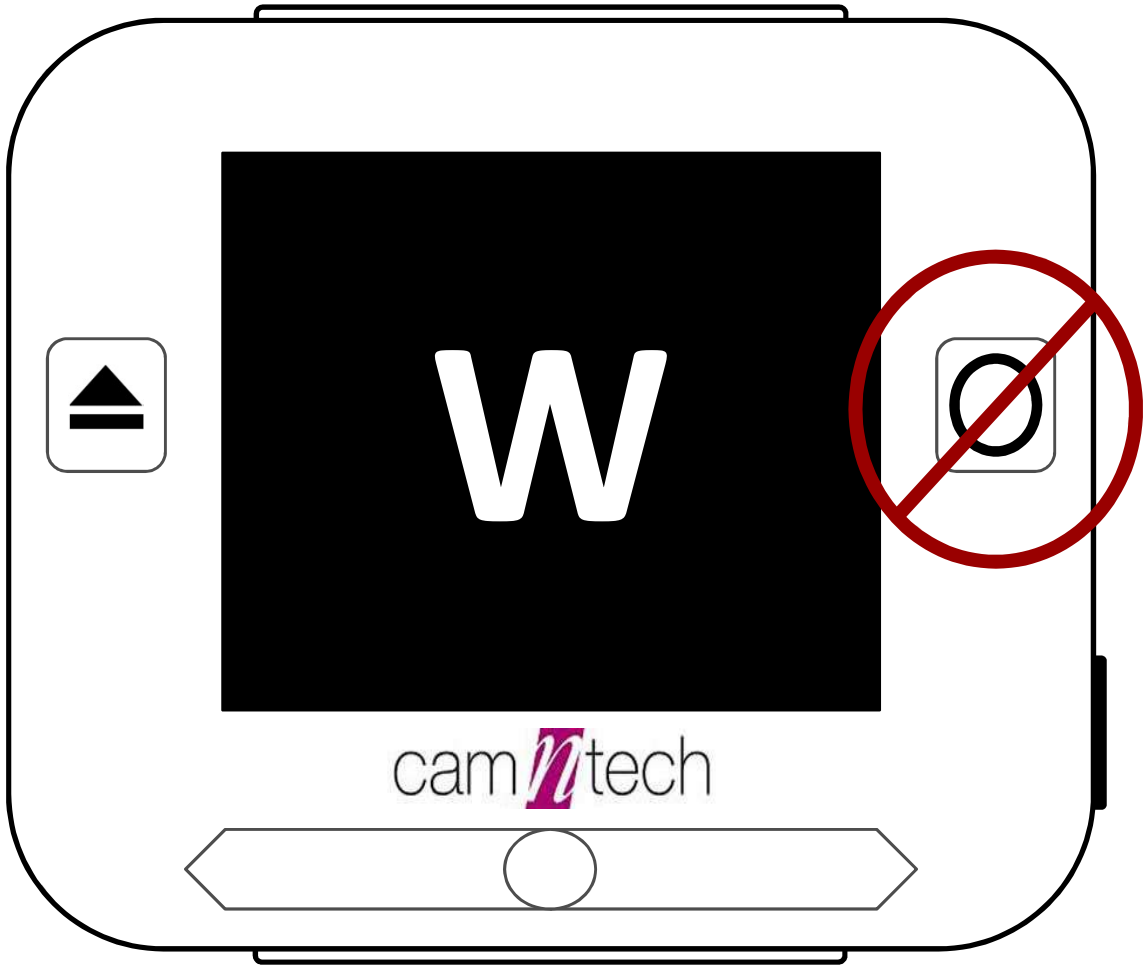

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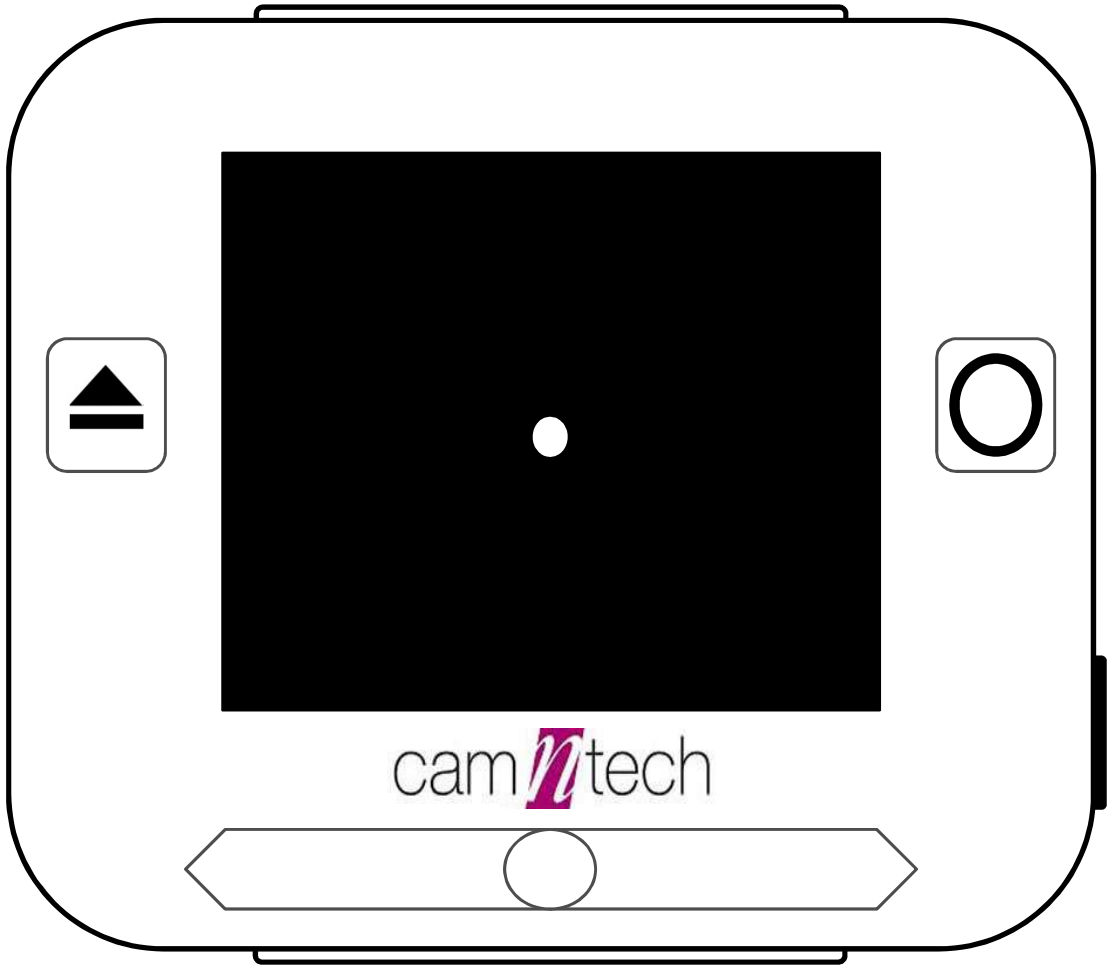

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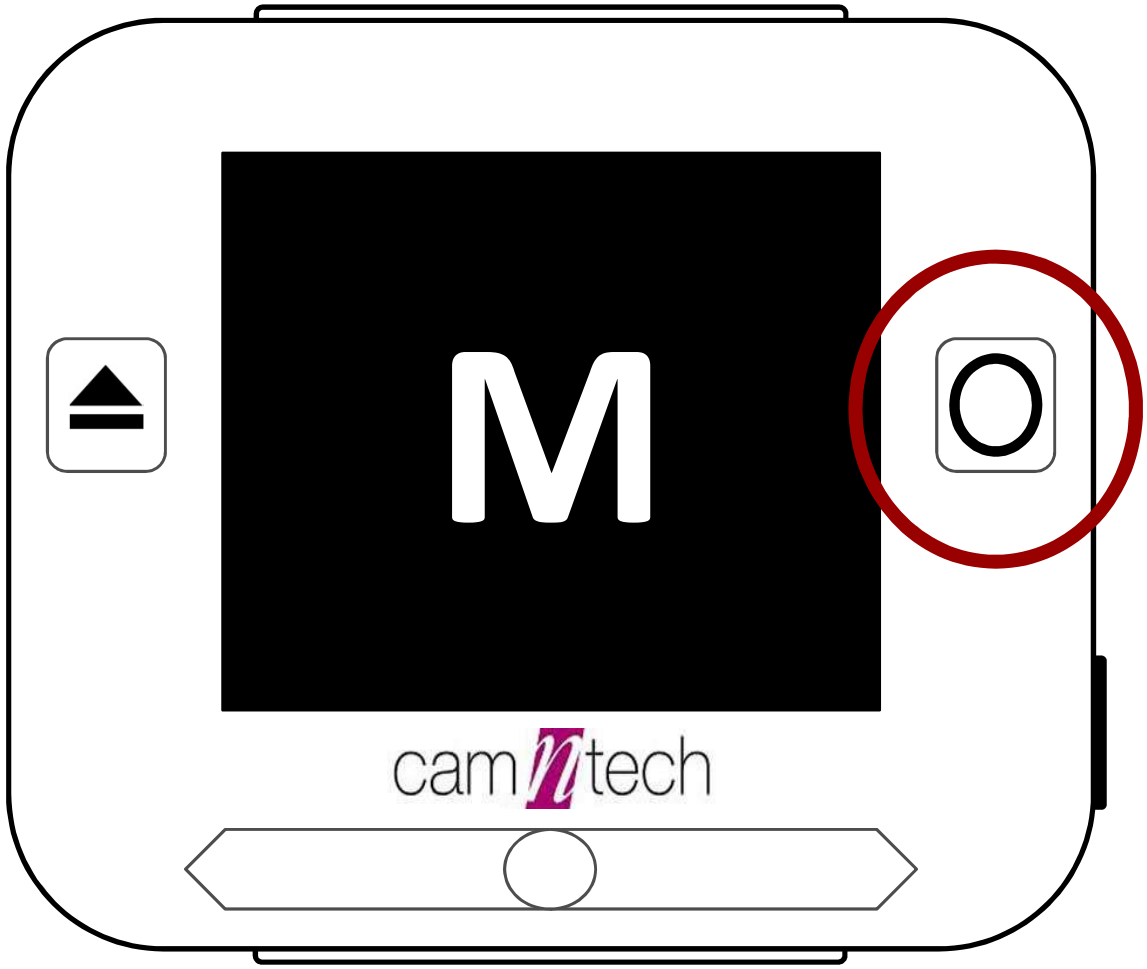


Go/No-Go task – assessing inhibitory control

Performance Indicator:

Reaction time for correct responses (ms)

Slower reaction times = poorer real-time inhibitory control

Correct responses (%)?

SNAPSHOT Design

- 7 consecutive days of EMA
- Fixed time-based design - hourly from 7am – 10pm
- Real-time Go/No-Go test assessments
- Short recall of snacking episodes

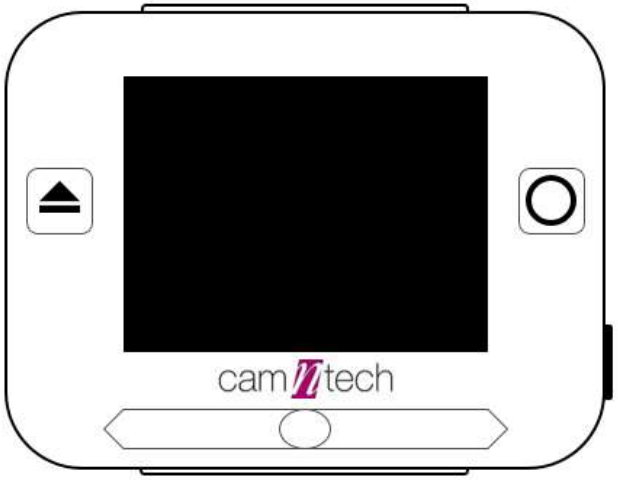
Go/No-Go Test Validation

Person-mean Go/No-Go reaction times correlated (in expected direction) with several measures taken at baseline (in the lab) that purport to measure inhibitory control

- Attention-Switching Task: Congruency Cost (r = .380, p = .002)
- Stop-Signal Task: Stop-Signal Delay (r = -.538, p < .001) and reaction time to Go Trials (r = .560, p < .001), but not Stop-Signal RT (r = .165, p = .20)
- Behaviour Rating Inventory of Executive Function - Behavioural Regulation Index (r = .262, p = .037)

Intra-class correlation coefficient (ICC) of EMA Go/No-Go test = .55

Snacking self-reports



Over the last hour…..

Have you eaten (non-core foods)…

- Chocolates/Sweets?
- Biscuits/Cakes/Pastries?
- Crisps/Savoury Snacks?
- Savoury pies/pastries?
- Takeaway/fast food?
- Soft drinks?

If **Yes**: ‘Small’, ‘Typical’ or ‘Large/Multiple’

Operationalised as a count variable = snack consumption

Participants (n = 68)

	Count or mean (SD)
Gender, Female	49
Current employment [a]	
Paid	39
Student	18
Retired	4
Housewife/husband	2
Household income [b]	
£0 – £20,000	20
£21,000 - £40,000	20
£41,000 – £60,000	7
£61,000 – £80,000	5
£81,000 – £100,000	4
> £101,000	5
Age (years) [c]	38.58 (15.54)
BMI [d]	25.67 (4.83)
Subjective Social Status [e]	6.42 (1.40)
Years in formal education [f]	16.94 (3.10)

[a] One response missing; [b] Three responses missing;
[c] Range = 18 – 70 years; [d] Range = 17.54 – 39.56;
[e] Range = 3.00 – 9.00; [f] Range = 10.00 – 23.00.

Results: Missing data

All participants **completed 7 days** of EMA

Go/No-Go test

74.2% (4664/6284) of requested Go/No-Go tests initiated;

Of these, **670 incomplete or noncompliant** (replaced with a missing value)*

Real-time snacking

78.2% (4912/6284) of **diary** reports completed

Negative Binomial Generalized Linear Mixed Model of Snacking Consumption

Effect	γ	*SE*	*p*	Exp (γ)[a]	95% confidence interval	
					Lower	Upper
Fixed effects						
Intercept	−2.00	.14	<.001	.14	.10	.18
Time of day (centered at 11:50 a.m.)	.08	.02	<.001	1.08	1.05	1.12
Go/No-Go RT (between-person)[b]	.02	.18	.965	1.02	.71	1.46
Go/No-Go RT (within-person)[b]	.23	.09	.002	1.26	1.06	1.49
Random effects[c]						
Intercept	.77	.22	<.001		.45	1.33
Time of day	.004	.003	.095		.001	.02
Covariance: Intercept and time of day	−.05	.02	.022		−.09	−.01
Residual[d]						
AR1 diagonal	1.24	.03	<.001		1.18	1.31
AR1 ρ	−.03	.02	.105		−.07	.007

Note. Probability distribution: Negative Binomial; link function: log.
[a] Exp (γ) is interpreted as a percentage increase (values > 1) or decrease (values < 1) in the consumption rate for a 1-unit increase in the predictor. [b] higher RTs indicate less inhibitory control. RT was transformed such that 1-unit equated to 100 ms (i.e. one-tenth of a second). [c] random effect covariance structure: unstructured. [d] residual covariance structure: first-order autoregressive (AR1).

Results

Within-person: Exp (γ) = 1.26, *p* = .002, CI_{95}: 1.06, 1.49

100 ms slower RT (than usual) = 25.67% higher consumption in subsequent hour

Between-person: Exp (γ) = 1.02, *p* = .965, CI_{95}: 0.71, 1.46

Results robust to analyses adjusting for BMI, alcohol intake, outliers.

Go/No-Go tests: spotting non-compliance

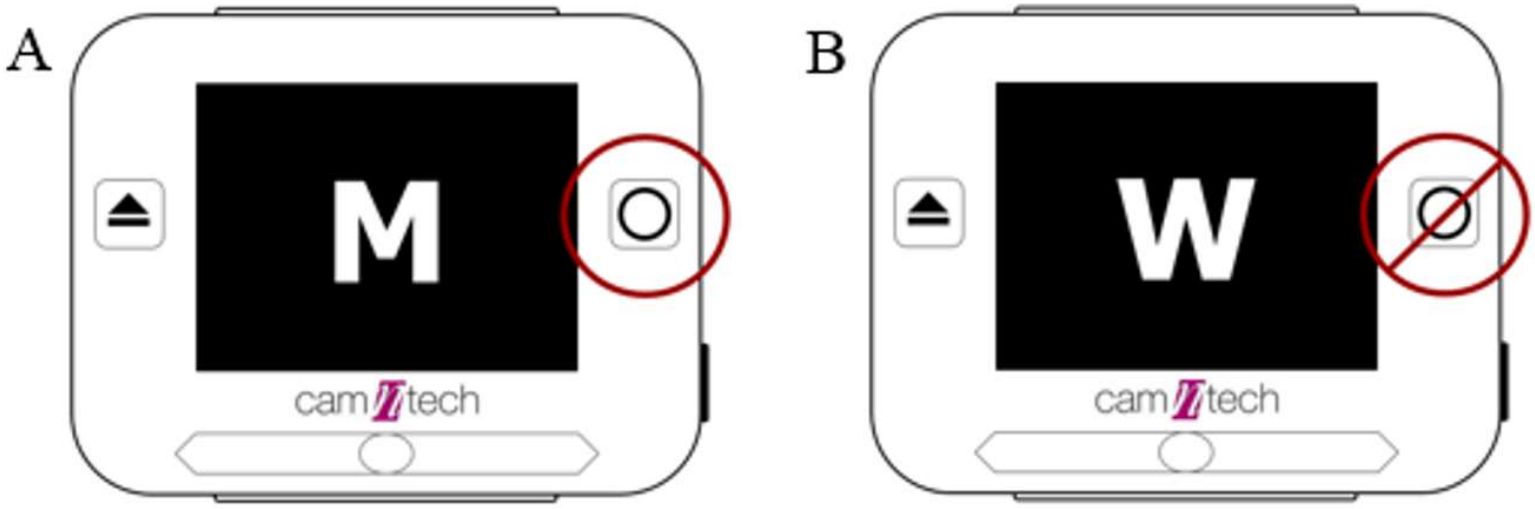
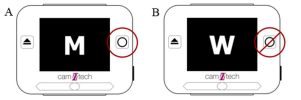


Figure S1.1. Representation of the PRO-Diary watch-faces for 'Go' trials (A) and 'No-Go' trials (B). Participants were asked to respond as quickly as possible to 'Go' trials using the response button on the right.

Go/No-Go tests: “Multi-tappers”



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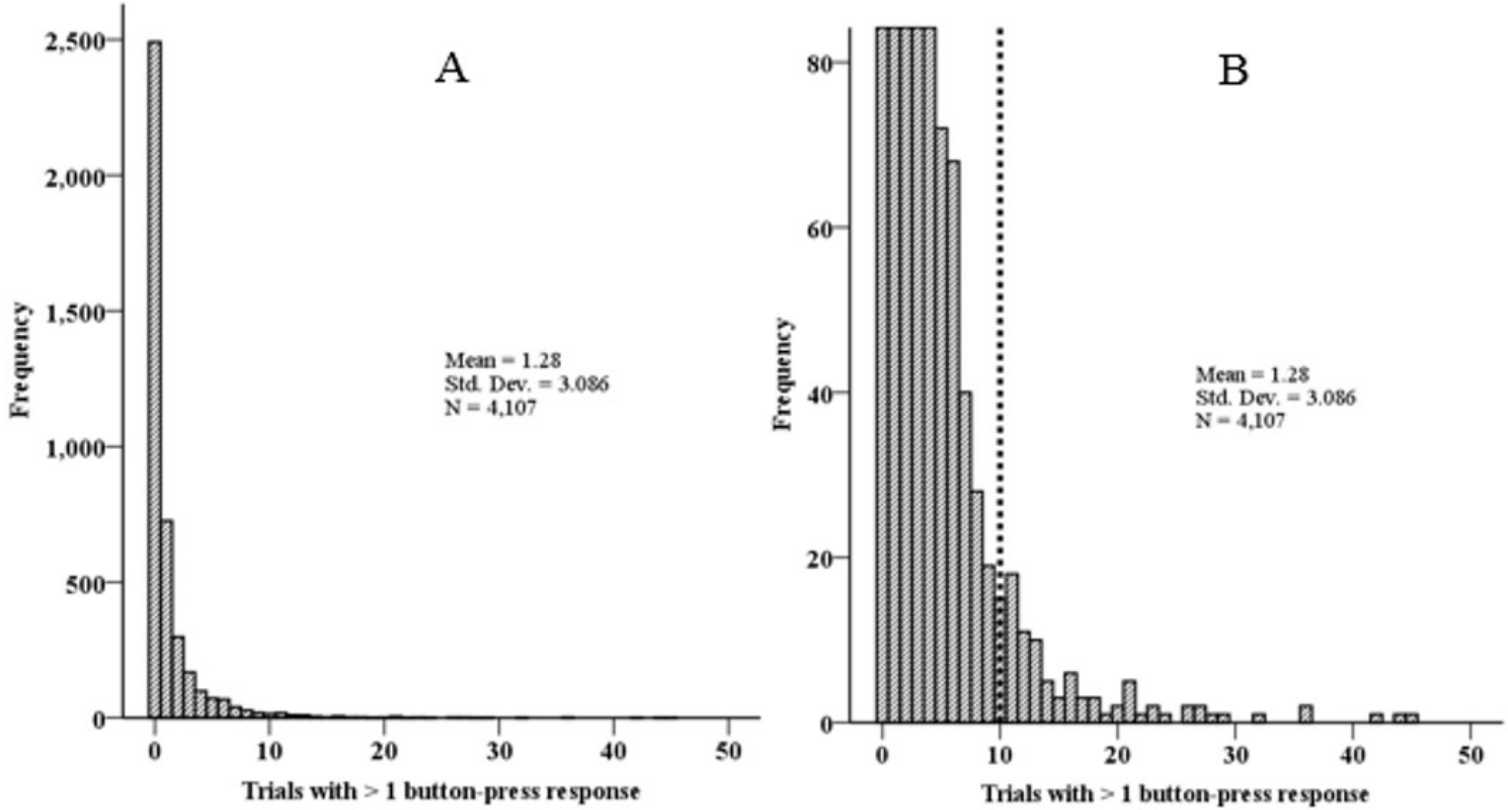
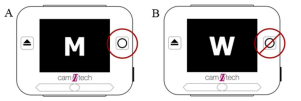


Figure S1.3. Frequency of tests by the number of constituent ‘Go’ trials with a button-press response (A) and focussing on the lower frequencies of the same histogram (B). The cut-off decision is denoted by the dashed line.

Powell et al. (2017), *Health Psychology*, *36(4),* Supp 1

Go/No-Go: “Tap-and-goers”



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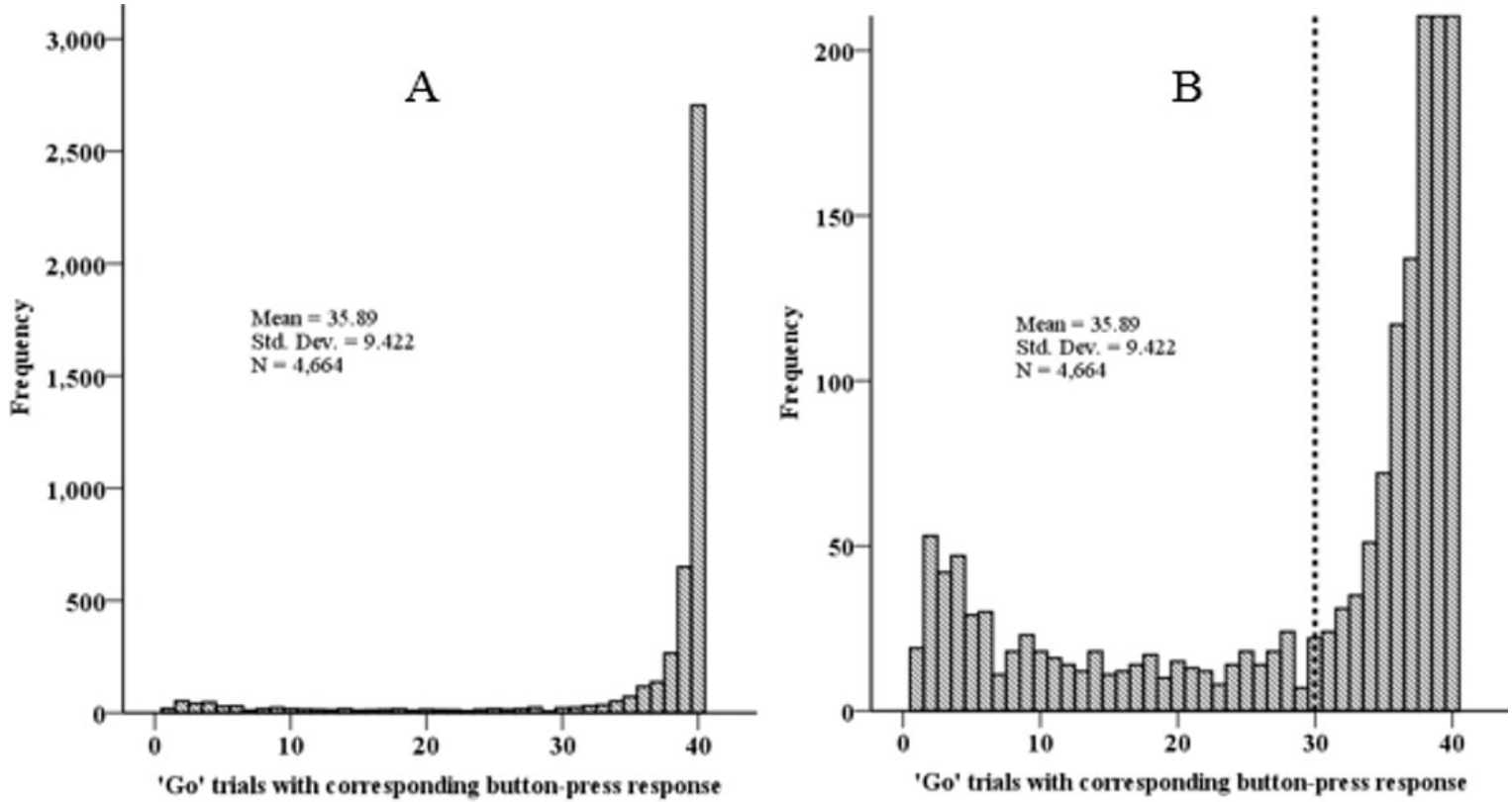


Figure S1.2. Frequency of tests by the number of constituent ‘Go’ trials with a button-press response (A) and focussing on the lower frequencies of the same histogram (B). The cut-off decision is denoted by the dashed line.

Powell et al. (2017), *Health Psychology*, *36(4),* Supp 1

Solution to non-compliance in data

- Realise that full compliance at all times is an unrealistic expectation, especially when burden is quite high
- Know what to look for – “cheat” in a pilot run yourself. How does this look in the data? Create syntax/code to identify
- Set pre-specified rules for where a test result is insufficiently or inappropriately completed
- Check for any predictors of invalid responses in your data. Include these predictors in the model (as not missing completely at random)

Summary

- Inhibitory control fluctuates significantly within-persons
- Consistent with theory, the relationship between inhibitory control and snacking appears best understood as a within-person process.
- Mediating effect on intention-behaviour relation untested.

- Go/No-Go test can detect changes in inhibitory control efficiency in an EMA study
- Too simple? A more selective inhibitory mechanism based on behavioural goals may be more realistic – deciding which cues to suppress and which to enact
- Careful data cleaning is needed. Know what to look for….!

MS Cortisol & Fatigue Study

Fatigue in MS

- 60 – 85% prevalence (Lerdal et al., 2003; Minden et al., 2006)
- Often described as the most disabling and distressing symptom

- Cortisol is the “end product” of the HPA axis
- Cortisol is an important regulator of the immune system (downregulation)
- HPA axis hyperactive in MS? (Gold et al., 2010; Kern et al., 2011)
- Cortisol important in energy metabolism
- Little examination in daily life using EMA

Main Hypothesis

Fatigue severity associated with an attenuated cortisol awakening response (CAR)

- Between individuals
- Within individuals (i.e. day-to-day)

MS Fatigue and Cortisol - Recruitment

People with relapsing-remitting MS (RRMS)

Exclusion criteria:

- Within 3 months of a clinical relapse
- (Self-reported) inability to walk 300m with/without use of a walking aid
- Diagnosed physical or psychiatric comorbidity
- HADS score ≥ 8 (indicative of moderate depression)
- Current antidepressant use
- Pregnancy
- Caregiving
- Shift-working

MS Fatigue and Cortisol Design

- Case-Control
- 4 consecutive days of EMA

- 4 x CAR; 4 x diurnal slopes
- CAR: fixed event-based design (awakening, +30min, +45min)
- Diurnal slope: variable time-based design (10am – 8pm)

- Baseline fatigue severity scale (Chalder Fatigue Scale)
- Momentary fatigue severity ratings

  How fatigued (tiredness, weariness, problems thinking clearly) do you feel right now?

Salivary cortisol in daily life

- Enables repeated assessments
- Non-invasive, relatively easy to administer

Markers of HPA axis activity:

(1) Cortisol awakening response
(2) Diurnal slope
(3) Stress reactivity

Salivary cortisol in daily life

- Enables repeated assessments
- Non-invasive, relatively easy to administer

Markers of HPA axis activity:

(1) Cortisol awakening response

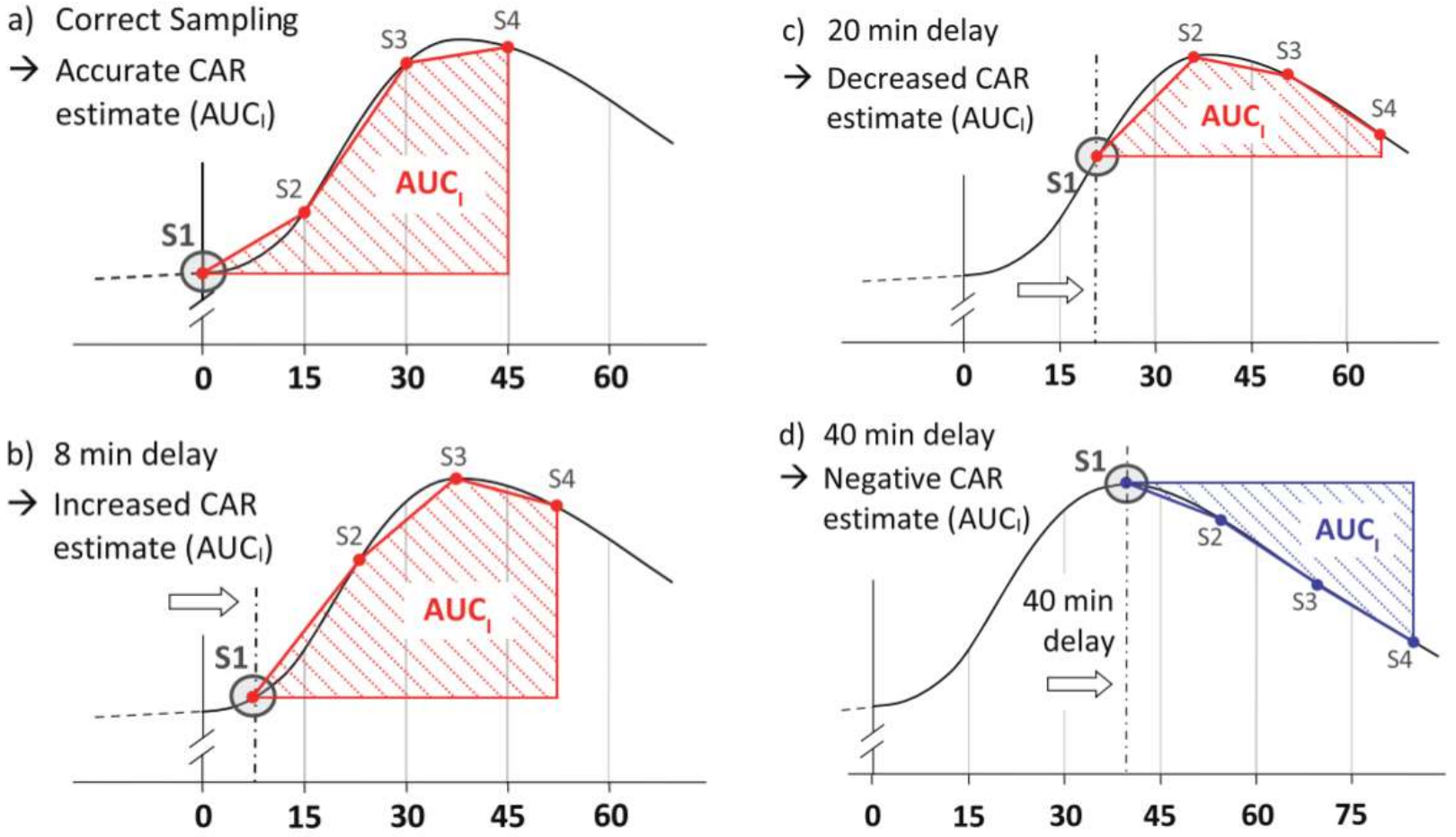
(2) Diurnal slope

(3) Stress reactivity

Sampling:

T0	Awakening
T30	Awakening + 30mins
T45	Awakening + 45 mins

Methodological Challenge



Stalder et al. (2016), *Psychoneuroendocrinology*, *63*, p. 419

Methodological Challenge

How to ensure participants collect samples promptly when asked?

Methodological Solution

Stetler, Dickerson, & Miller (2004)

- Use the device as an alarm clock
- Present time-limited code
- Require code be transferred to label
- Exclude any delayed samples, or samples with incorrect code

Remaining weaknesses

- Spontaneous awakenings

Participants (n = 76)

	RRMS	Control
N	38	38
Age	41.89 (7.53)	40.34 (8.16)
Gender	31f/7m	31f/7m
EDSS	4.35 (1.40)	
Years since diagnosis	6.03 (5.18)	
HADS-D	4.00 (2.29)	2.08 (2.27)
HADS-A	7.50 (3.90)	4.82 (3.12)
Fatigue Scale	17.58 (7.09)	11.55 (2.87)
FS-Phys	11.18 (4.89)	7.26 (2.34)
FS-Ment	6.39 (2.66)	4.29 (0.96)
Sleep Quality (Mean)	6.07 (1.57)	6.22 (1.97)
Sleep Hrs (Mean)	7.83 (1.00)	7.63 (0.89)

Results: Missing data

All participants completed 4 days of EMA

Salivary cortisol

One participant did not provide any CAR samples, leaving 75 participants with data

42 from 300 (14%) remaining CARs had missing or delayed samples

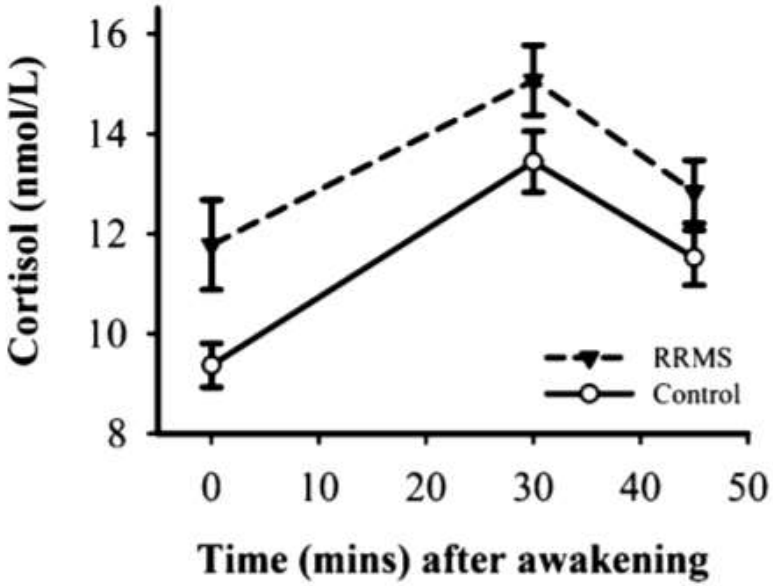


Figure 1 Cortisol awakening response represented by the mean of the within-subject means for samples at 0 (S1), 30 (S2), and 45 min (S3) post-awakening. Error bars represent the standard error of the mean.

Powell, Moss-Morris, Liossi, & Schlotz, W. (2015)

Results

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	RRMS					Control				
Fixed effect	Coef.	*SE*	*t*	*p*	95% CI	Coef.	*SE*	*t*	*p*	95% CI
Models for CAR AUCi										
FS Score	0.157	0.064	2.442	.017	[0.029, 0.285]	0.087	0.160	0.543	.588	[−0.231, 0.405]
FS Physical	0.216	0.093	2.316	.023	[0.031, 0.400]	0.094	0.194	0.482	.631	[−0.292, 0.480]
FS Mental	0.391	0.175	2.235	.028	[0.044, 0.739]	0.219	0.502	0.324	.663	[−0.776, 1.214]
Models for (ln) S1 cortisol										
FS Score	−0.022	0.008	−2.781	.007	[−0.038, −0.006]	−0.008	0.019	−0.387	.700	[−0.046, 0.031]
FS Physical	−0.028	0.012	−2.454	.016	[−0.051, −0.005]	−0.009	0.024	−0.393	.695	[−0.058, 0.039]
FS Mental	−0.060	0.021	−2.865	.005	[−0.102, −0.018]	−0.011	0.059	−0.191	.849	[−0.129, 0.106]

Analyses robust to sensitivity analyses with “responders”-only

Powell, Moss-Morris, Liossi, & Schlotz, W. (2015)

Summary

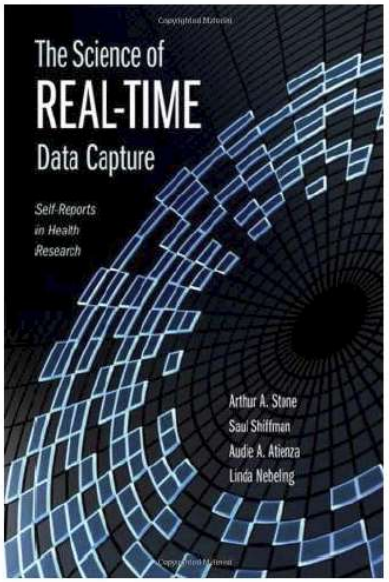
- Fatigue in MS associated with lower CAR AUCi and higher S1 cortisol
- No relation between fatigue in controls with any CAR marker

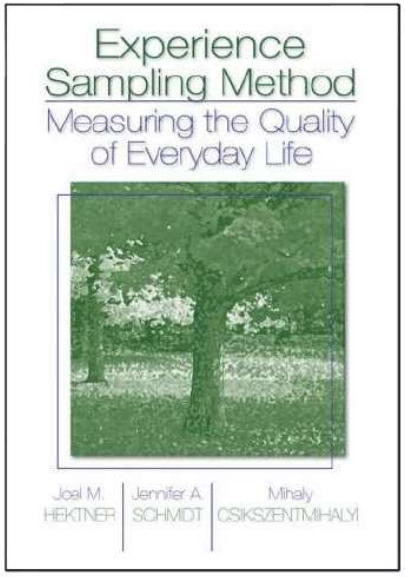
- <u>Timing is crucial in salivary cortisol studies</u>
- In 2013-14, **7.9%** of CAR studies had objective control of awakening time (Stalder et al., 2016)
- In 2013-14, **18.6%** of CAR studies had objective control of sampling time (Stalder et al., 2016)
- In 2013-14, a diary log method in **65.5%** of studies (Stalder et al., 2016)
- CAR on a single day is determined mostly by situational factors (Hellhammer et al., 2007) yet in 2013-14, **31.7%** of studies observed CAR on 1 day alone and only **4.8%** over 4-5 days (Stalder et al., 2016)

Overall EMA Summary and Tips

- EMA methods present unique opportunities but also challenges
- Have a theory of change and design your study accordingly
- Pilot, pilot, pilot
- Account for time in your models – avoid spurious relationships
- Deal with missing data appropriately. MLMs do not automatically resolve this issue
- You will have missings, but also ‘partial missings’ and ‘invalid completes’. Decide how you will (i) discourage these; (ii) identify these and (iii) what you’ll do about them.
- Do not fall into the trap of thinking more-objective measures are immune from challenges. They aren’t.

- Lots of useful, accessible texts on both the method and its analysis


The Science of
REAL-TIME
Data Capture
Self-Reports in Health Research
Arthur A. Stone
Saul Shiffman
Audie A. Atienza
Linda Nebeling


Experience Sampling Method
Measuring the Quality of Everyday Life
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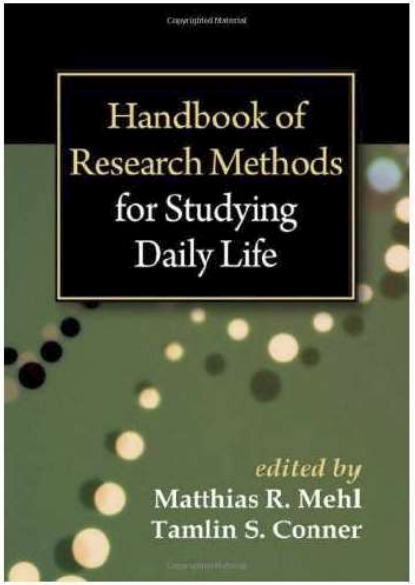
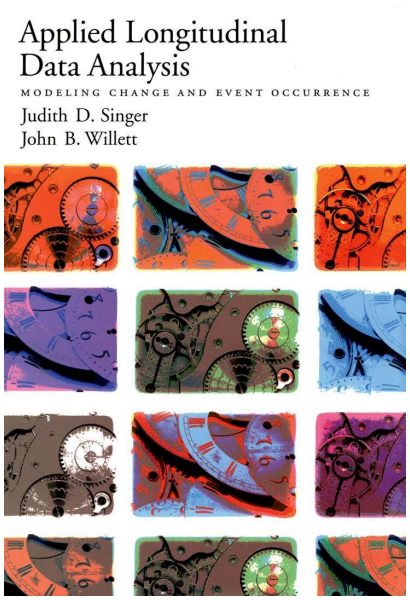
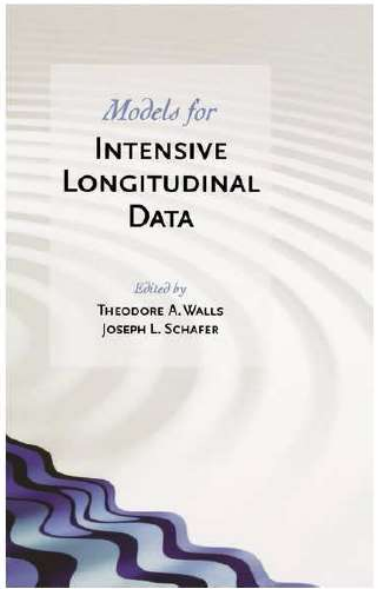

Handbook of Research Methods for Studying Daily Life
edited by
Matthias R. Mehl
Tamlin S. Conner


Applied Longitudinal Data Analysis
MODELING CHANGE AND EVENT OCCURRENCE
Judith D. Singer
John B. Willett


Models for
INTENSIVE LONGITUDINAL DATA
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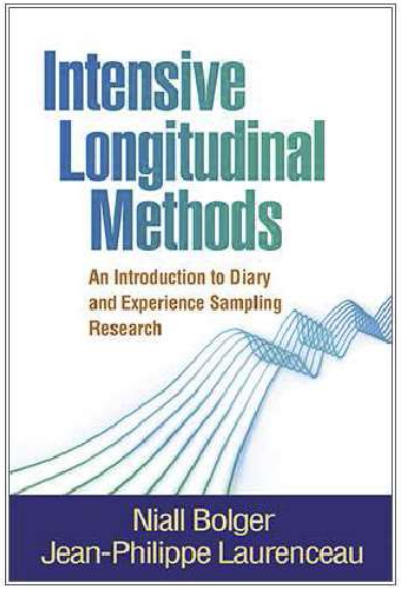
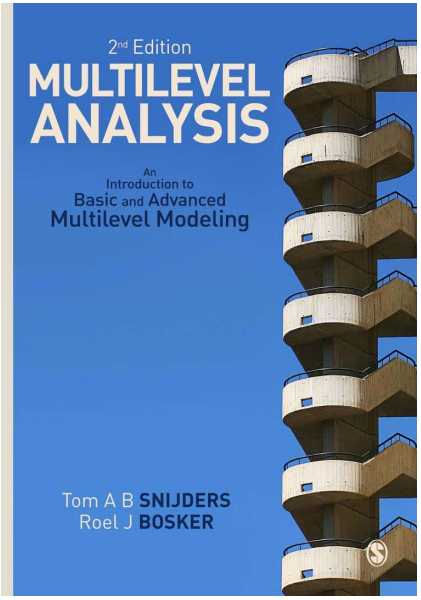
JOSEPH L. SCHAFER


Intensive Longitudinal Methods
An Introduction to Diary and Experience Sampling Research
Niall Bolger
Jean-Philippe Laurenceau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MULTILEVEL ANALYSIS
An Introduction to Basic and Advanced Multilevel Modeling
Tom A B SNIJDERS
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daniel.powell@abdn.ac.uk

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@danpowell83