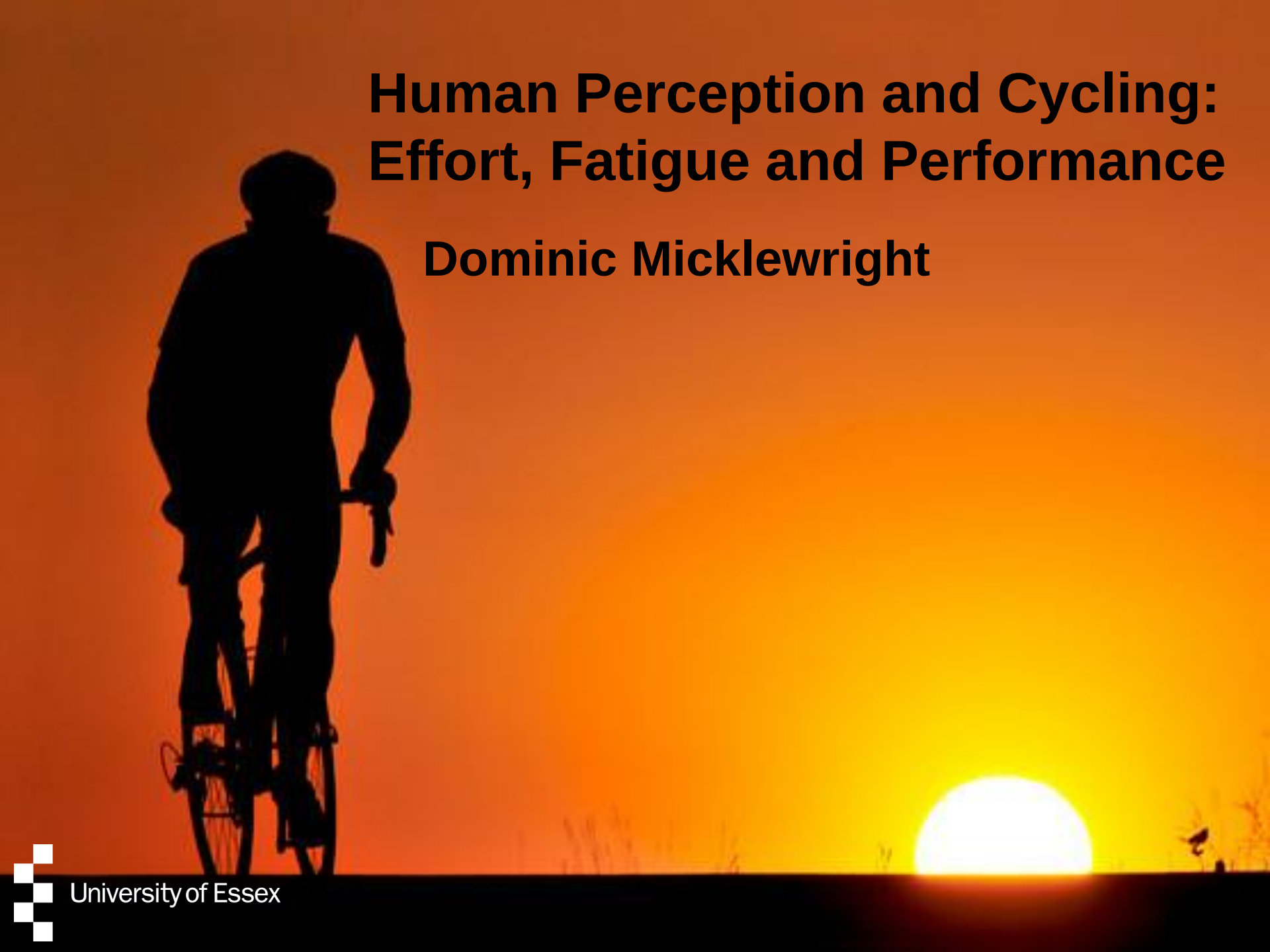
# Human Perception and Cycling: Effort, Fatigue and Performance

Dominic Micklewright



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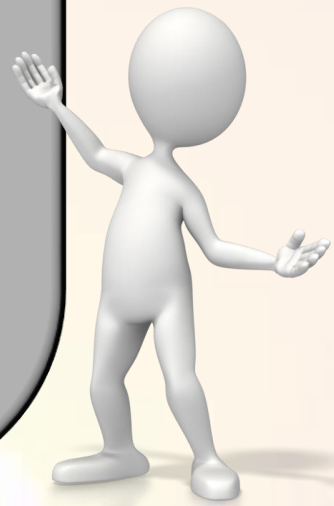
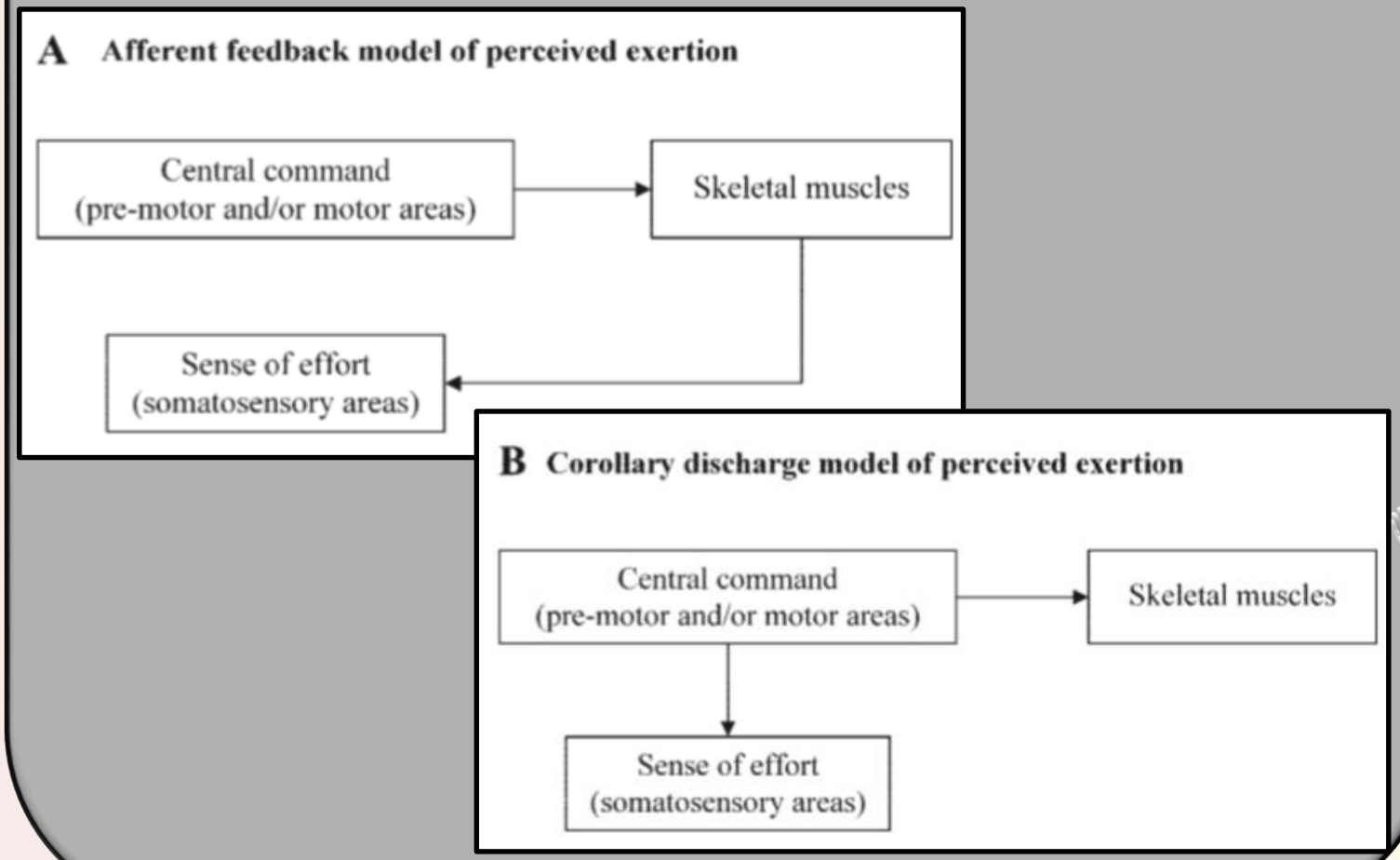
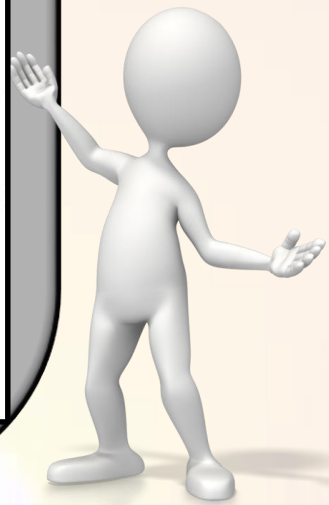
# Myth 1: Perception = Reality

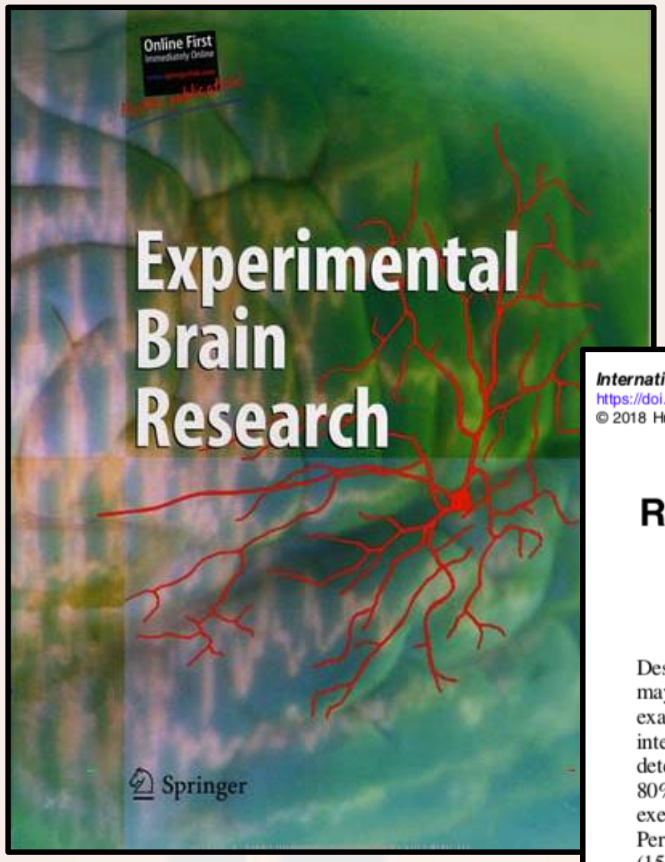


# Fig. 1 Afferent vs Corollary Models of RPE

## Marcora (2009)



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https://doi.org/10.1123/ijspp.2017-0171


Human Kinetics
ORIGINAL INVESTIGATION

# Rating of Perceived Exertion During Concentric and Eccentric Cycling: Are We Measuring Effort or Exertion?

**Luis Peñailillo, Karen Mackay, and Chris R. Abbiss**

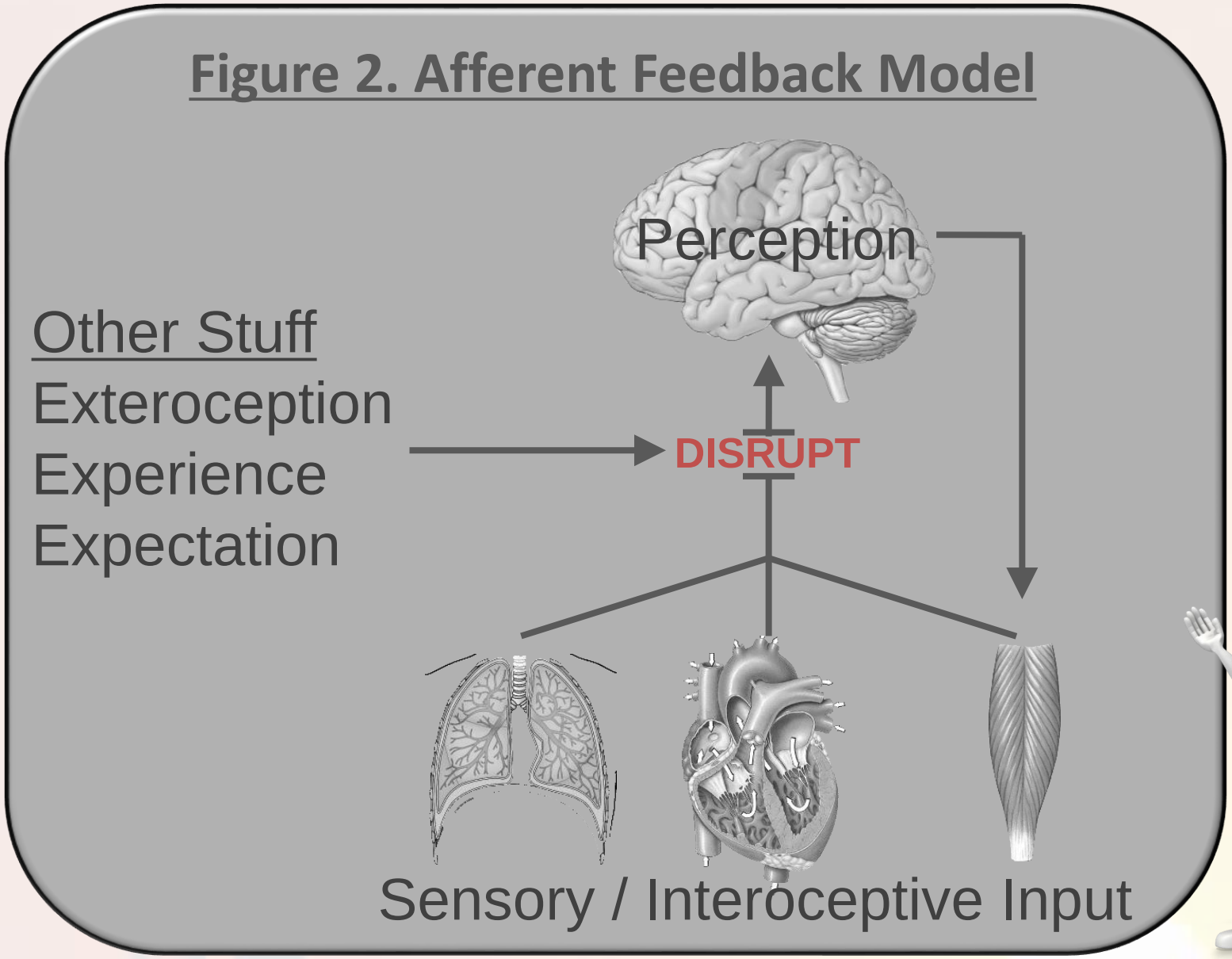
Despite the terms' often being used interchangeably, it has been suggested that perceptions of effort and perceptions of exertion may differ. Eccentric (ECC) cycling may provide a model of exercise by which differences between these perceptions can be examined. ***Purpose:*** To examine and compare perceptions of effort and exertion during ECC and concentric (CONC) cycling at 4 intensities. ***Methods:*** Ten healthy male participants (mean [SD]: age = 29.8 [2.3] y) performed an incremental cycling test for the determination of maximal aerobic power output, followed in a randomized and crossover design, by four 5-min bouts (30%, 60%, 80%, and maximal) of either ECC or CONC cycling. Through each bout, participants were asked to report their perceived effort, exertion, and muscle pain. Heart rate and oxygen consumption were continuously recorded throughout each bout. ***Results:*** Perceived exertion was greater for CONC at 30% (8.5 [1.5] vs 7.1 [1.8]; $P = .01$), 60% (12.4 [1.4] vs 10.3 [2.0]; $P = .01$), 80% (15.8 [1.7] vs 12.4 [2.5]; $P < .01$), and maximal (17.2 [1.3] vs 15.6 [1.8]; $P = .03$) in comparison with ECC. Perceptions of effort and pain were similar between CONC and ECC. Heart rate and oxygen consumption were greater during CONC than ECC. ***Conclusions:*** Perceived exertion was greater during CONC compared with ECC cycling, yet effort was similar between conditions despite different physiological stress. Such findings have implications for understanding the development of such perceptions during exercise.

***Keywords:*** efference copy, corollary command, perceptions

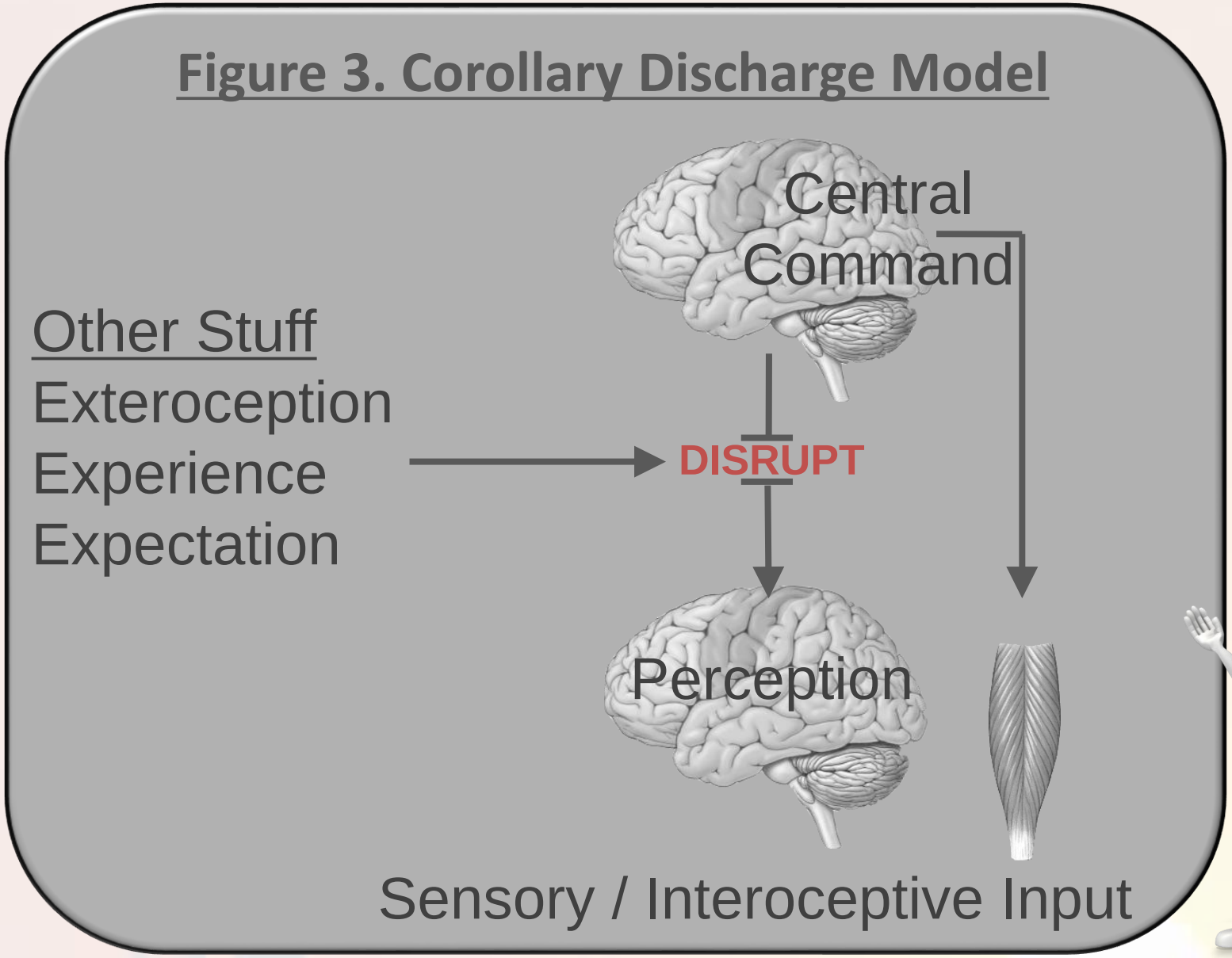
Rating of perceived exertion (RPE) is one of the most utilized measurements in exercise and sports science settings. Exercise-induced increases in psychophysiological stress are extremely important in many aspects of exercise capacity and performance including the development and perceptions of fatigue,[1] the distribution of pace,[2–4] and one's motivation or desire to exercise. To date, several RPE scales have been developed to assess psycho-

they are not identical and differ slightly in their meaning. Exertion may been defined as the "degree of heaviness and strain experienced in physical work,"[17] whereas effort may be regarded as "the amount of mental or physical energy being given to a task."[7] Based on such definitions, it is plausible that the relative contribution of factors important in the development of such perceptions differs slightly and that an individual's physiological state (ie, cardio-

# Figure 2. Afferent Feedback Model




# Figure 3. Corollary Discharge Model




# **Fig 4.** Optic flow study experimental design

Parry, Chinnasamy & Micklewright, 2012: *J Sport & Ex. Psych.*


REFERENCE TIME TRIAL

5 MIN WARM-UP

20 KM SELF PACED TIME TRIAL

REPEAT 3 x 20 km CYCLE TRIALS
PACE FIXED USING AVERAGE POWER & CADENCE FROM REFERENCE TRIAL
ORDER COUNTERBALANCED

OPTIC FLOW=SPEED-15% ($TT_{SLOW}$)

SLOW

5 MIN WARM-UP

20 KM FIXED PACE CYCLE TRIALS

OPTIC FLOW=SPEED ($TT_{NORM}$)

NORM

5 MIN WARM-UP

20 KM FIXED PACE CYCLE TRIALS

OPTIC FLOW=SPEED+15% ($TT_{FAST}$)

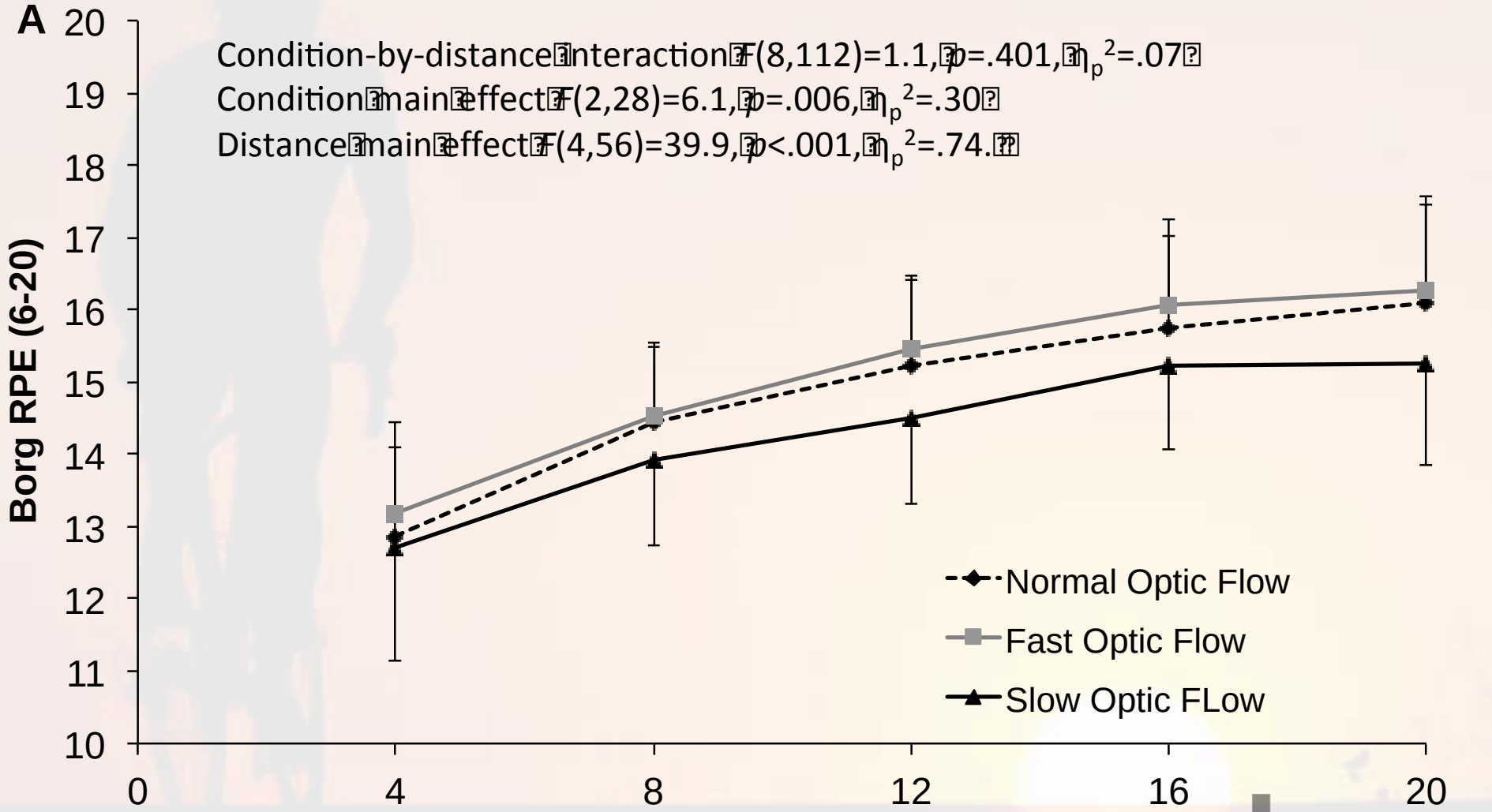
FAST

5 MIN WARM-UP

20 KM FIXED PACE CYCLE TRIALS

# **Fig 5.** RPE and Optic Flow

Parry, Chinnasamy & Micklewright, 2012: *J Sport & Ex. Psych.*

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# **Fig 6.** Perception-Reality Discrimination

Power Output
RPE
Power Output (W)
Borg Rating of Perceived Exertion (6-20)
Time (s)
0
30
60
90
120
150
180
210
240
270
300
330
360
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
0
200
400
600
800
1000
1200

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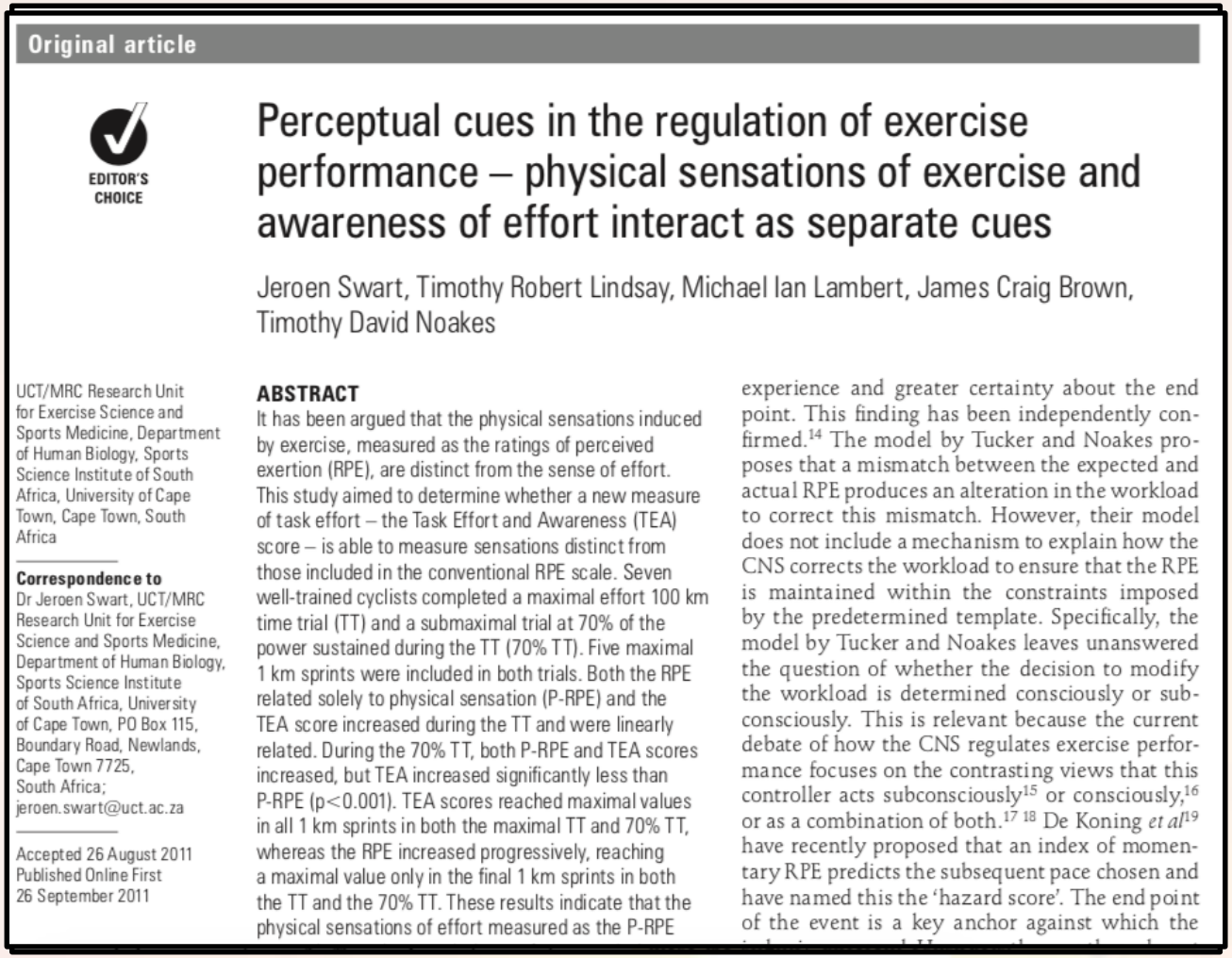
# Myth 2: Exertion and Effort are the same



Original article

EDITOR'S CHOICE

## Perceptual cues in the regulation of exercise performance – physical sensations of exercise and awareness of effort interact as separate cues

Jeroen Swart, Timothy Robert Lindsay, Michael Ian Lambert, James Craig Brown, Timothy David Noakes

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**ABSTRACT**
It has been argued that the physical sensations induced by exercise, measured as the ratings of perceived exertion (RPE), are distinct from the sense of effort. This study aimed to determine whether a new measure of task effort – the Task Effort and Awareness (TEA) score – is able to measure sensations distinct from those included in the conventional RPE scale. Seven well-trained cyclists completed a maximal effort 100 km time trial (TT) and a submaximal trial at 70% of the power sustained during the TT (70% TT). Five maximal 1 km sprints were included in both trials. Both the RPE related solely to physical sensation (P-RPE) and the TEA score increased during the TT and were linearly related. During the 70% TT, both P-RPE and TEA scores increased, but TEA increased significantly less than P-RPE ($p<0.001$). TEA scores reached maximal values in all 1 km sprints in both the maximal TT and 70% TT, whereas the RPE increased progressively, reaching a maximal value only in the final 1 km sprints in both the TT and the 70% TT. These results indicate that the physical sensations of effort measured as the P-RPE

experience and greater certainty about the end point. This finding has been independently confirmed.[14] The model by Tucker and Noakes proposes that a mismatch between the expected and actual RPE produces an alteration in the workload to correct this mismatch. However, their model does not include a mechanism to explain how the CNS corrects the workload to ensure that the RPE is maintained within the constraints imposed by the predetermined template. Specifically, the model by Tucker and Noakes leaves unanswered the question of whether the decision to modify the workload is determined consciously or subconsciously. This is relevant because the current debate of how the CNS regulates exercise performance focuses on the contrasting views that this controller acts subconsciously[15] or consciously,[16] or as a combination of both.[17 18] De Koning *et al*[19] have recently proposed that an index of momentary RPE predicts the subsequent pace chosen and have named this the 'hazard score'. The end point of the event is a key anchor against which the

# Myth 2: Exertion and Effort are the same

Perceived Exertion: "…degree of heaviness and strain experienced in physical work."

Perceived Effort: "…the amount of mental or physical energy being given to a task."

Borg, 1998

Task Effort & Awareness: "…psychological effort required to sustain or increase work…"

Physical Sensations of Effort: "…experienced physical sensations …distinct from psychological effort."

Swart et al., 2012

# Truth 1: Perceptions are Real

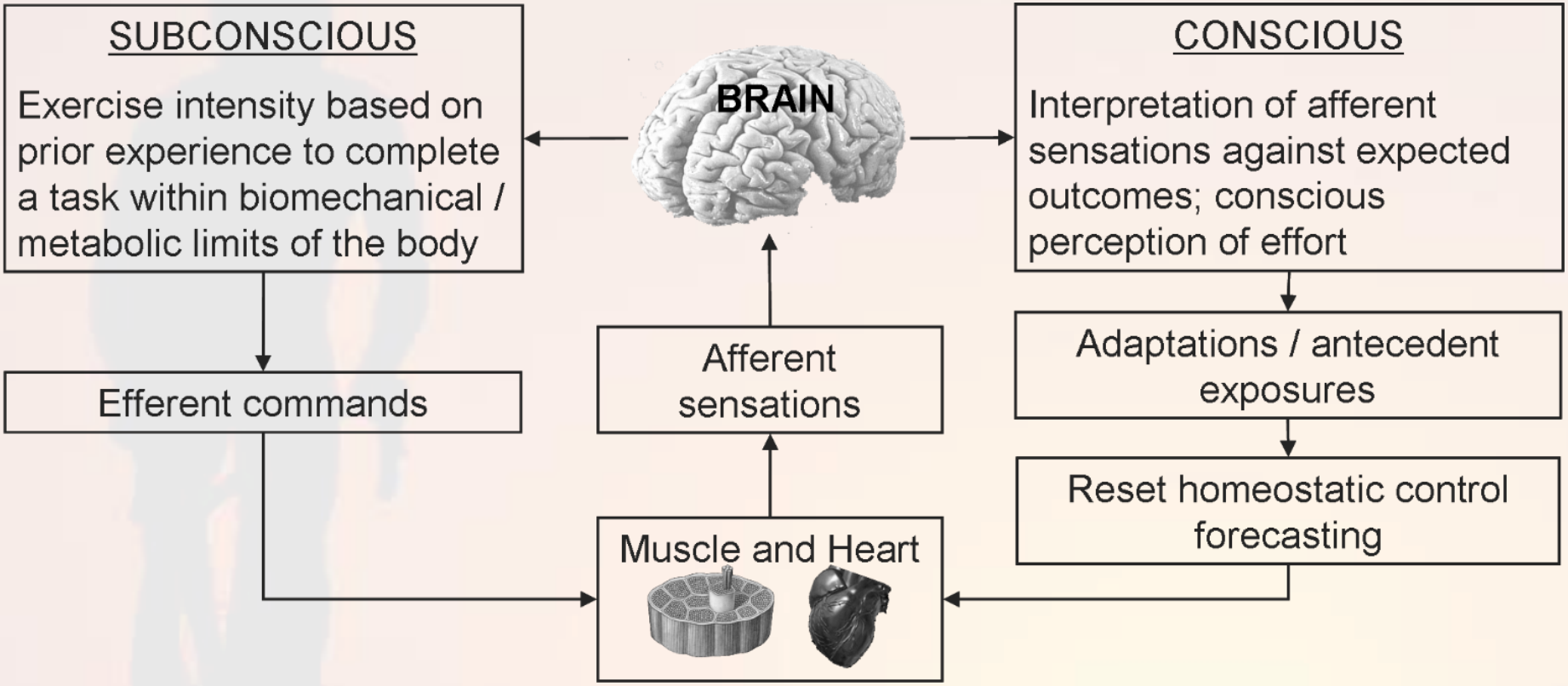


**Fig 7. Central Governor Theory**

(Adapted from Lambert, St Clair Gibson & Noakes, 2005 *Br J Sports Med*)

Eur J Appl Physiol (2012) 112:2303–2312
DOI 10.1007/s00421-011-2197-4

ORIGINAL ARTICLE

**Self-re**

M. Garcin
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Received: 3
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**Abstract**
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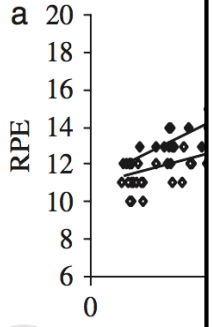
*Psychophysiology*, 45 (2008), 977–985. Wiley Periodicals, Inc. Printed in the USA.
Copyright © 2008 Society for Psychophysiological Research
DOI: 10.1111/j.1469-8986.2008.00712.x

# The rating of perceived exertion during competitive running scales with time

JAMES FAULKNER,
School of Sport and Health Sc

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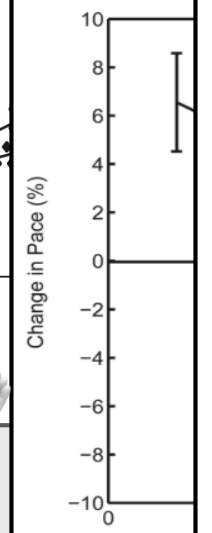
PLoS one

# Regulation of Pacing Strategy during Athletic Competition

**Jos J. de Koning[1,2]*, Carl Foster[1,2], Arjan Bakkum[1], Sil Kloppenburg[1], Christian Thiel[3], Trent Joseph[2], Jacob Cohen[2], John P**

1 Faculty of Human Movement Scie
University of Wisconsin La Crosse, L




Subconscious s
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*European Journal of Sport Science*, 2018
Vol. 18, No. 1, 25–36, https://doi.org/10.1080/17461391.2017.1321688

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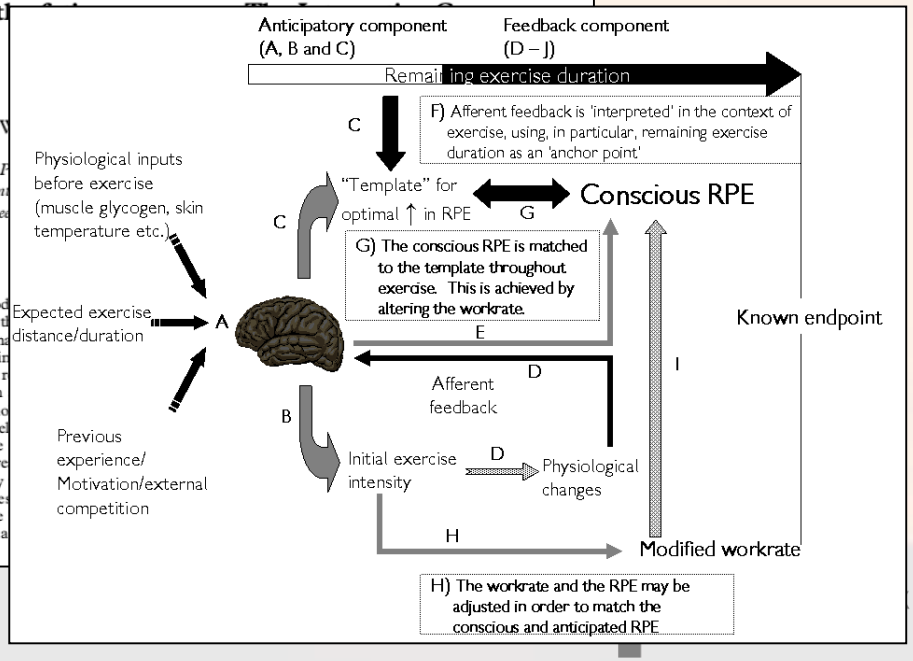
REVIEW ARTICLE

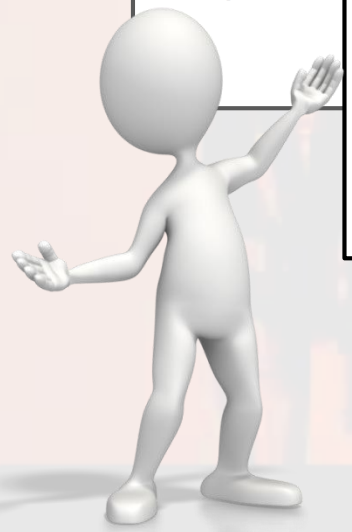
# The interaction of psychological and physiological homeostatic drives and role of general control principles in the regulation of physiological systems, exercise and th theory

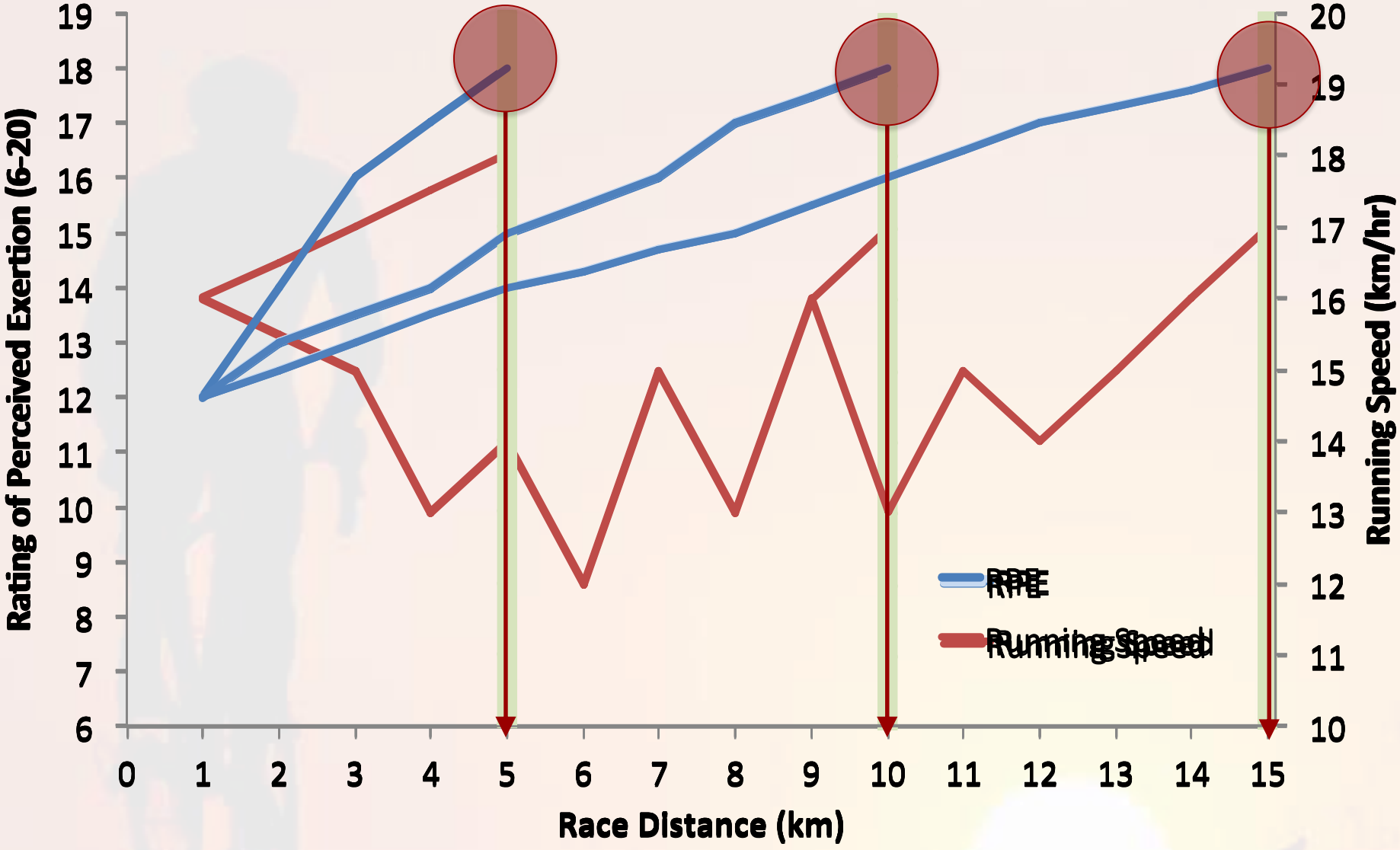
A. ST CLAIR GIBSON[1], J. SW

[1]*Faculty of Health, Sport and Human P Science and Sports Medicine, Departmen of Health Sciences, University of the Fre*

**Abstract**
Either central (brain) or peripheral (bod championed in the last few decades in t regulated. In this review, we suggest tha that have 'straight-jacketed' research in homeostatic drives is central to the r processes, underpin all physical system this review, we suggest that both psycho principles, and that regulation of the rel general operational controller. Because will oscillate, that these oscillations cre information, current activity, or activity in a similarly dynamic manner. Changes system itself, the behavioural causative and awareness of change occurs as a psychological state.





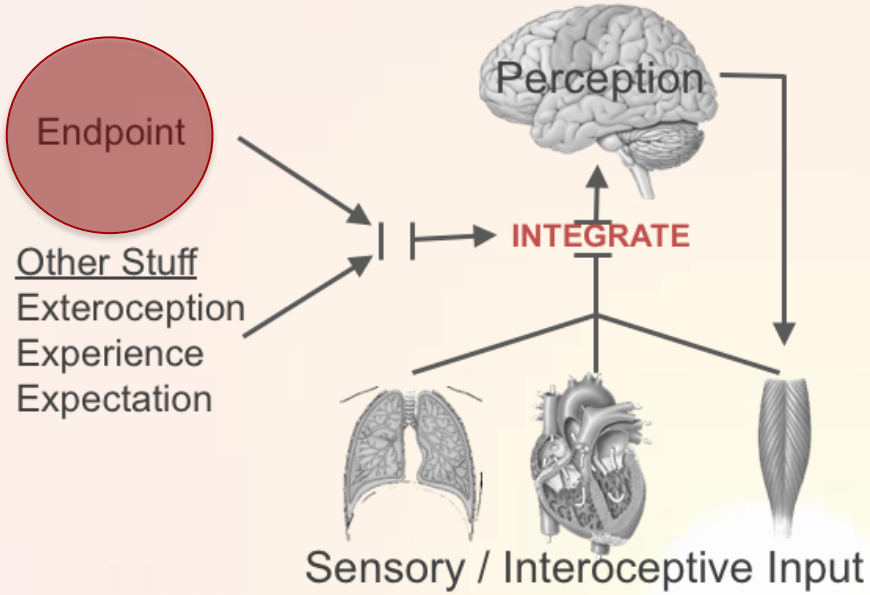
# Truth 2: The future is uncertain

Retrospection: re-experiencing the past

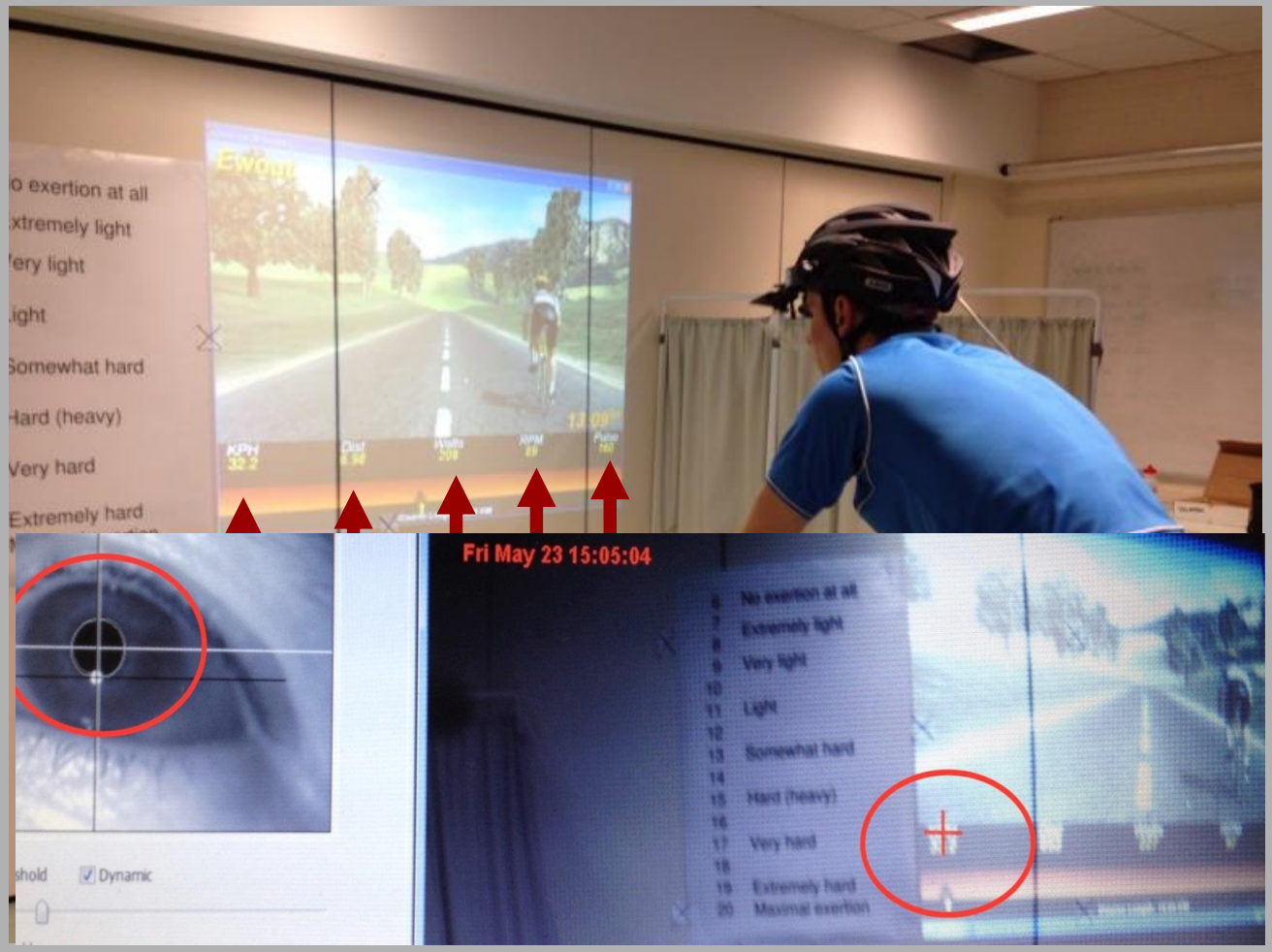
**Is it the universal mechanism for contextualising RPE in the future ?**

Perception: mental representation of the present

Prospection: imagining a range of possibilities and their consequences through mental simulation…

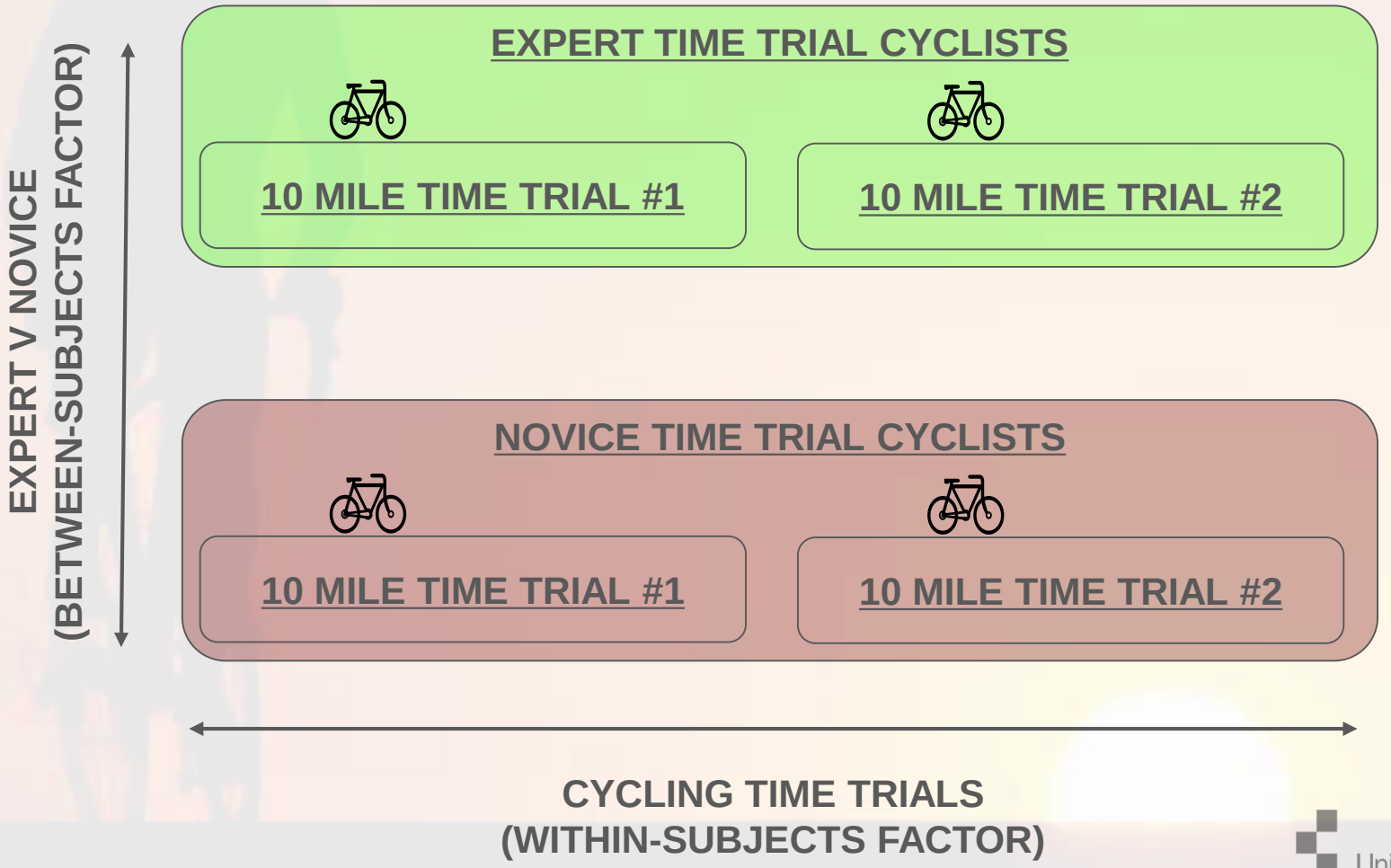


# Fig 8. Eye-tracking methods




# **Fig 9.** Experimental design – expert vs novice differences in information acquisition

Boya et al. (2017) Medicine & Science in Sports & Exercise. 49(9),1884-1898.

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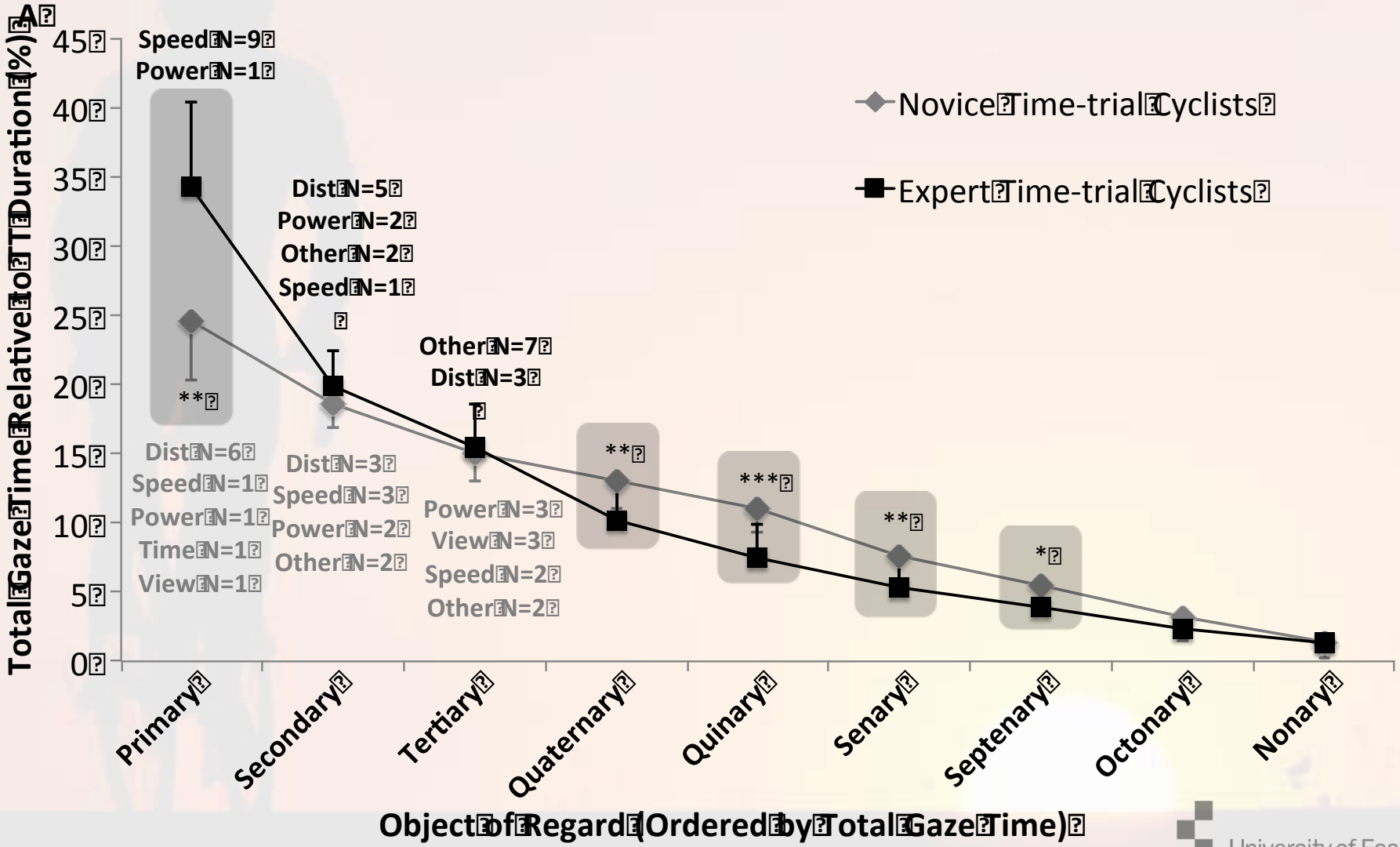
# **Fig 10.** Expert vs. novice object of regard

Boya et al. (2017) Medicine & Science in Sports & Exercise. 49(9),1884-1898.

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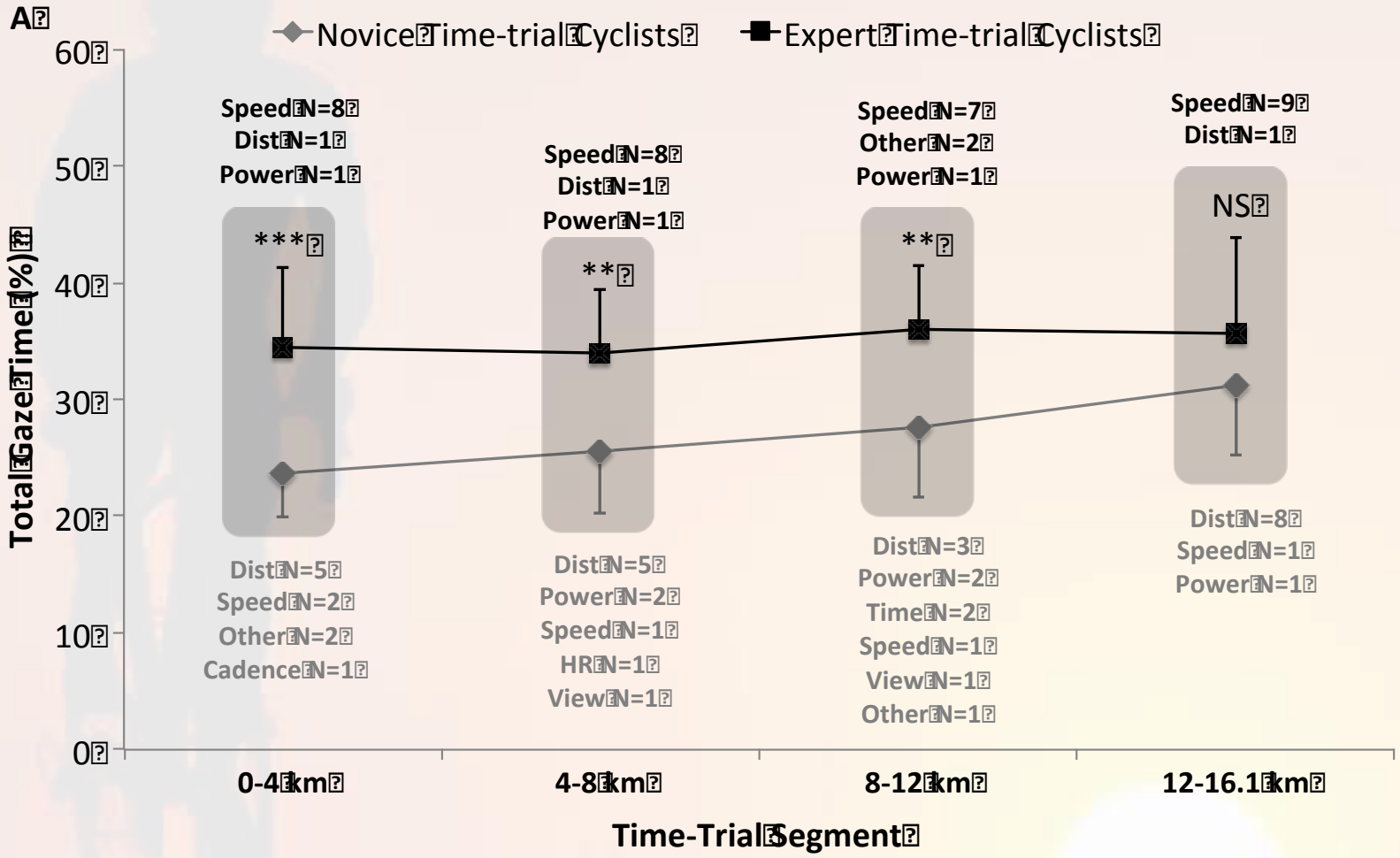
# **Fig 11.** Object of Regard Gaze Duration 10 mile

Boya et al. (2017) Medicine & Science in Sports & Exercise. 49(9),1884-1898.

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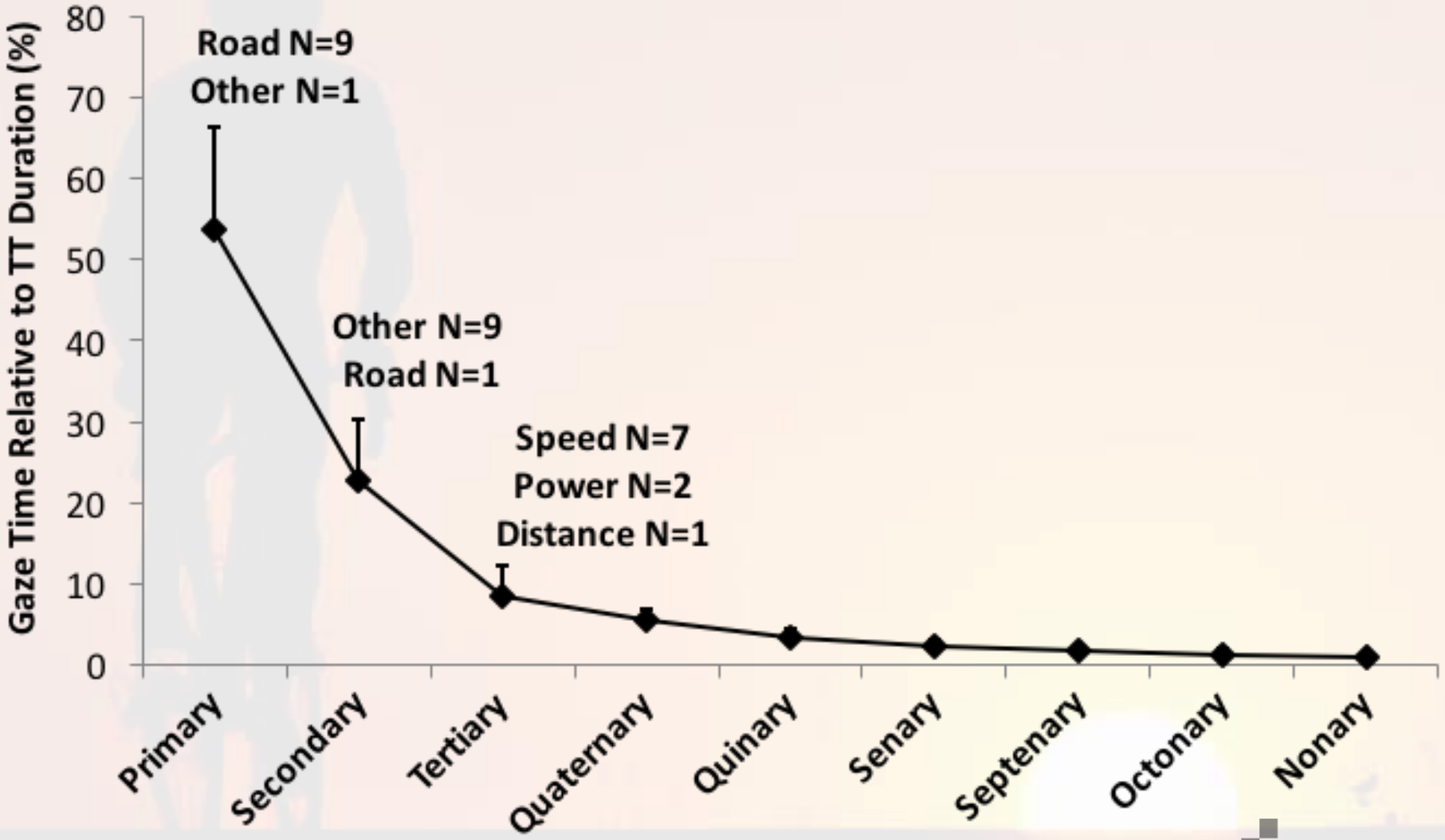
# Fig 12. Taking it in the field…


# **Fig 13.** Road Time Trial Gaze Duration 10 mile

Unpublished

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# **Fig 14.** Rating of Fatigue (Micklewright et al. 2017, *Sports Med.* 47:2375-93.)

Sports Med (2017) 47:2375–2393
DOI 10.1007/s40279-017-0711-5

ORIGINAL RESEARCH ARTICLE

## Development and Validity of the Rating-of-Fatigue Scale

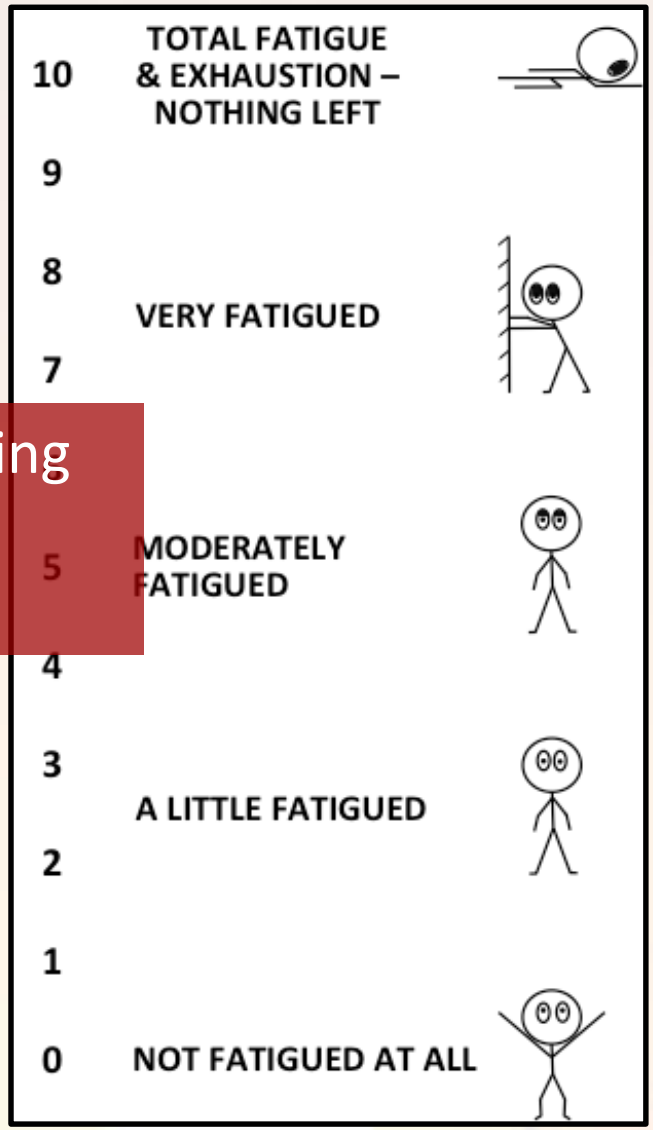
D. Micklewright[1] · A. St Clair Gibson[2] · V. Gladwell[1] · A. Al Salman[3]

Perceived fatigue is a feeling of diminishing capacity to cope with physical or mental stressors, either imagined or real.

**Abstract**
*Objective* The purpose of these experiments was to develop a rating-of-fatigue (ROF) scale capable of tracking the intensity of perceived fatigue in a variety of contexts.
*Methods* Four experiments were carried out. The first provided the evidential basis for the construction of the ROF scale. The second tested the face validity of the ROF, and the third tested the convergent and divergent validity of the ROF scale during ramped cycling to exhaustion and 30 min of resting recovery. The final experiment tested the convergent validity of the ROF scale with time of day and physical activity (accelerometer counts) across a whole week.
*Results* Modal selections of descriptions and diagrams at different levels of exertion and recovery were found during Experiment 1 upon which the ROF scale was constructed and finalised. In Experiment 2, a high level of face validity was indicated, in that ROF was reported to represent fatigue rather than exertion. Descriptor and diagrammatic elements of ROF reportedly added to the coherence and were all $P < 0.001$). During ramped cycling to exhaustion ROF and RPE did correspond ($P < 0.0001$) but not during recovery, demonstrating discriminant validity. Experiment 4 found ROF to correspond with waking time during each day (Mon–Sun all $P < 0.0001$) and with physical activity (accelerometer count) (Mon–Sun all $P < 0.001$).
*Conclusions* The ROF scale has good face validity and high levels of convergent validity during ramped cycling to exhaustion, resting recovery and daily living activities. The ROF scale has both theoretical and applied potential in understanding changes in fatigue in a variety of contexts.

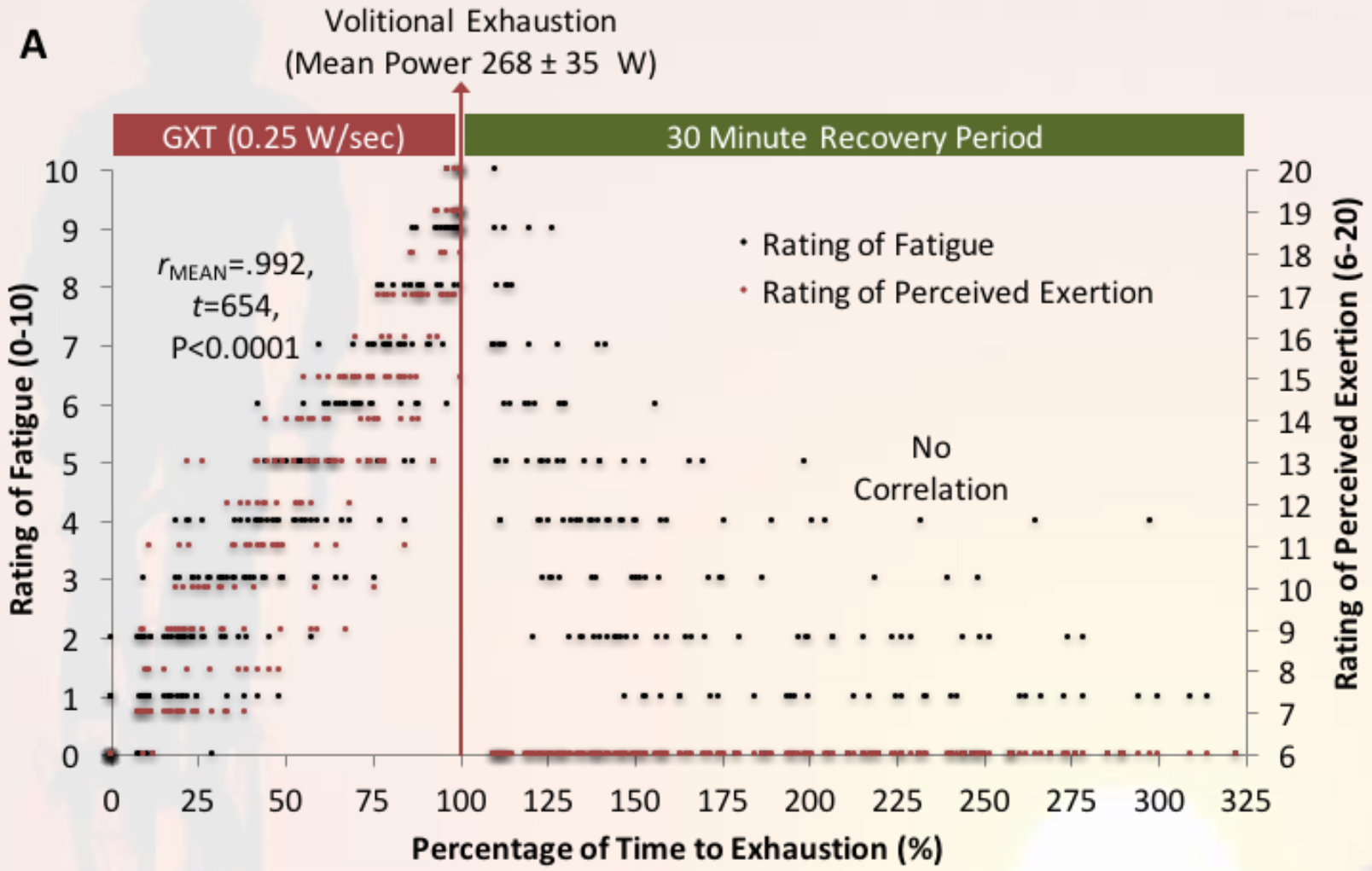
**Key Points**

A new method of measuring perceived fatigue



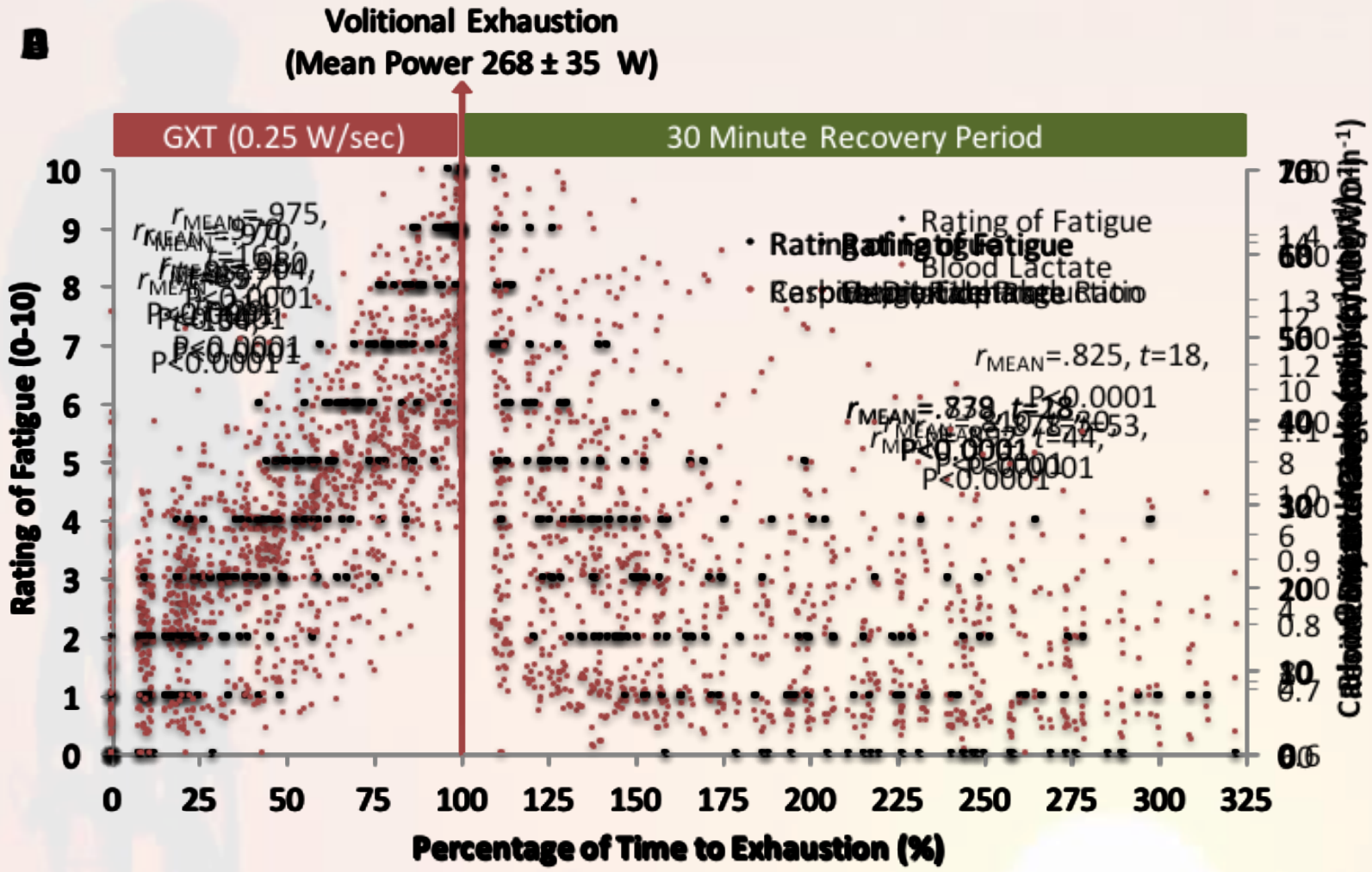
# **Fig 15.** RPE-ROF Discriminant Validity during Recovery

Micklewright et al. 2017, *Sports Med.* 47:2375-93.



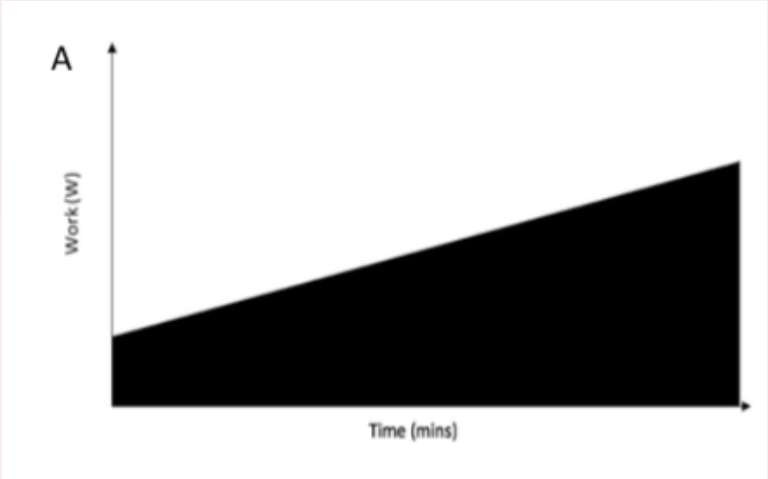
# **Fig 16.** RPE-ROF Discriminant Validity during Recovery

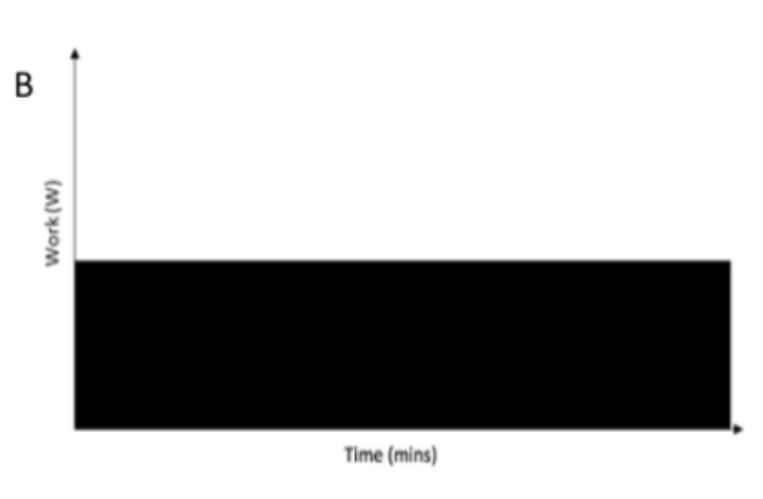
Micklewright et al. 2017, *Sports Med.* 47:2375-93.

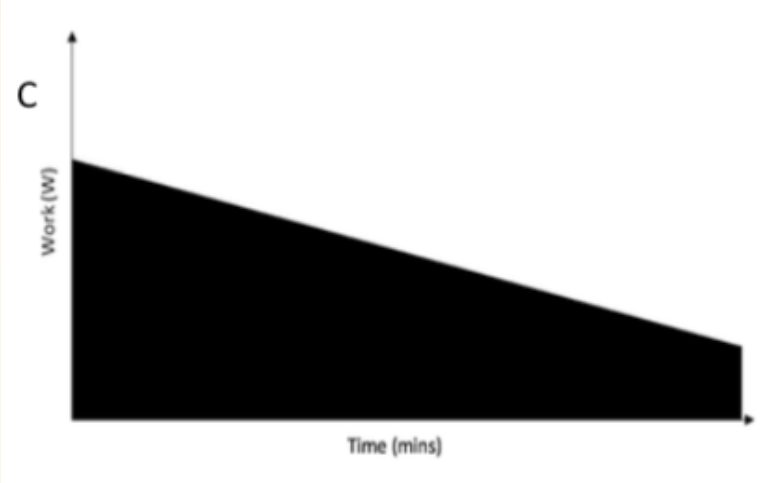


# **Fig 17.** RPE versus ROF Discrimination during Cycling

Micklewright, West, Williamson, St Clair Gibson & Gladwell (unpublished)

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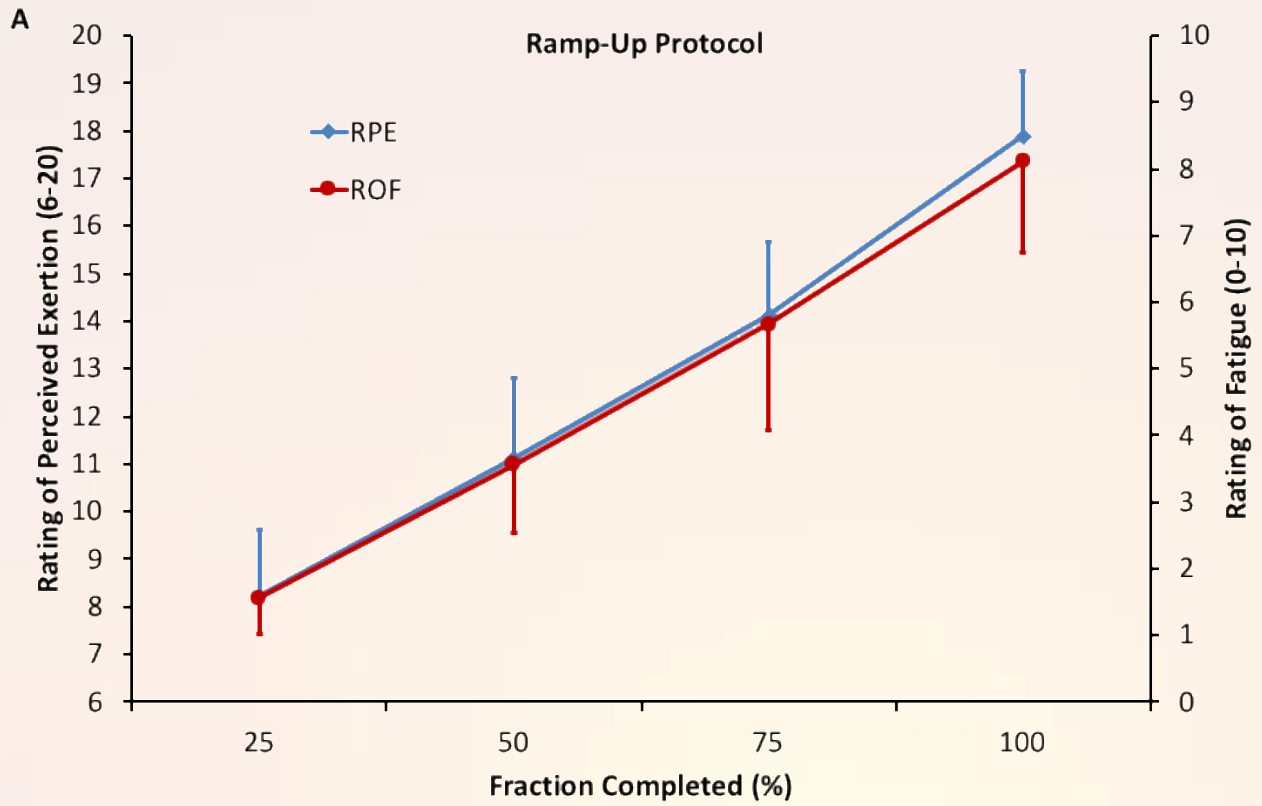
# **Fig 17.** RPE versus ROF Ramp-up

Micklewright, West, Williamson, St Clair Gibson & Gladwell (unpublished)

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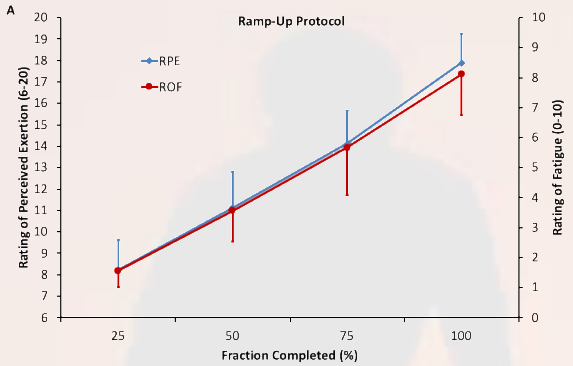
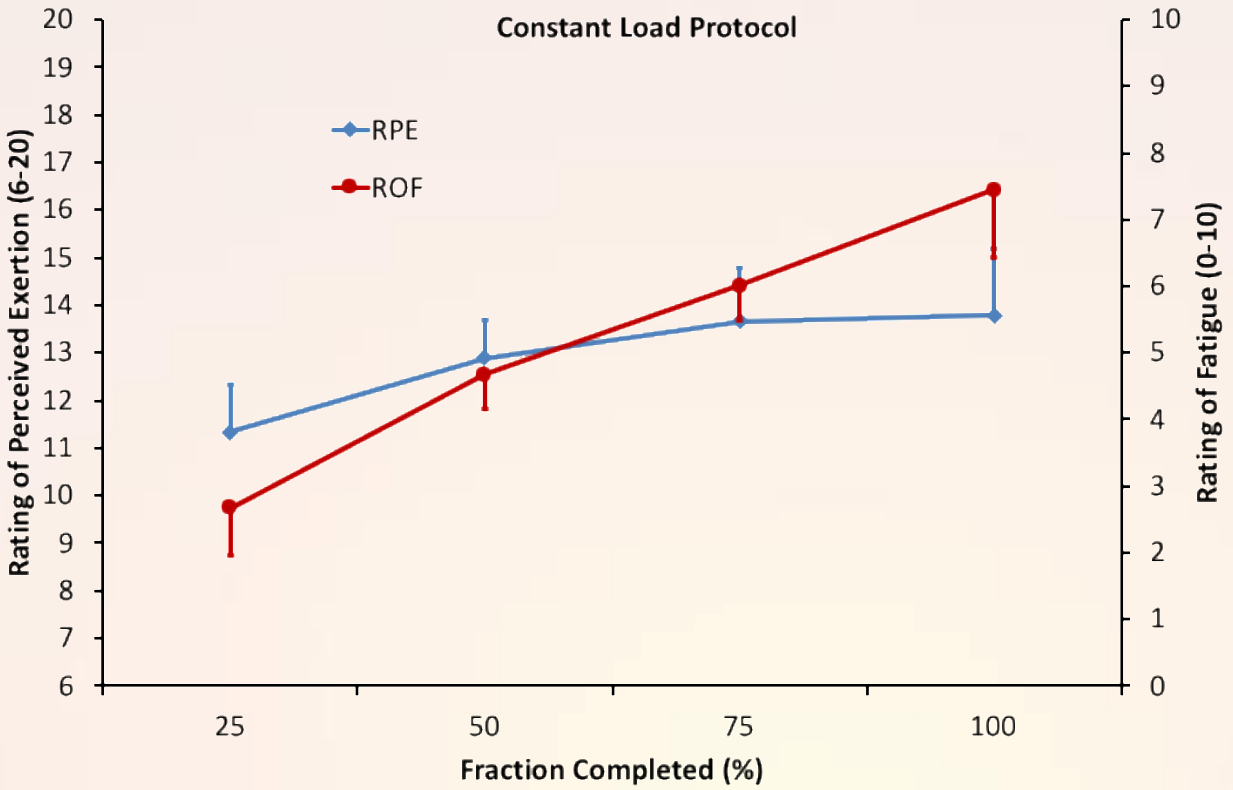
# **Fig 18.** RPE versus ROF Constant Load

Micklewright, West, Williamson, St Clair Gibson & Gladwell (unpublished)

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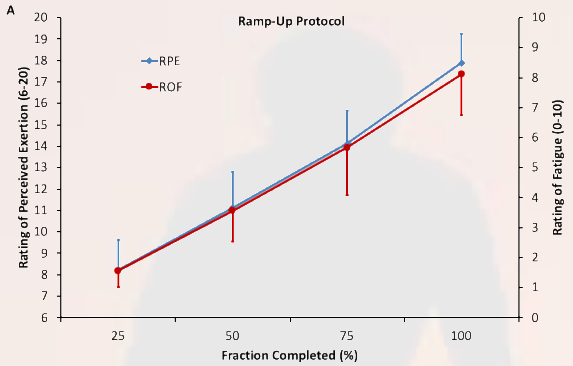
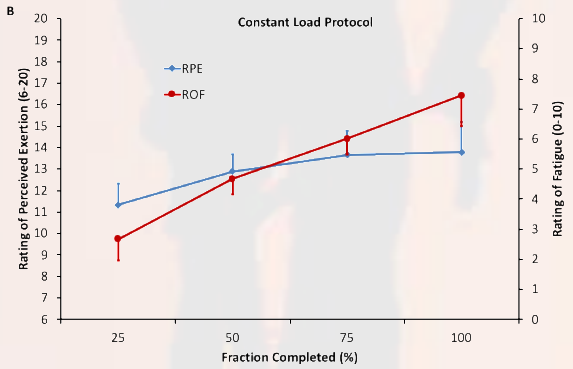
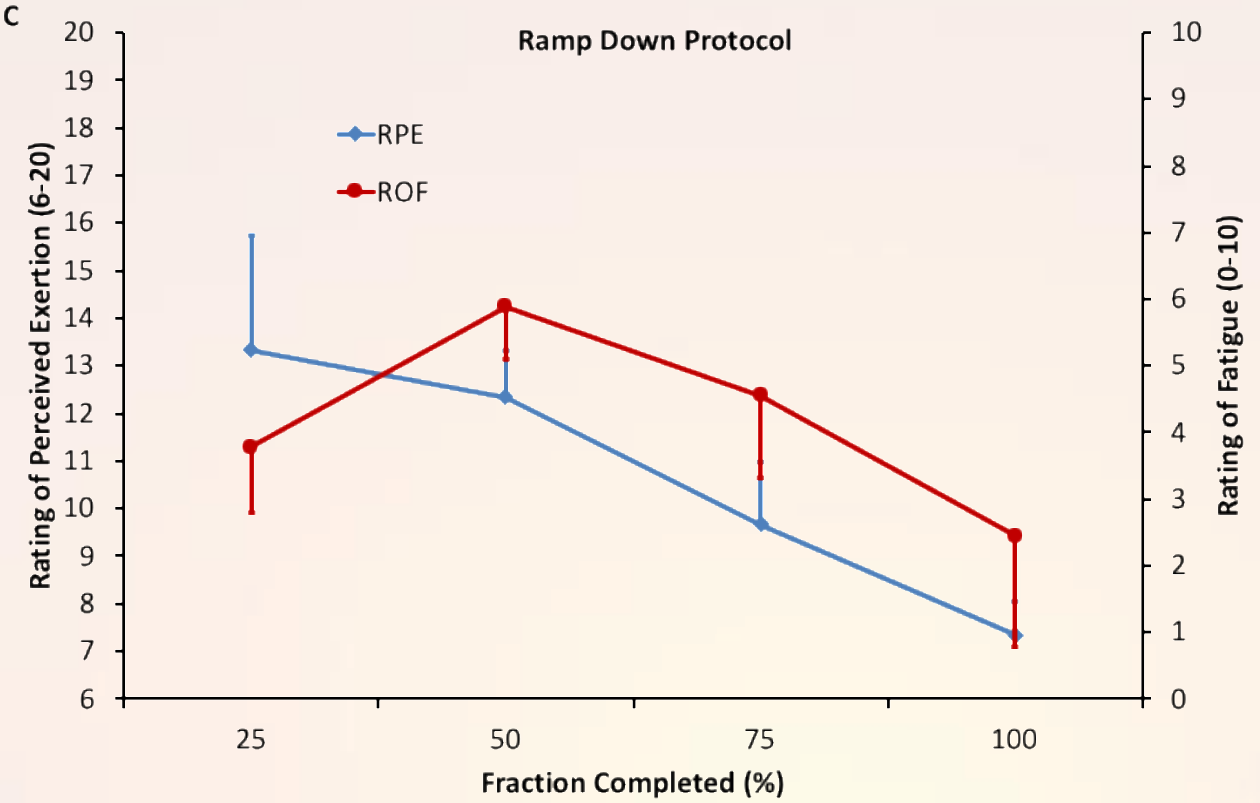
# **Fig 19.** RPE versus ROF Ramp-down

Micklewright, West, Williamson, St Clair Gibson & Gladwell (unpublished)

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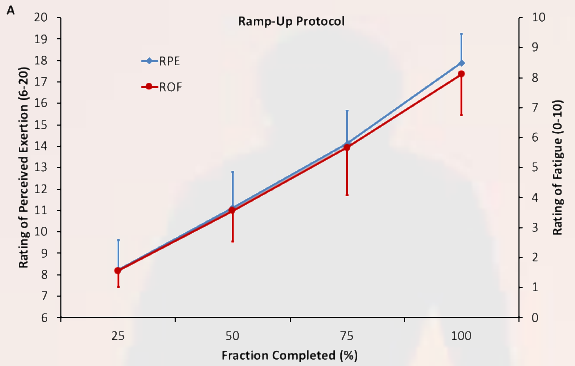
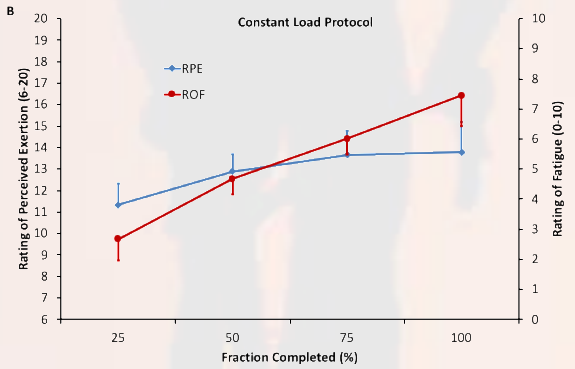
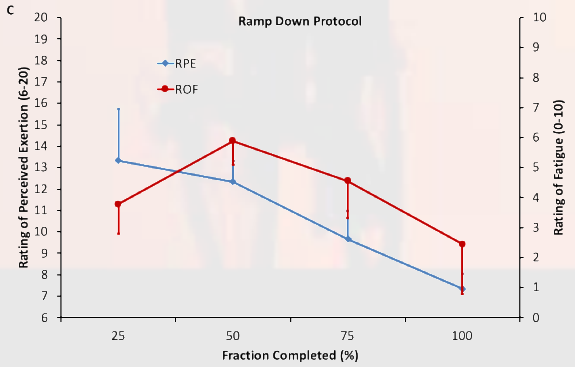
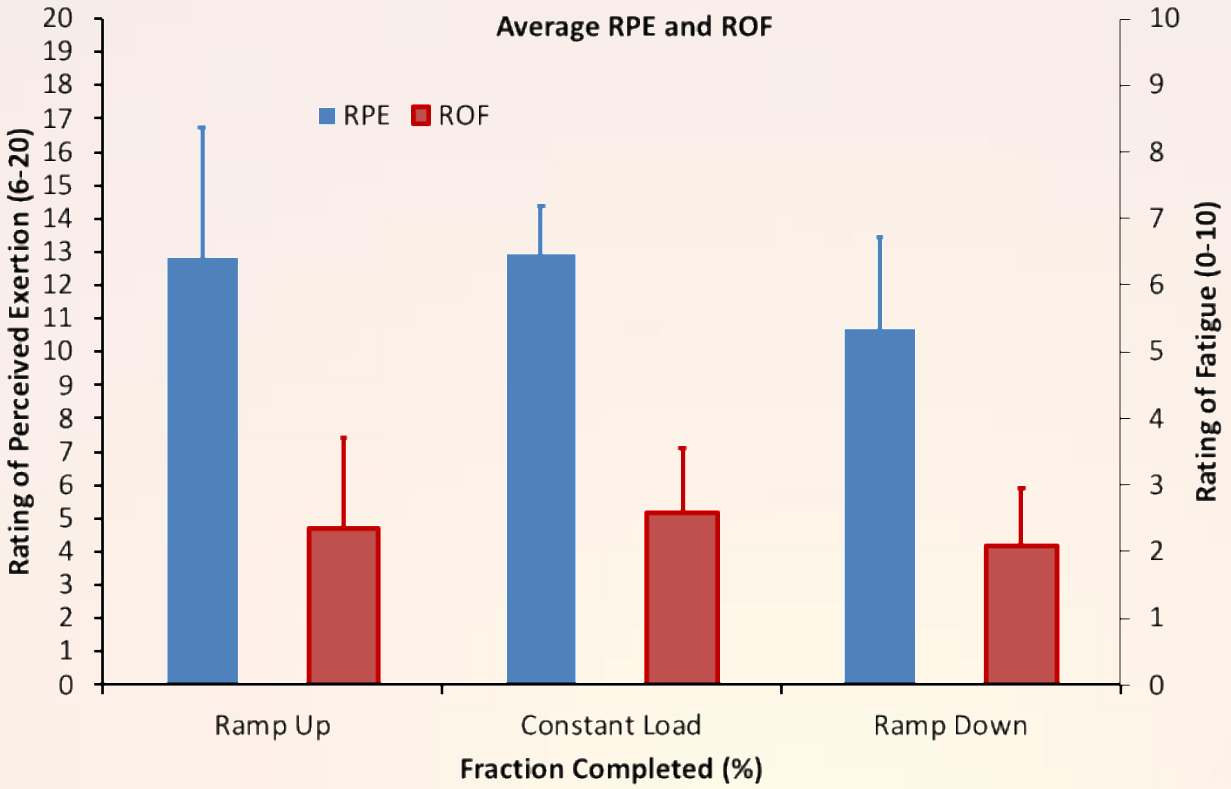
# **Fig 20.** Lower average RPE during Ramp Down

Micklewright, West, Williamson, St Clair Gibson & Gladwell (unpublished)

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# Conclusions

## Perceptions…

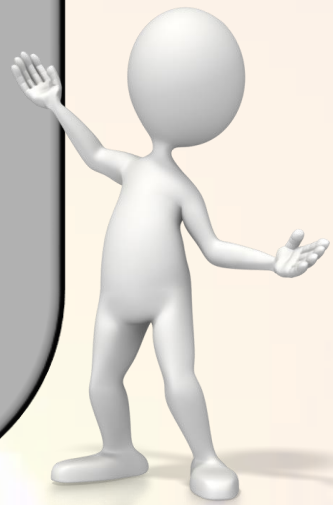
Do not always truly represent actual physiological state
Are context specific
Are multifarious in nature
Must be measured, interpreted & applied with great care

## Performance…

RPE-Endpoint explanations may be too rigid
Context and individual-specific systems are more adaptive
Remember, perceptions feel ‘real’ to your cyclists
Perceived fatigue may be of greater applied relevance

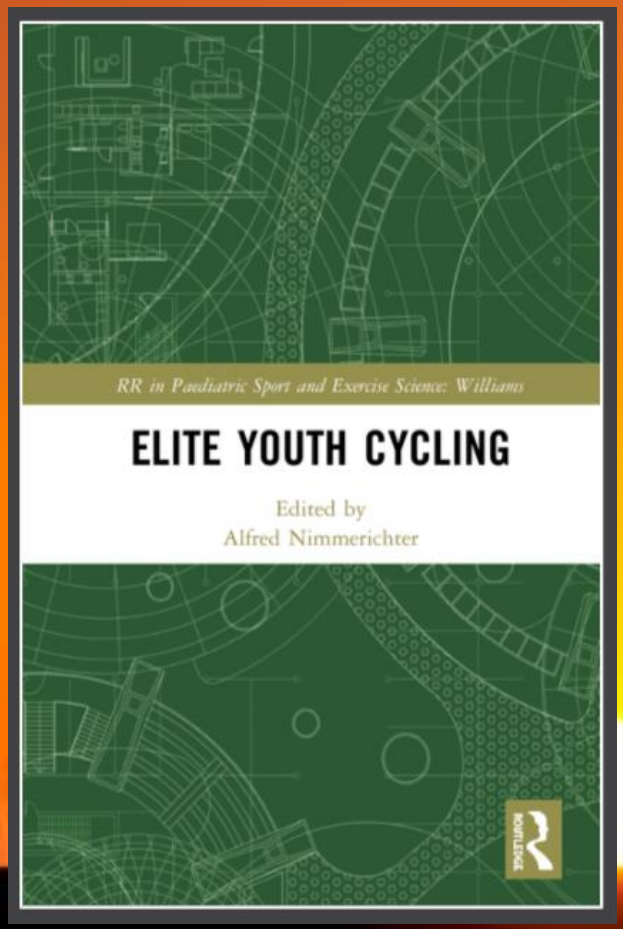
“Many of the truths we cling to depend greatly on our point of view.”

Obi-Wan Kenobi



# Human Perception and Cycling: Effort, Fatigue and Performance

Dominic Micklewright

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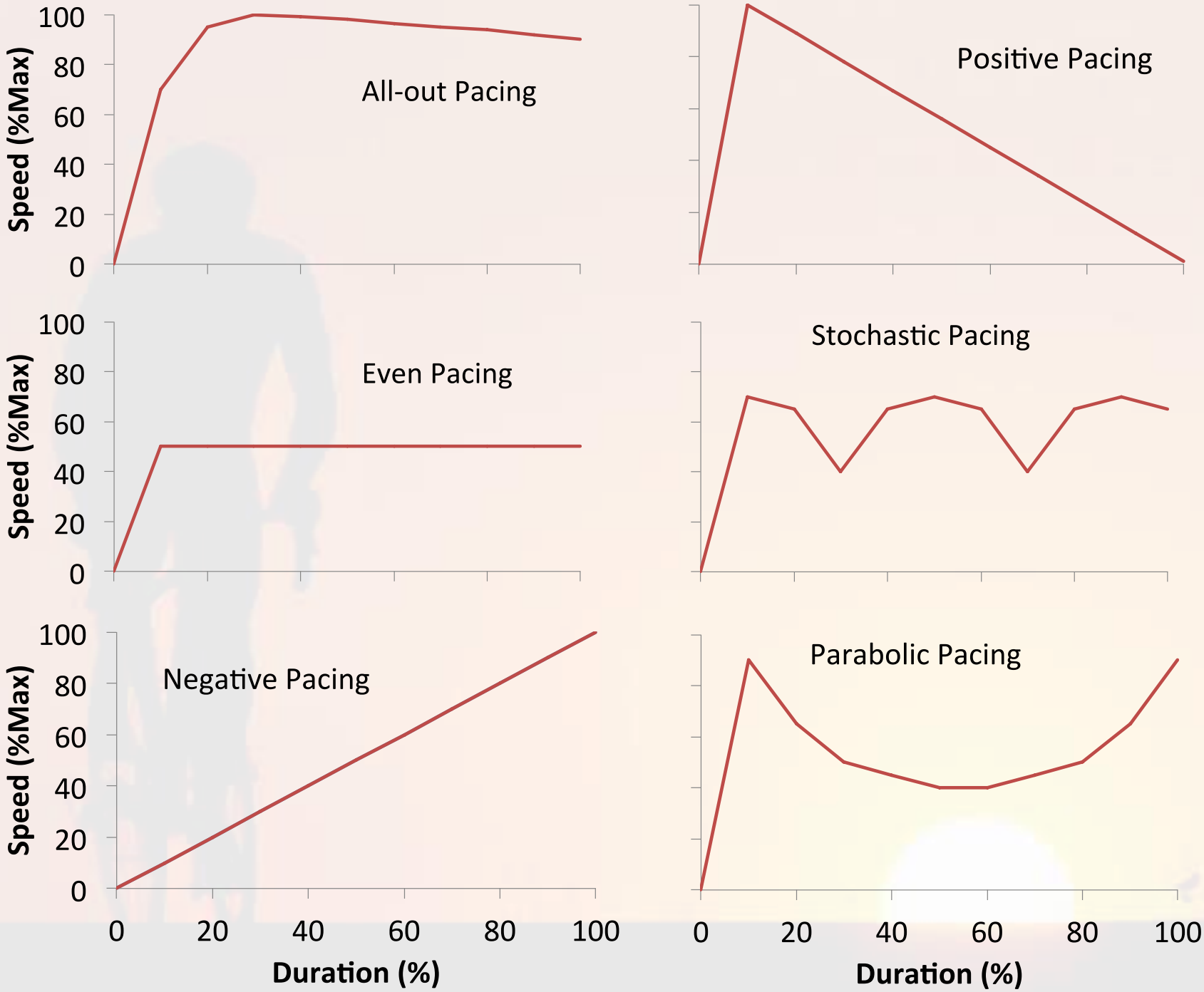
# The Conscious-Subconscious Pacing Quagmire! New Opportunities in Dual Process Theory and Process Tracing Methods


- Dominic Micklewright, PhD CPsychol FBASES FACSM

University of Essex

# Horsea Island



All-out Pacing
Positive Pacing
Even Pacing
Stochastic Pacing
Negative Pacing
Parabolic Pacing
Speed (%Max)
Duration (%)
0
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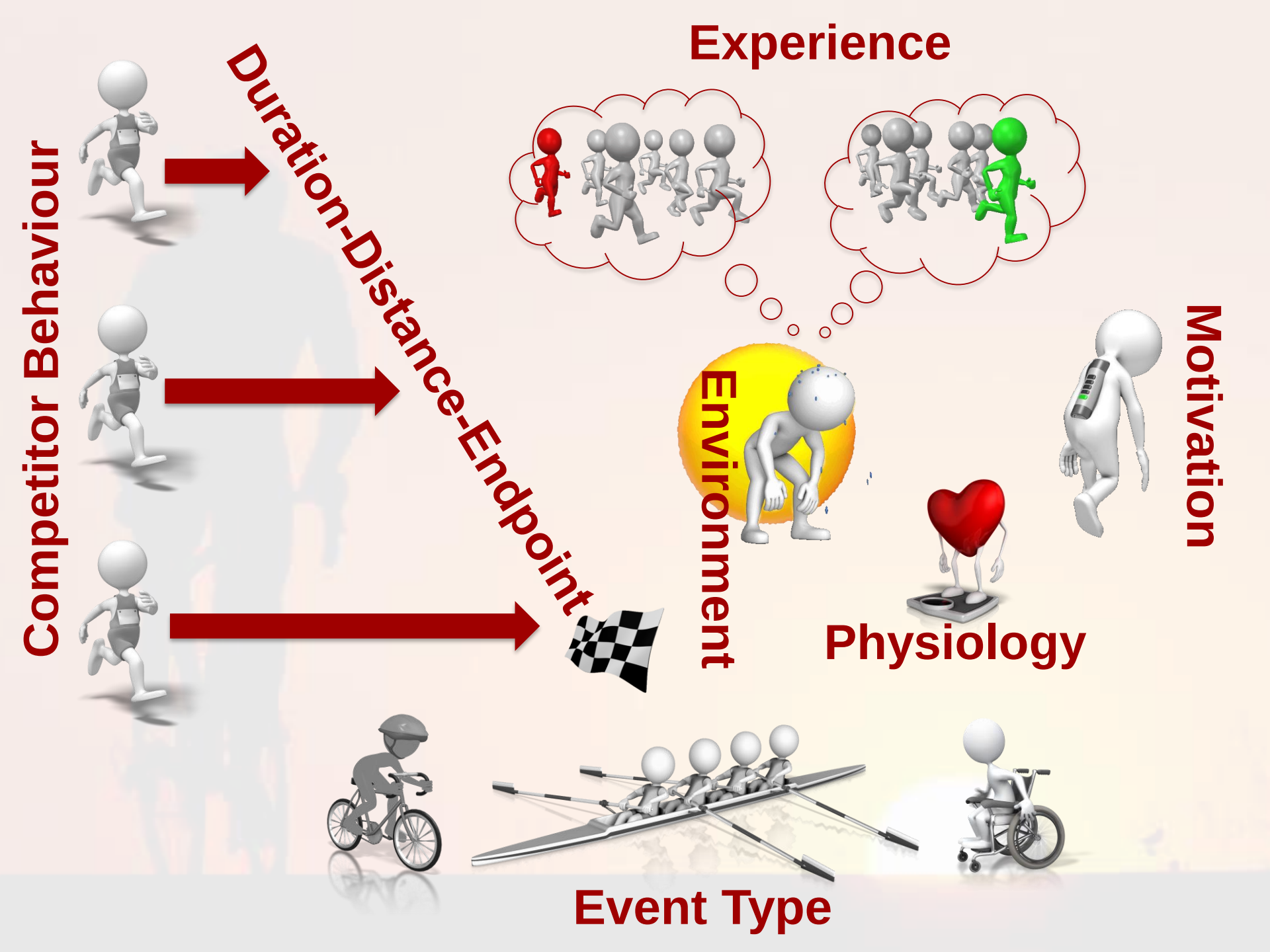
Experience
Competitor Behaviour
Duration-Distance-Endpoint
Environment
Physiology
Motivation
Event Type

Eur J Appl Physiol (2012) 112:2303–2312
DOI 10.1007/s00421-011-2197-4

ORIGINAL ARTICLE

# Self-regulation of exercise intensity by estimated time limit scale

M. Garcin · J. Coquart · J. Sa
N. Voy · R. Matran

Received: 3 May 2011 / Accepted: 29
© Springer-Verlag 2011

**Abstract** The purpose of this
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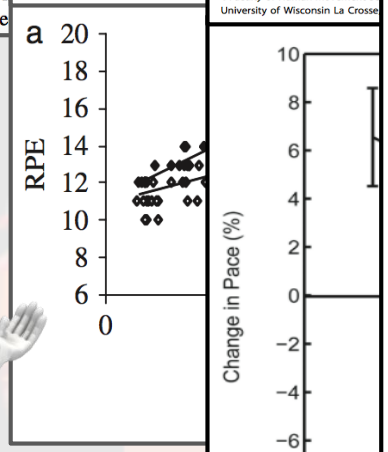
*Psychophysiology*, *45* (2008), 977–985. Wiley Periodicals, Inc. Printed in the USA.
Copyright © 2008 Society for Psychophysiological Research
DOI: 10.1111/j.1469-8986.2008.00712.x

# The rating of perceived exertion during competitive running scales with time

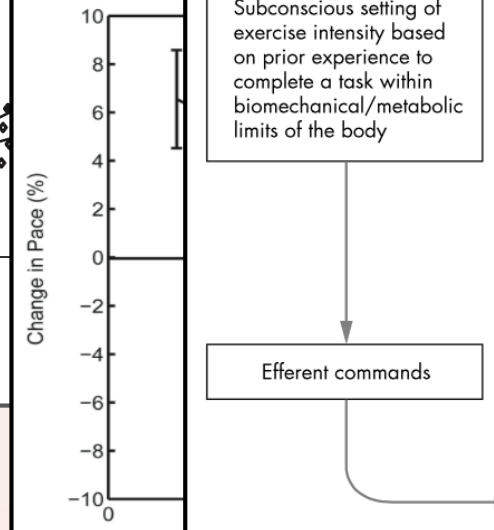
JAMES FAULKNER
School of Sport and Health




OPEN ACCESS Freely available online PLoS one

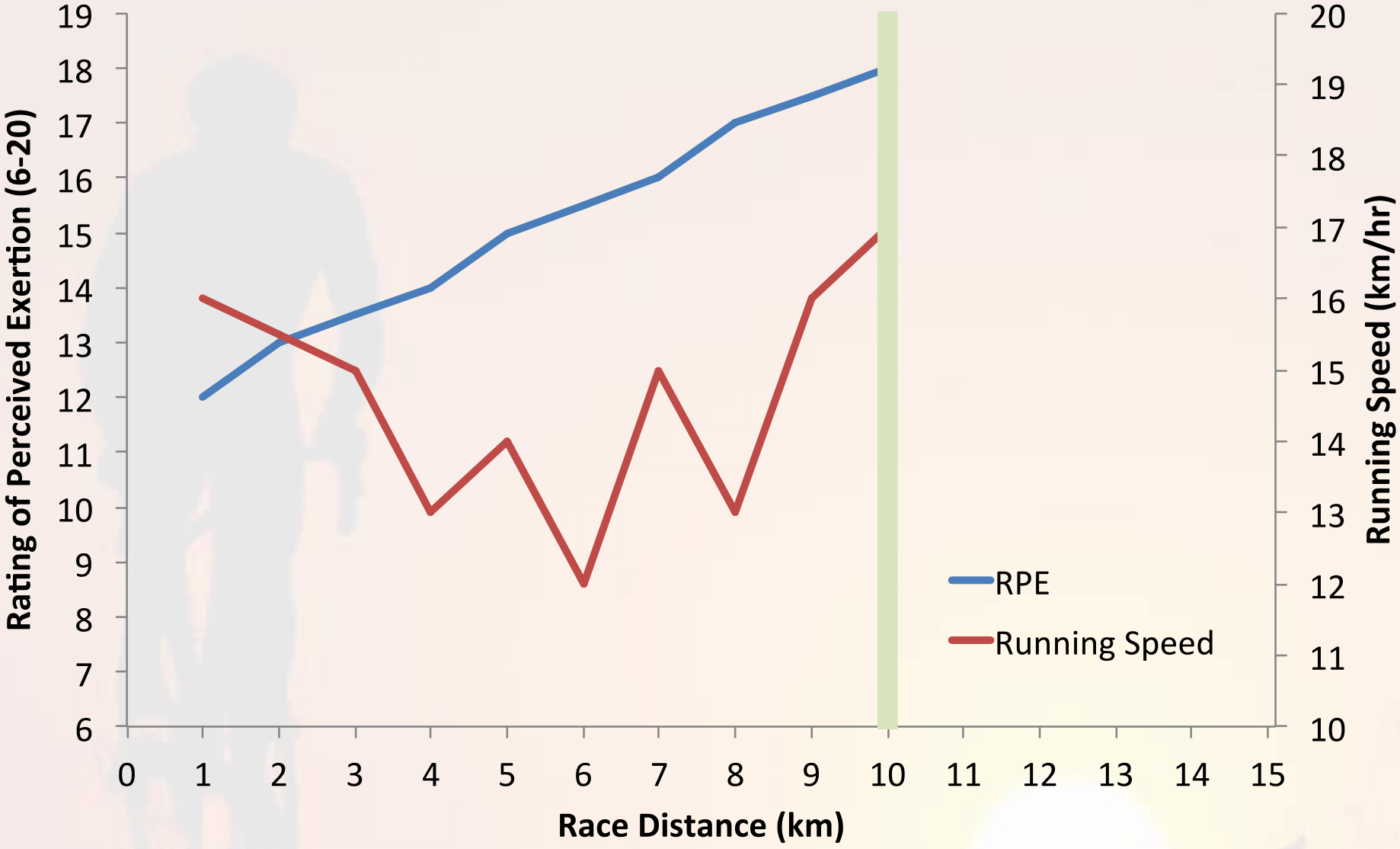
# Regulation of Pacing Strategy during Athletic Competition

Jos J. de Koning[1,2]*, Carl Foster[1,2], Arjan Bakkum[1], Sil Kloppenburg[1], Christian Thiel[3], Trent Joseph[2], Jacob Cohen[2], John
1 Faculty of Human Movement Sc
University of Wisconsin La Crosse





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Running Speed (km/hr)
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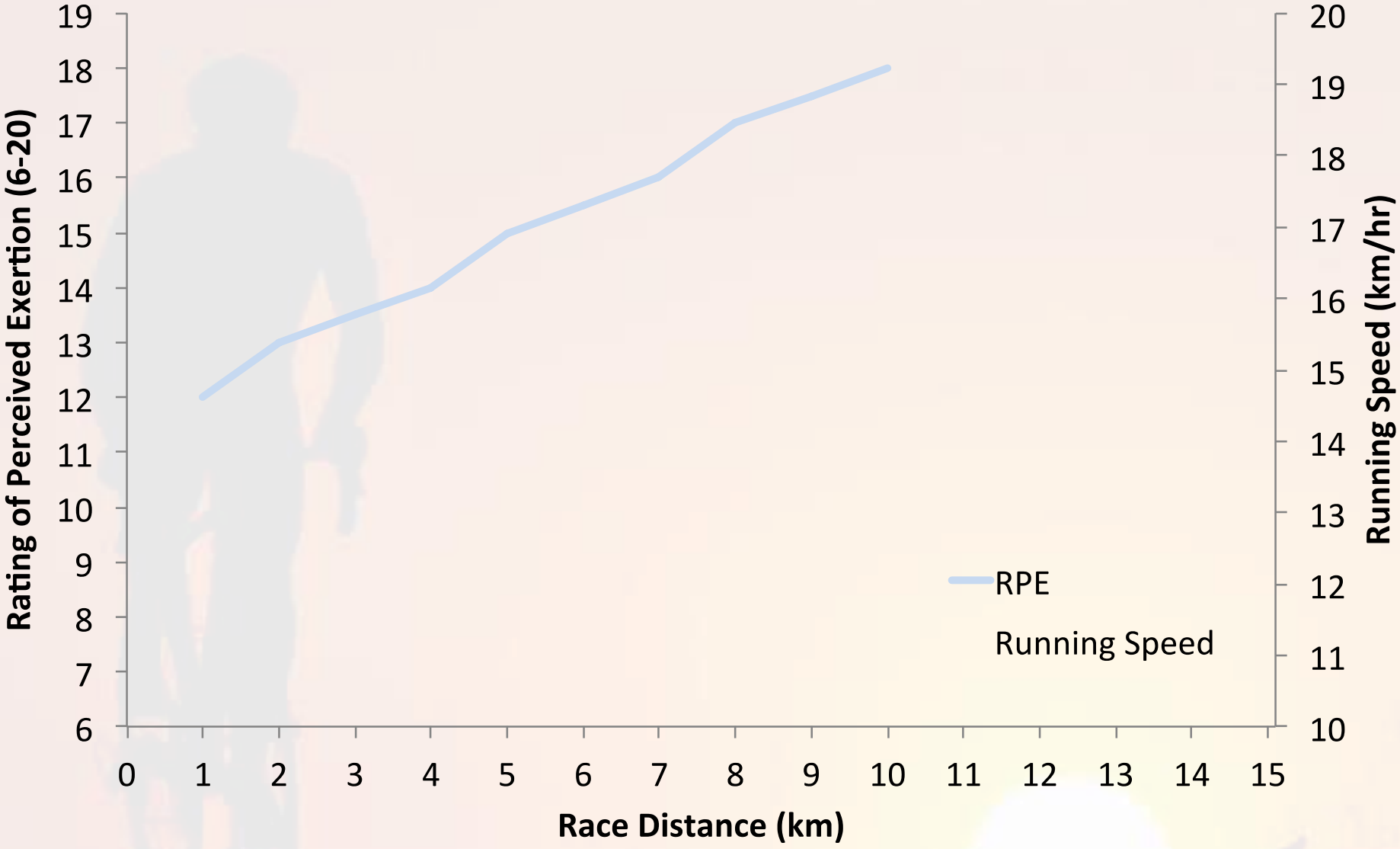
Race Distance (km)
RPE
Running Speed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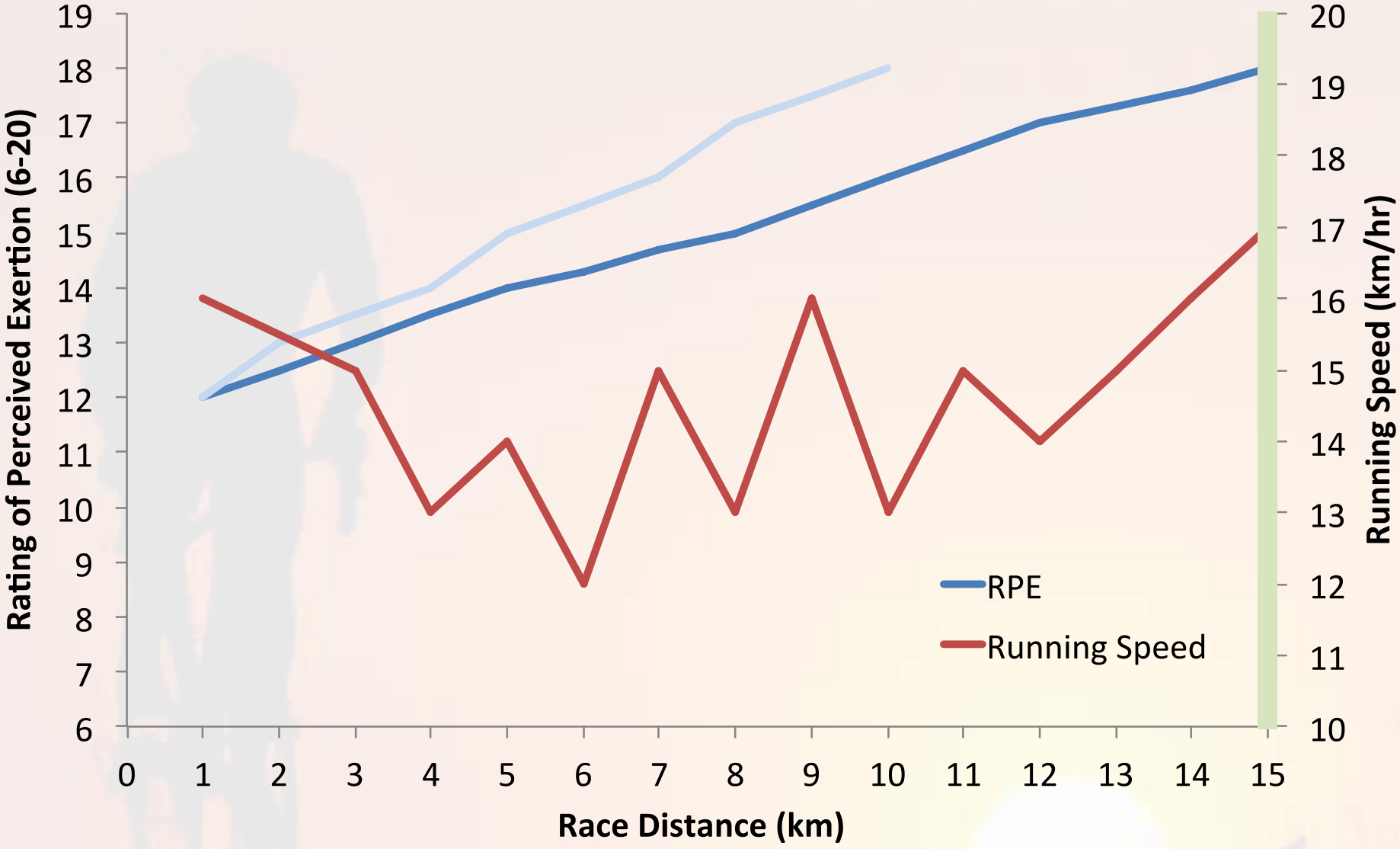
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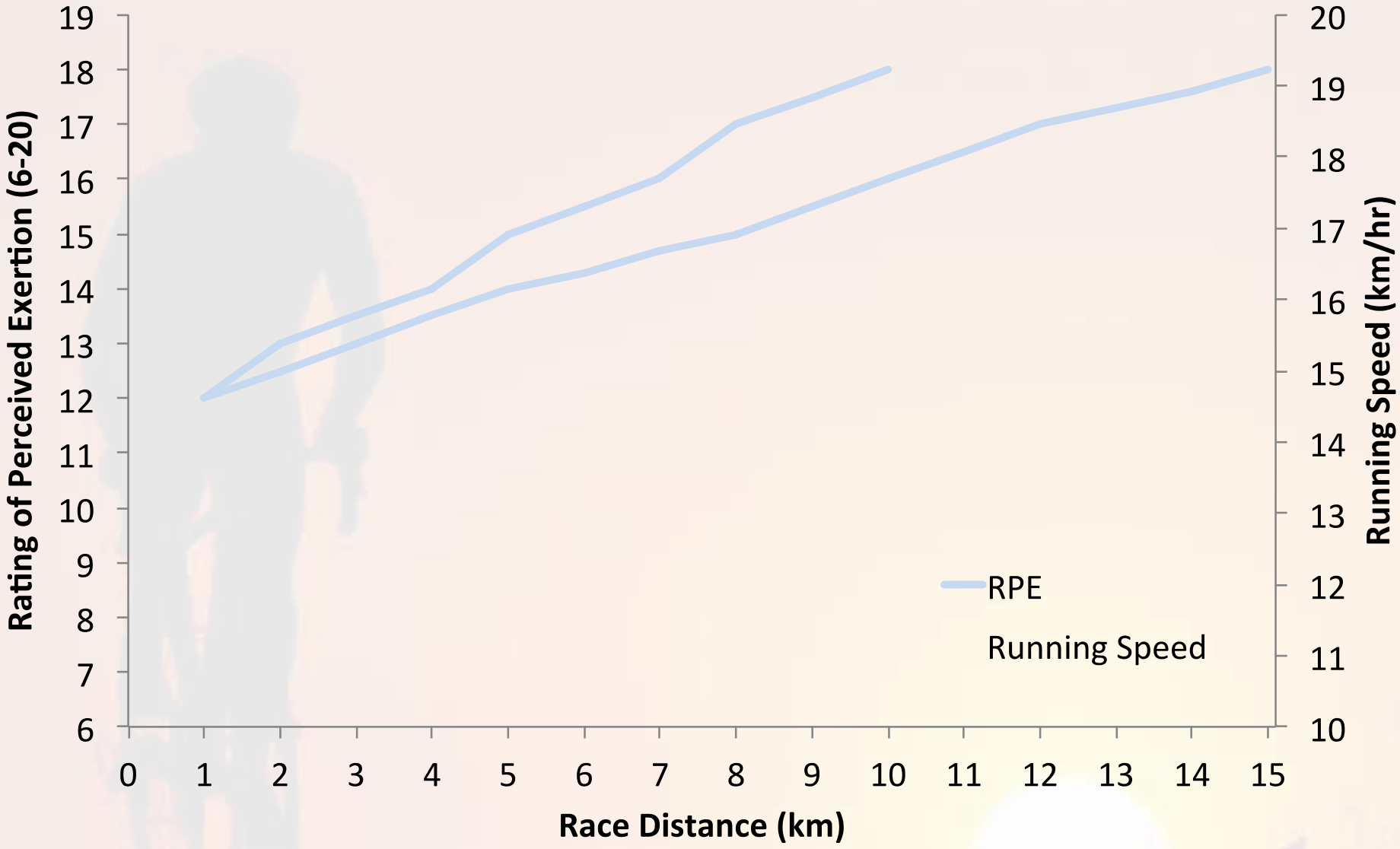
Race Distance (km)
RPE
Running Speed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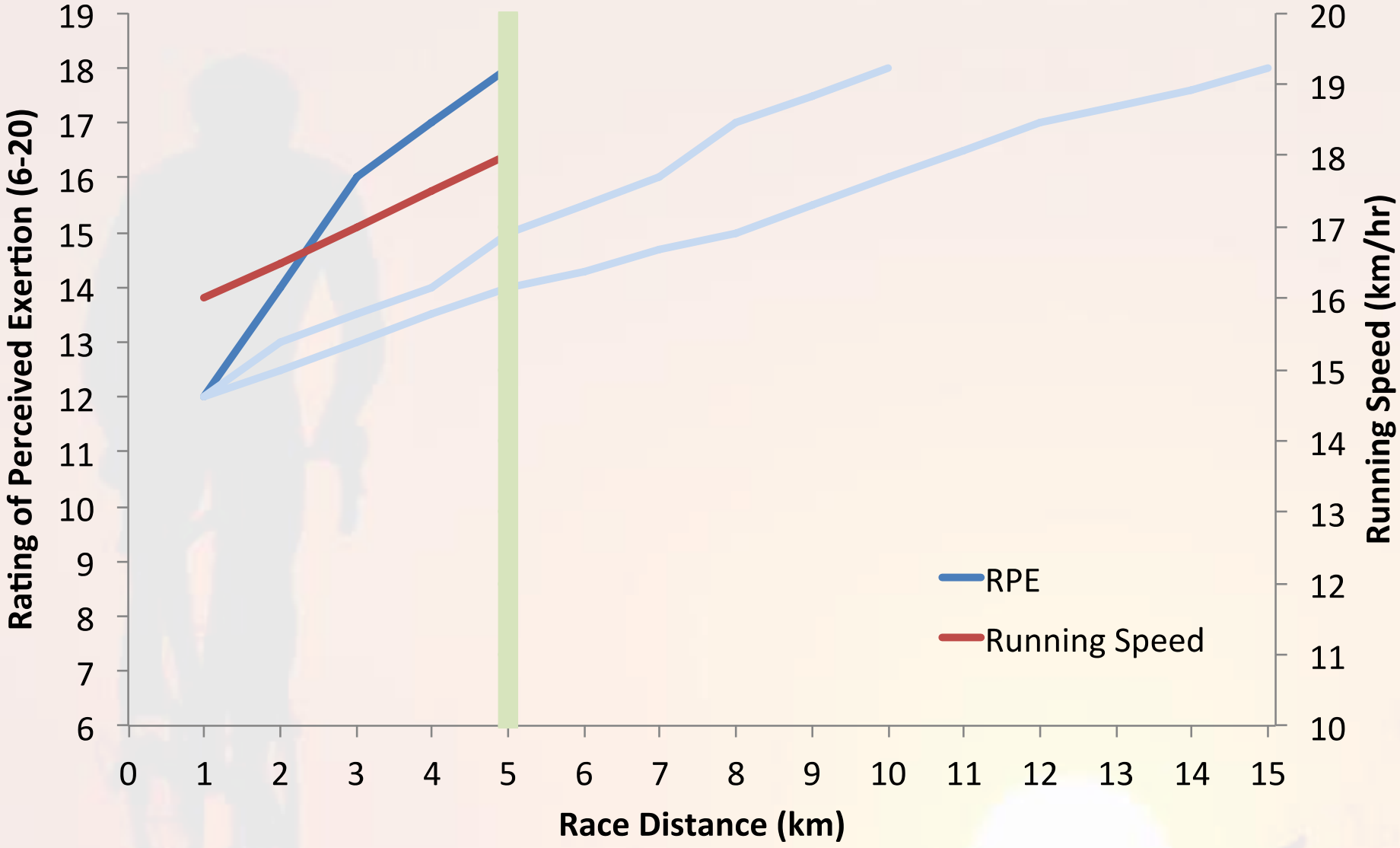
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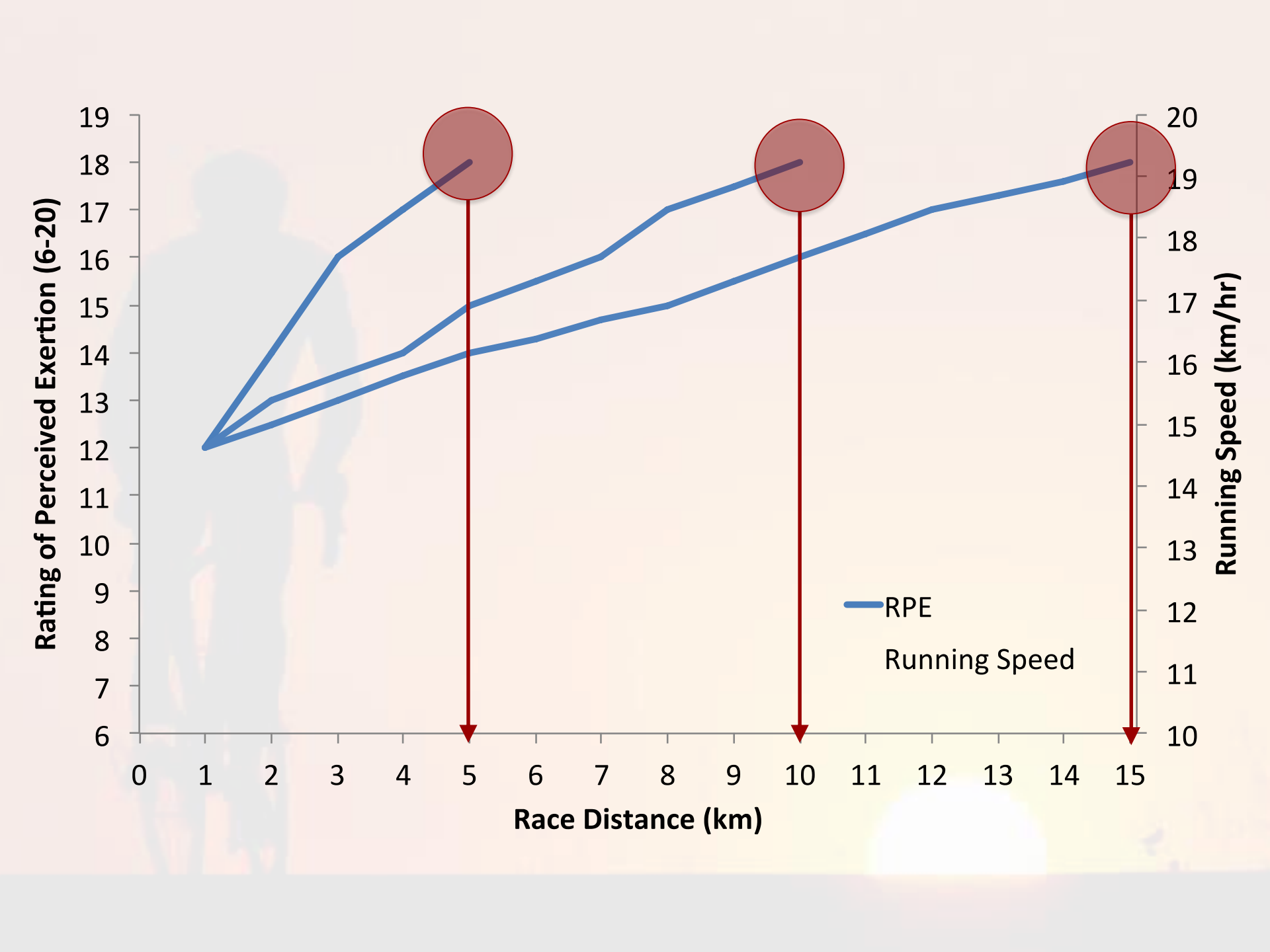
Race Distance (km)
RPE
Running Speed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Race Distance (km)
RPE
Running Speed

Sports Med (2015) 45:1235–1243
DOI 10.1007/s40279-015-0344-5

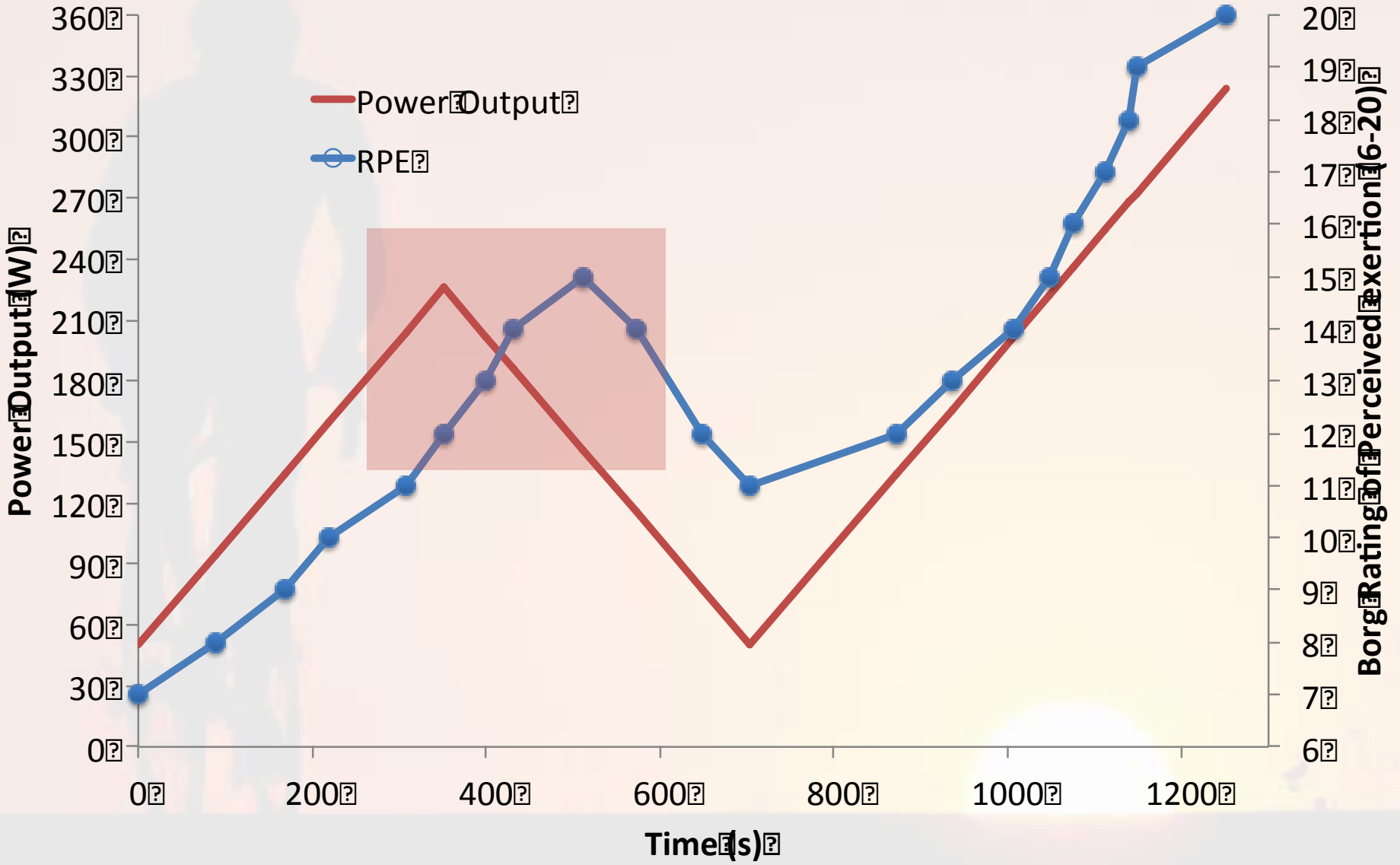
REVIEW ARTICLE

# Role of Ratings of Perceived Exertion during Self-Paced Exercise: What are We Actually Measuring?

Chris R. Abbiss[1] · Jeremiah J. Peiffer[2] · Romain Meeusen[3,4] · Sabrina Skorski[5,6]

- Most pacing models are heavily dependent on perceived exertion and
- are derived from studies where RPE was measured
- …but we should be cautious of RPE measurements and what it is actually measuring

# **Fig 1.** RPE Performance Template & Expectation



Sports Med
DOI 10.1007/s40279-013-0094-1

REVIEW ARTICLE

# Physiological and Psychological Effects of Deception on Pacing Strategy and Performance: A Review

**Hollie S. Jones · Emily L. Williams · Craig A. Bridge · Dave Marchant · Adrian W. Midgley · Dominic Micklewright · Lars R. Mc Naughton**



**Abstract** The aim of an optimal pa
exercise is to enhance performance w
ologi al limits is not surpassed, whic

# Deception Studies Manipulating Centrally Acting Performance Modifiers: A Review

EMILY L. WILLIAMS[1], HOLLIE S. JONES[1], SANDY SPARKS[1], DAVID C. MARCHANT[1], DOMINIC MICKLEWRIGHT[2], and LARS R. MCNAUGHTON[1]

[1]Department of Sport and Physical Activity, Edge Hill University, Ormskirk, Lancashire, UNITED KINGDOM; and [2]School of Biological Sciences, University of Essex, Colchester, Essex, UNITED KINGDOM

ABSTRACT

E. L. WILLIAMS, H. S. JONES, S. SPARKS, D. C. MARCHANT, D. MICKLEWRIGHT, and L. R. MCNAUGHTON. Deception Studies Manipulating Centrally Acting Performance Modifiers: A Review. *Med. Sci. Sports Exerc.*, Vol. 46, No. 7, pp. 1441–1451, 2014.

Athletes anticipatorily set and continuously adjust pacing strategies before and during events to produce optimal performance. Self-
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as although they contextualize theoretical propositions, there are few ecological and practical approaches which integrate theory with practice. In addition, the different methods and measures demonstrated in manipulation studies have produced inconsistent results. This review examines and critically evaluates the current methods of how specific centrally controlled performance modifiers have

- **Only a rudimentary understanding of cognitive mechanisms of pacing**
- **More sophisticated methods needed to understand and evidence mechanisms**

Eur J Appl Physiol (2012) 112:2303–2312
DOI 10.1007/s00421-011-2197-4

ORIGINAL ARTICLE

## Self-regulation of exercise intensity by estimated time limit scale

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Received: 3 May 2011 / Accepted: 29
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*Psychophysiology*, *45* (2008), 977–985. Wiley Periodicals, Inc. Printed in the USA.
Copyright © 2008 Society for Psychophysiological Research
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## The rating of perceived exertion during competitive running scales with time

JAMES FAULKNER
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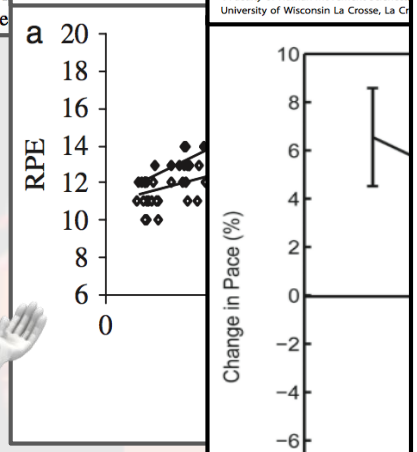


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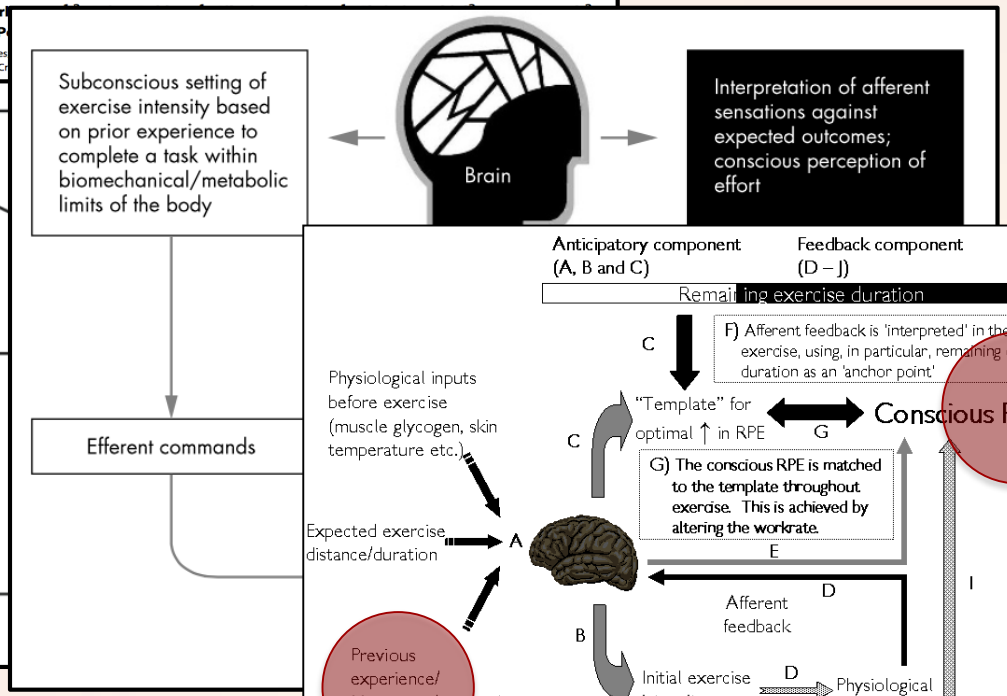
PLOS one

## Regulation of Pacing Strategy during Athletic Competition

Jos J. de Koning[1,2]*, Carl
Jacob Cohen[2], John P. P
1 Faculty of Human Movement Sciences
University of Wisconsin La Crosse, La Cr

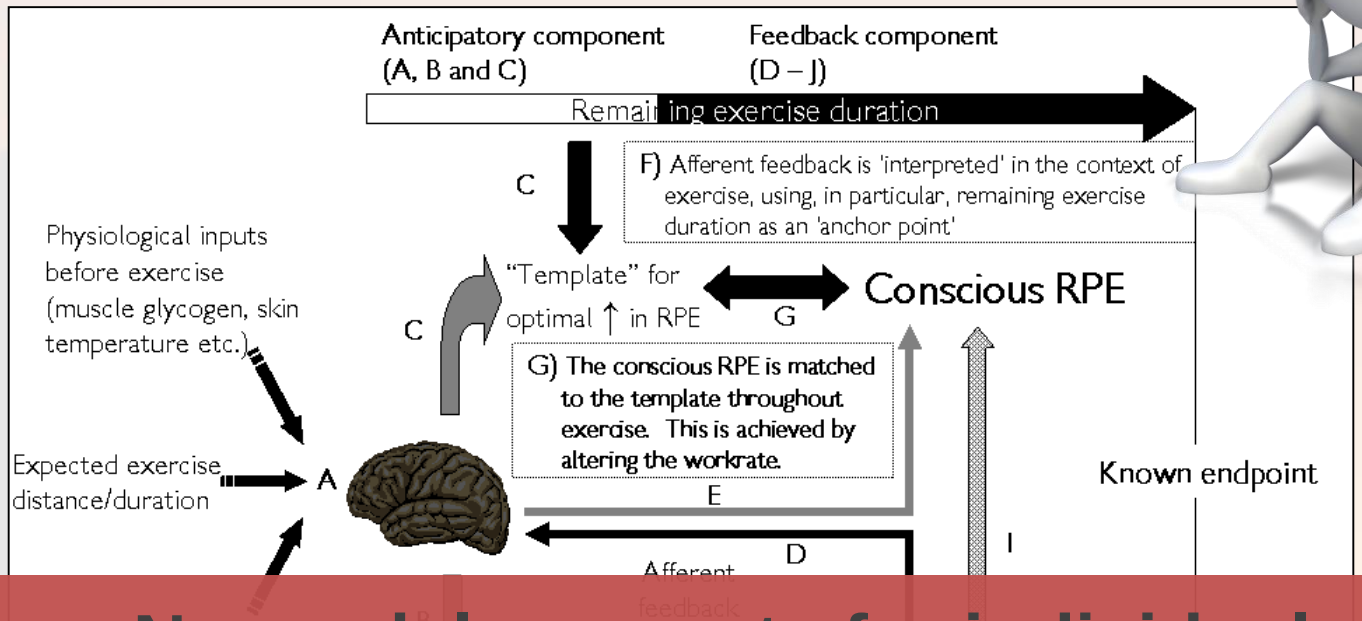


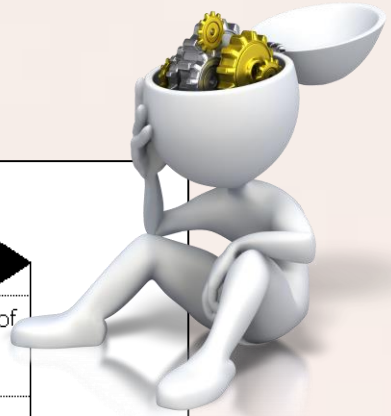







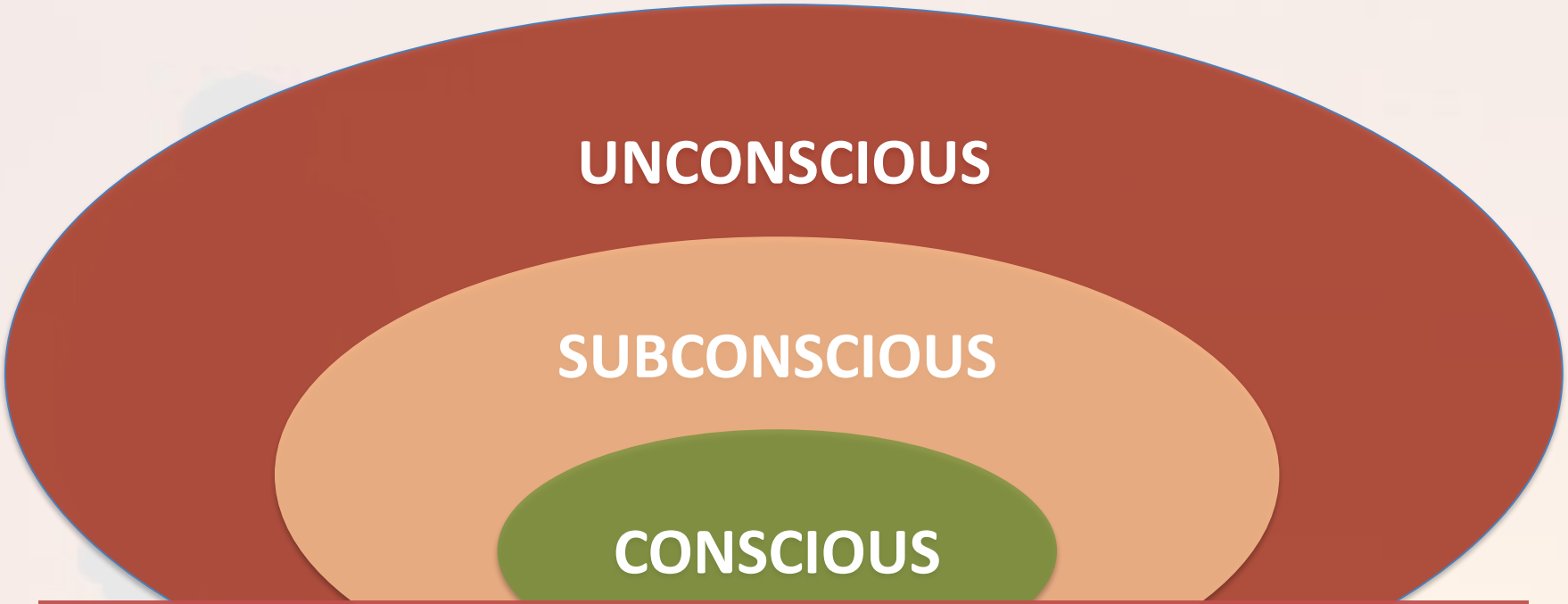
# Adapted from Tucker & Noakes (2009) *Br J Sports Med*



- **No model accounts for individual traits…for instance, riskiness**
- **Conscious-subconscious: A useful dichotomy?...**

# Conscious ⊆ Subconscious ⊆ Unconscious




- **Lack of clarity around terminology**
- **Pacing can never be conscious <u>OR</u> un/subconscious. Think shifting subsets.**

Sports Med (2013) 43:1057–1064
DOI 10.1007/s40279-013-0091-4

CURRENT OPINION

# Pacing and Awareness: Brain Regulation of Physical Activity

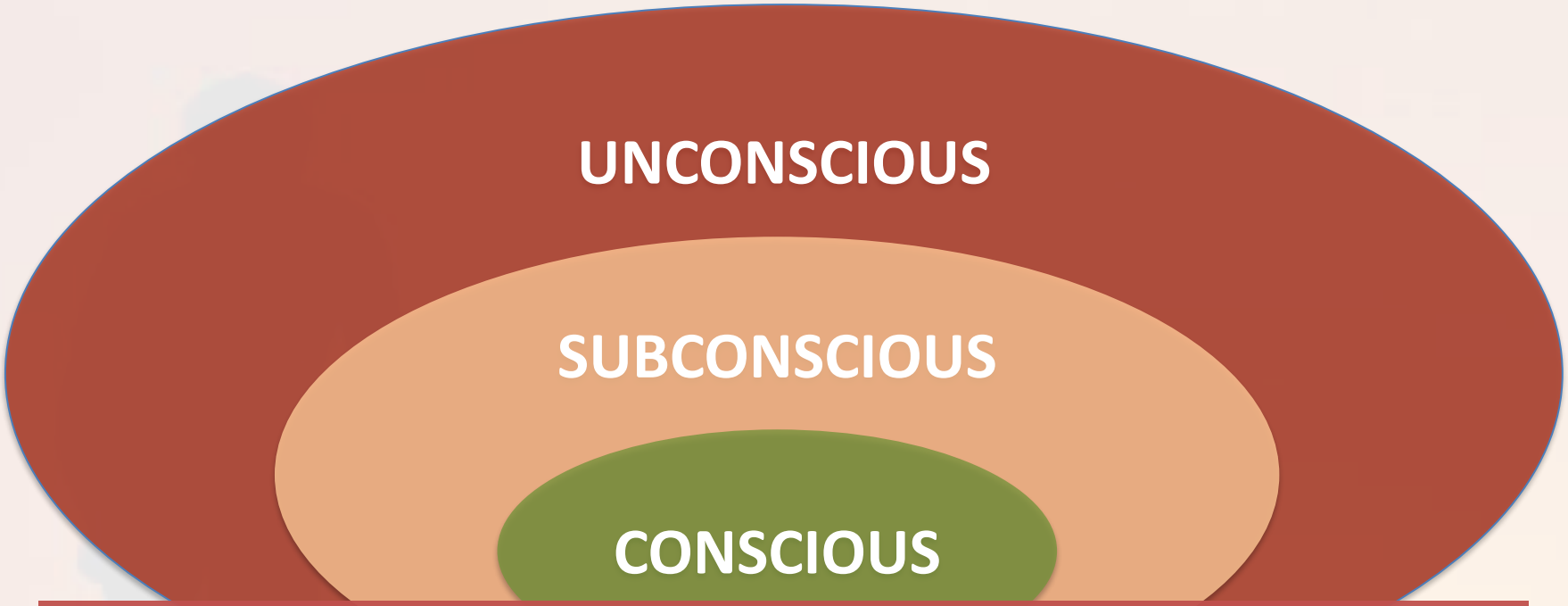
A. M. Edwards · R. C. J. Polman

1. Minor homeostatic pacing modifications could operate at a subconsciously
2. …Major threats to homeostasis lead to conscious awareness and a deliberate behavioural pacing response

ualised priorities and knowledge of personal capabilities.

effort [5]. This can been seen in the diverse actions of daily

# Conscious ⊆ Subconscious ⊆ Unconscious



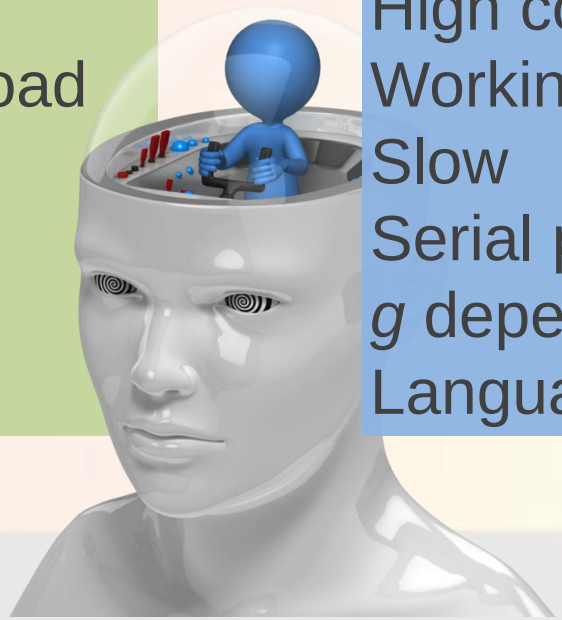

- **Lack of clarity around terminology**
- **Pacing can never be conscious <u>OR</u> un/subconscious. Think shifting subsets.**
- **Chasing the conscious-subconscious question probably won't help**

# Are pacing decisions intuitive or deliberative?

More dimensions than conscious-subconscious

Dual processes: Fast & slow thinking (Kahneman & Frederick, 2002)

| **INTUITION** | **DELIBERATION** |
| --- | --- |
| Automatic / subconscious | Conscious |
| Low cognitive effort | High cognitive effort |
| No working memory load | Working memory load |
| Quick | Slow |
| Parallel processes | Serial processes |
| Independent of *g* | *g* dependent |
| | Language-related reflection |



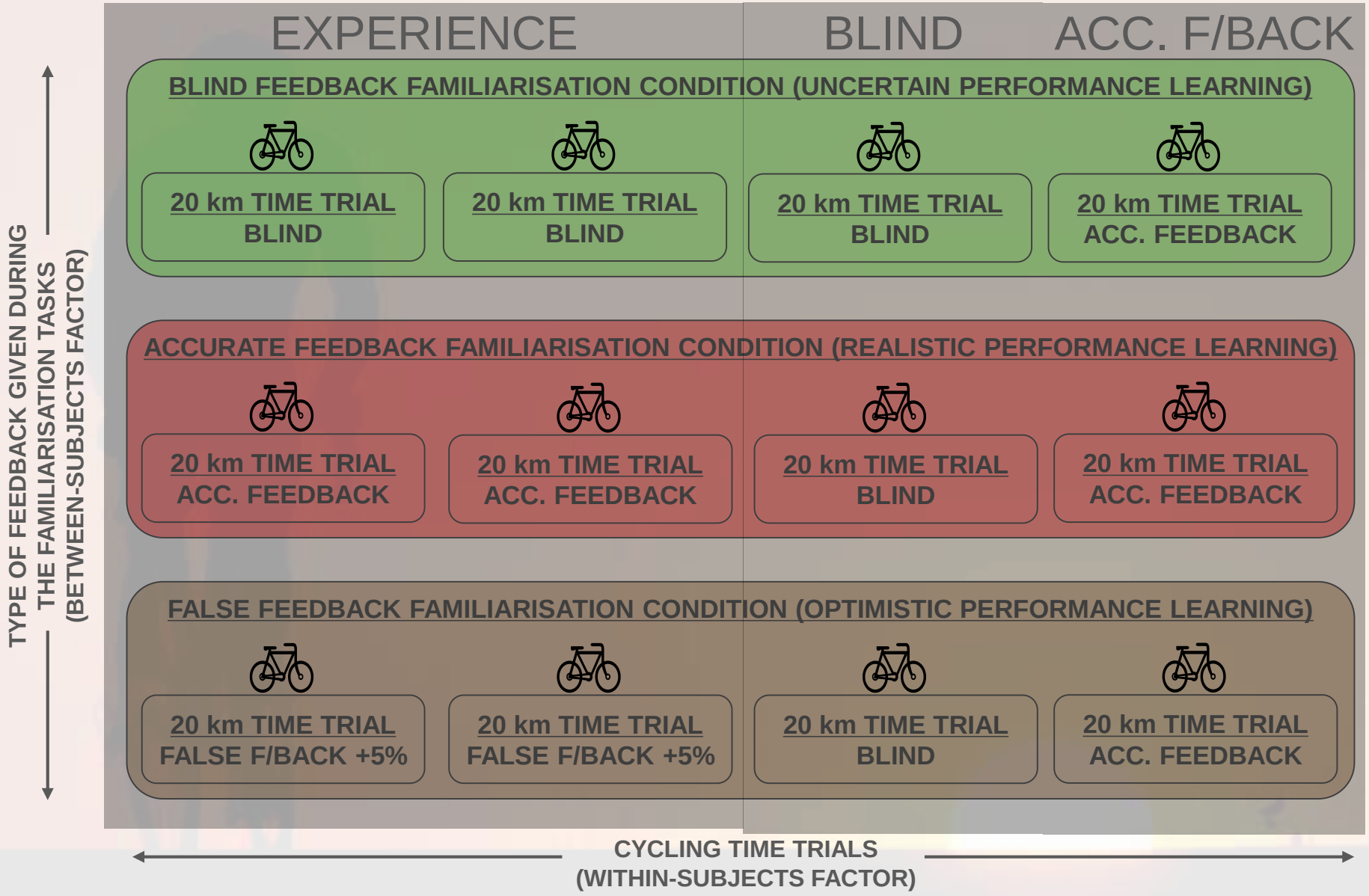
# The pro's & con's of intuition…

Very fast, little cognitive effort and effective in complex or confusing situations with imperfect information

Easily (too easily?) modifiable…consistency issues:

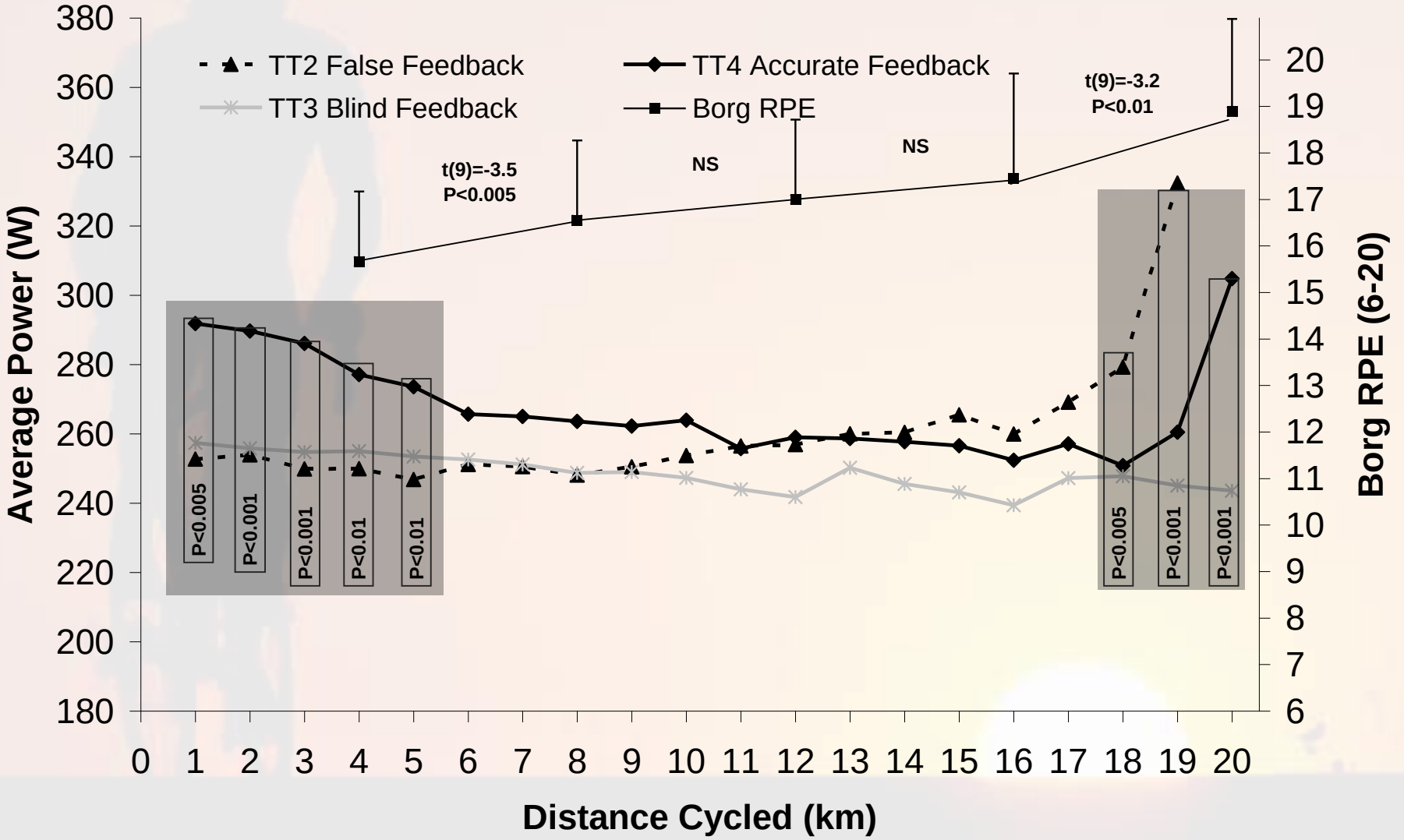
- Affect Heuristic
- Framing Heuristic
- **Belief Heuristic…**

**Fig 2.** Experimental Design. Adapted from Micklewright D, Papadopoulou E, Swart J, Noakes T (2010) *Br J Sports Med.*

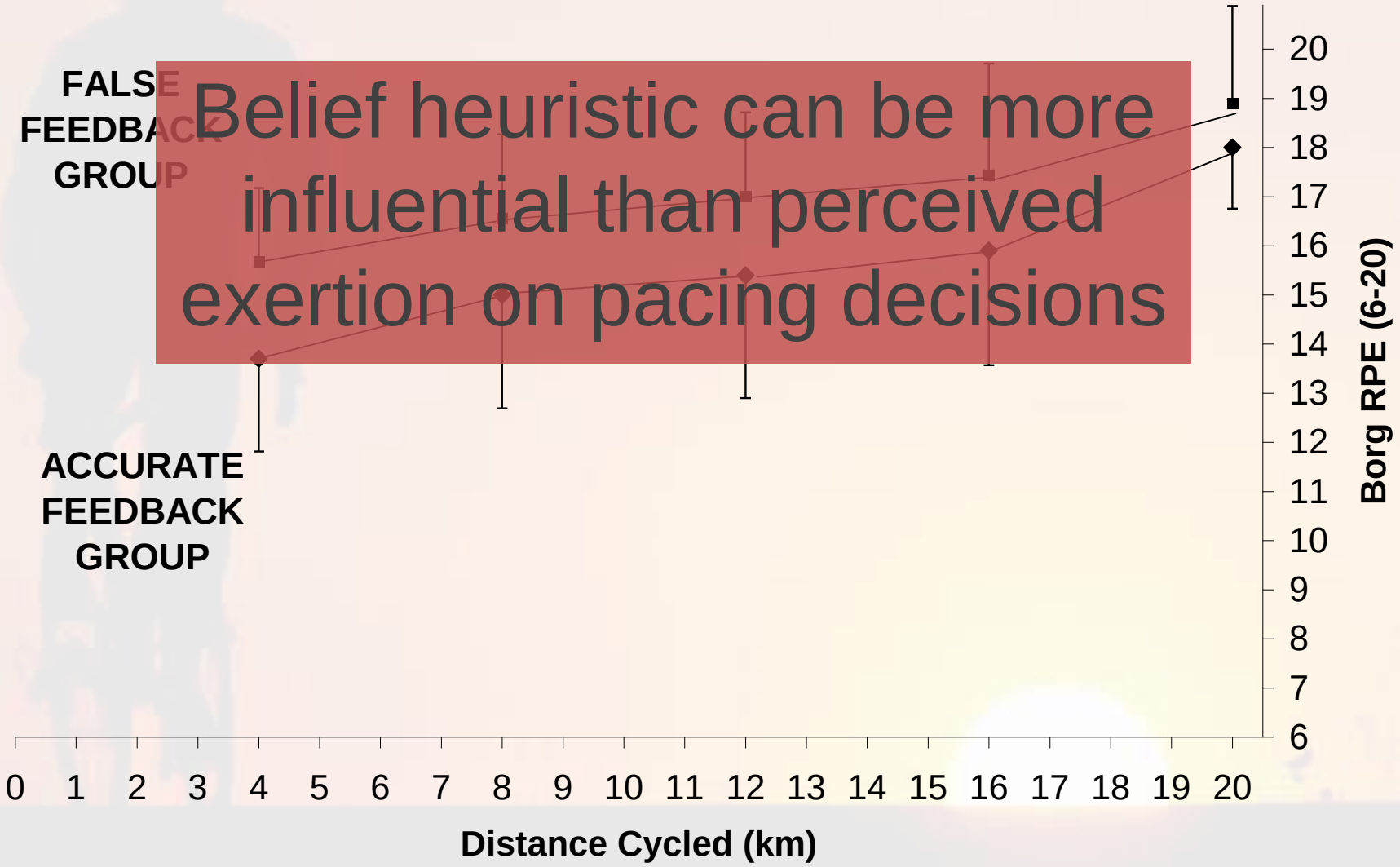


# **Fig 3.** False Experience Group: Power Output & RPE when Feedback is not Consistent with Experience

(Micklewright, Papadopoulou, Swart & Noakes, 2010. *Br. J. Sports Med)*



# **Fig 4.** False Experience Group: Power Output & RPE when provided with feedback



# The pro's & con's of intuition…

Very fast, little cognitive effort and effective in complex or confusing situations with imperfect information

Easily (too easily?) modifiable…consistency issues:

- Affect Heuristic
- Framing Heuristic
- Belief Heuristic
- **Personality…**

**Risk Perception**

People often see some risk in situations that contain uncertainty about what the outc
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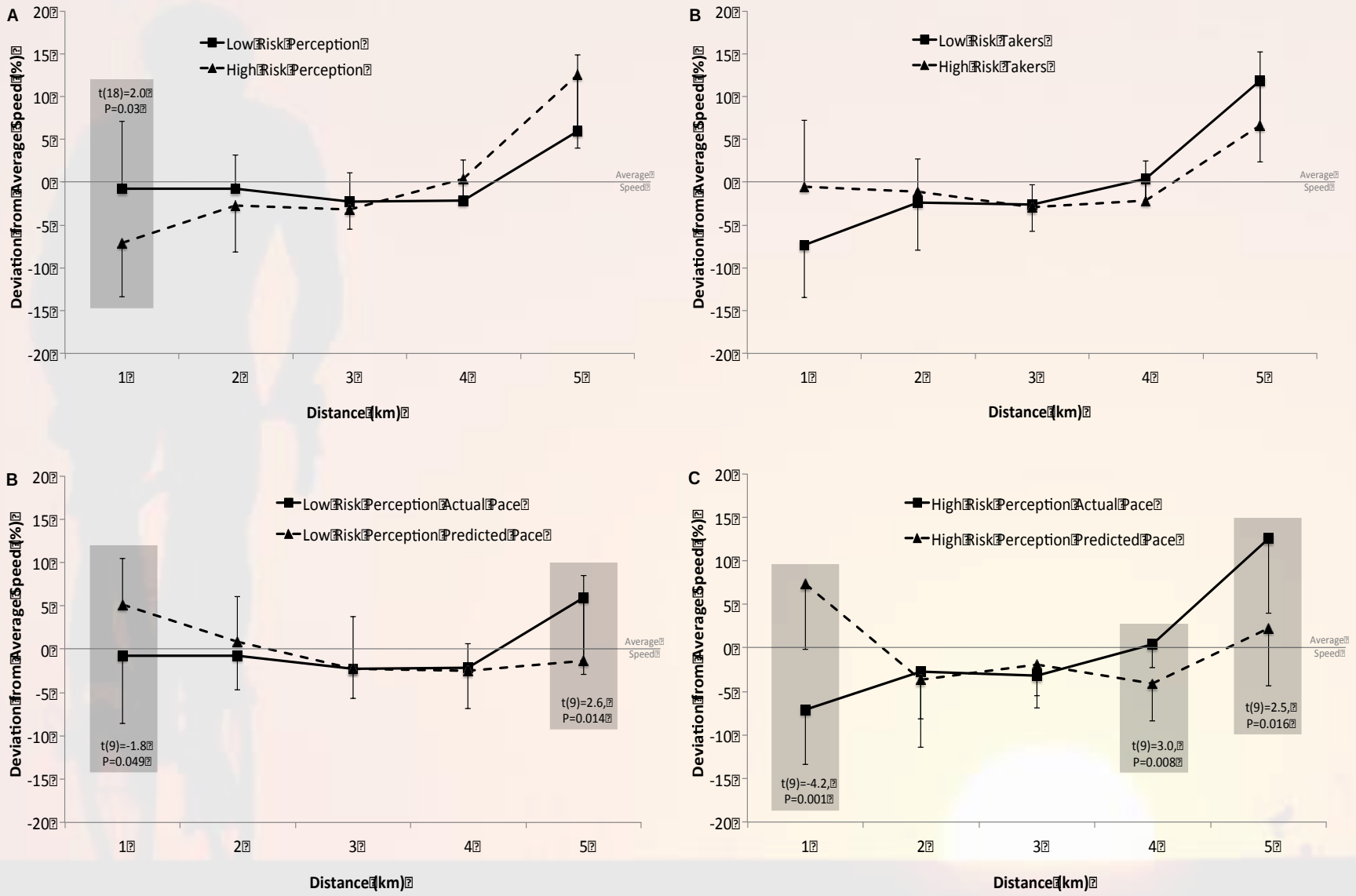
**Risk Taking**

For each of the following statements, please indicate the likelihood that you would engage in the described activity or behavior if you were to find yourself in that situation. Provide a rating from 'Extremely Unlikely' to 'Extremely Likely', using the following scale:

| | Extremely unlikely | Moderately unlikely | Somewhat unlikely | Not sure | Somewhat likely | Moderately likely | Extremely likely |
|---|---|---|---|---|---|---|---|
| Admitting that your tastes are different from those of a friend | EU | MU | SU | NS | SL | ML | EL |
| Going camping in the wilderness | EU | MU | SU | NS | SL | ML | EL |
| Betting a day's income at the horse races | EU | MU | SU | NS | SL | ML | EL |
| Investing 10%of your annual income in a moderate growth mutual fund | EU | MU | SU | NS | SL | ML | EL |
| Drinking heavily at a social function | EU | MU | SU | NS | SL | ML | EL |
| Taking some questionable deduction on your tax return | EU | MU | SU | NS | SL | ML | EL |
| Disagreeing with an authority figure on a major issue | EU | MU | SU | NS | SL | ML | EL |
| Betting a day's income at a high stake poker game | EU | MU | SU | NS | SL | ML | EL |
| Having an affair with a married man/women | EU | MU | SU | NS | SL | ML | EL |
| Passing off somebody else's work as your own | EU | MU | SU | NS | SL | ML | EL |
| Going down a ski run that is beyond your ability | EU | MU | SU | NS | SL | ML | EL |
| Investing 5% of your annual income in very speculative stock | EU | MU | SU | NS | SL | ML | EL |
| Going white water rafting at high water in the spring | EU | MU | SU | NS | SL | ML | EL |
| Betting a day's income in the outcome of a sporting event | EU | MU | SU | NS | SL | ML | EL |
| Engaging in unprotected sex | EU | MU | SU | NS | SL | ML | EL |

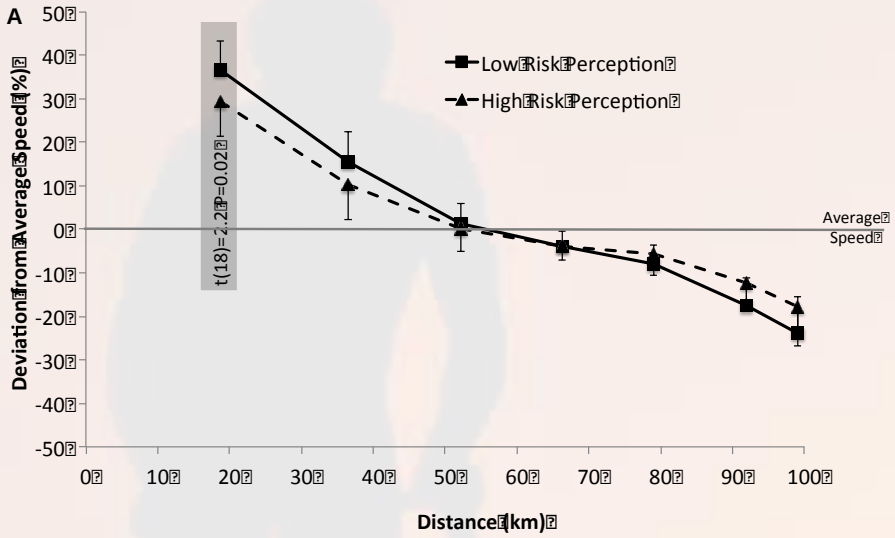
# **Fig 5.** Risk perception group 5 km cycling TT pace differences

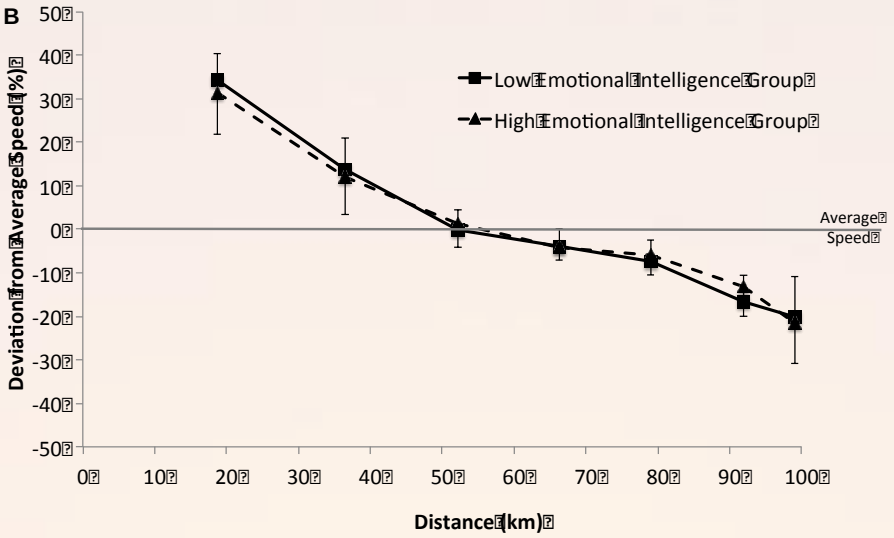
Micklewright et al. (2015) *Med Sci Sports Ex.* 47(5), 1026-1037

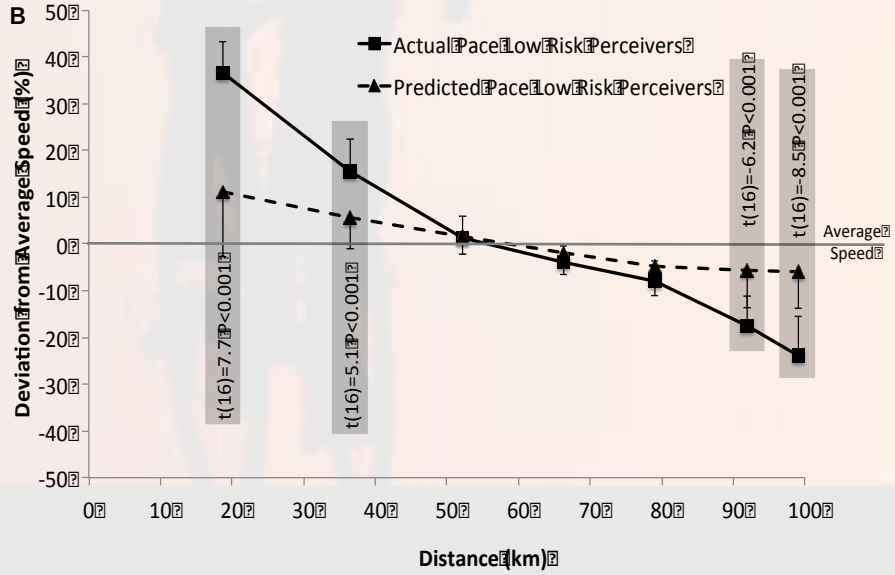


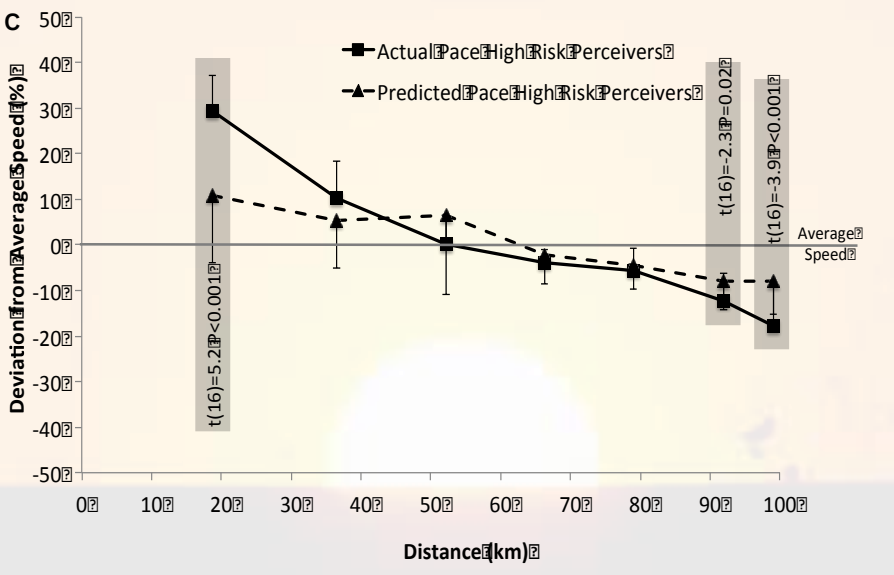
# **Fig 6.** Risk perception 100 km ultramarathon pace differences

Micklewright et al. (2015) *Med Sci Sports Ex.* 47(5), 1026-1037



# Judgement, Hypothetical Thinking and Choice

**Do you choose:**

**Conservative starting pace with 90% chance of completing & 10% chance of achieving PB**

**OR**

**Fast start with 50% chance of completing & 50% chance of achieving PB**

Deciding requires hypothetical/prospective thinking which is an extremely complex process…

# Endpoint Focused Pacing: Retrospection, Perception and Prospection

Retrospection: re-experiencing the past

Perception: mental representation of the present

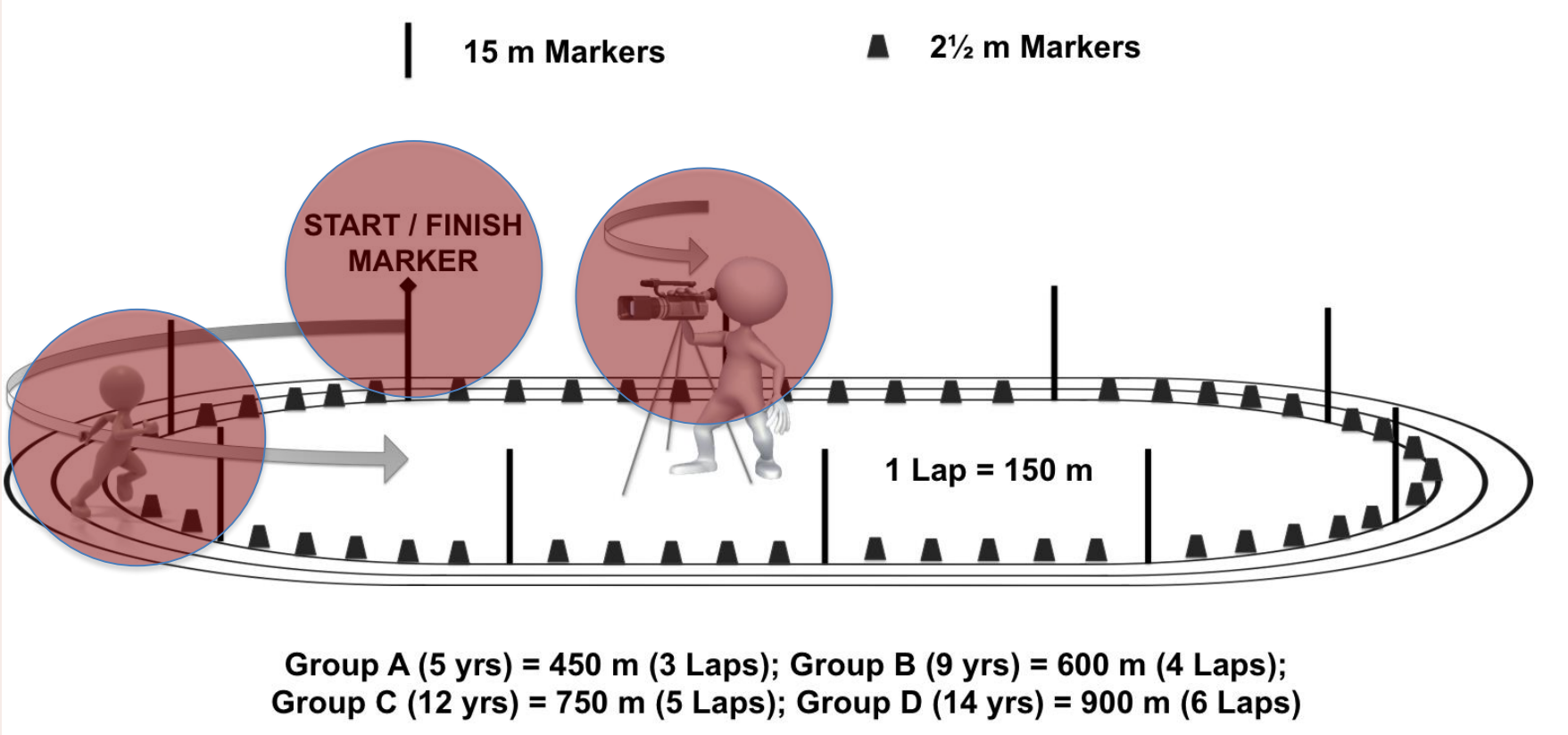
Prospection: imagining a range of possibilities and their consequences through mental simulation…

Brain combines incoming information with memories of past events to 'simulate' the future. Evidence:

1. PFC damaged patients (Fellows, 2005)
2. Neuroimaging studies PFC & medial temporal lobe activation with prospective thought (Schacter, 2007)
3. Prospection not present in young children (Atance, 2005)…

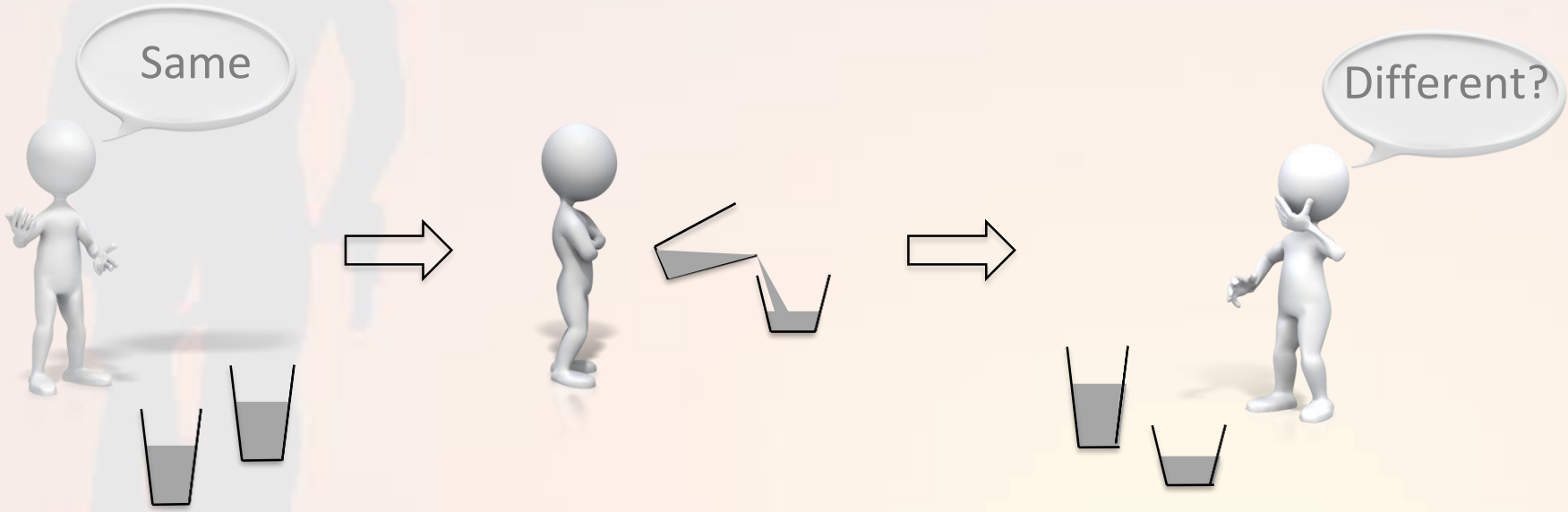
# **Fig 7.** Experimental protocol – Cognitive development and pacing behaviour in children

Micklewright et al. (2012) *Med Sci Sports Ex.* 44(2), 362-369



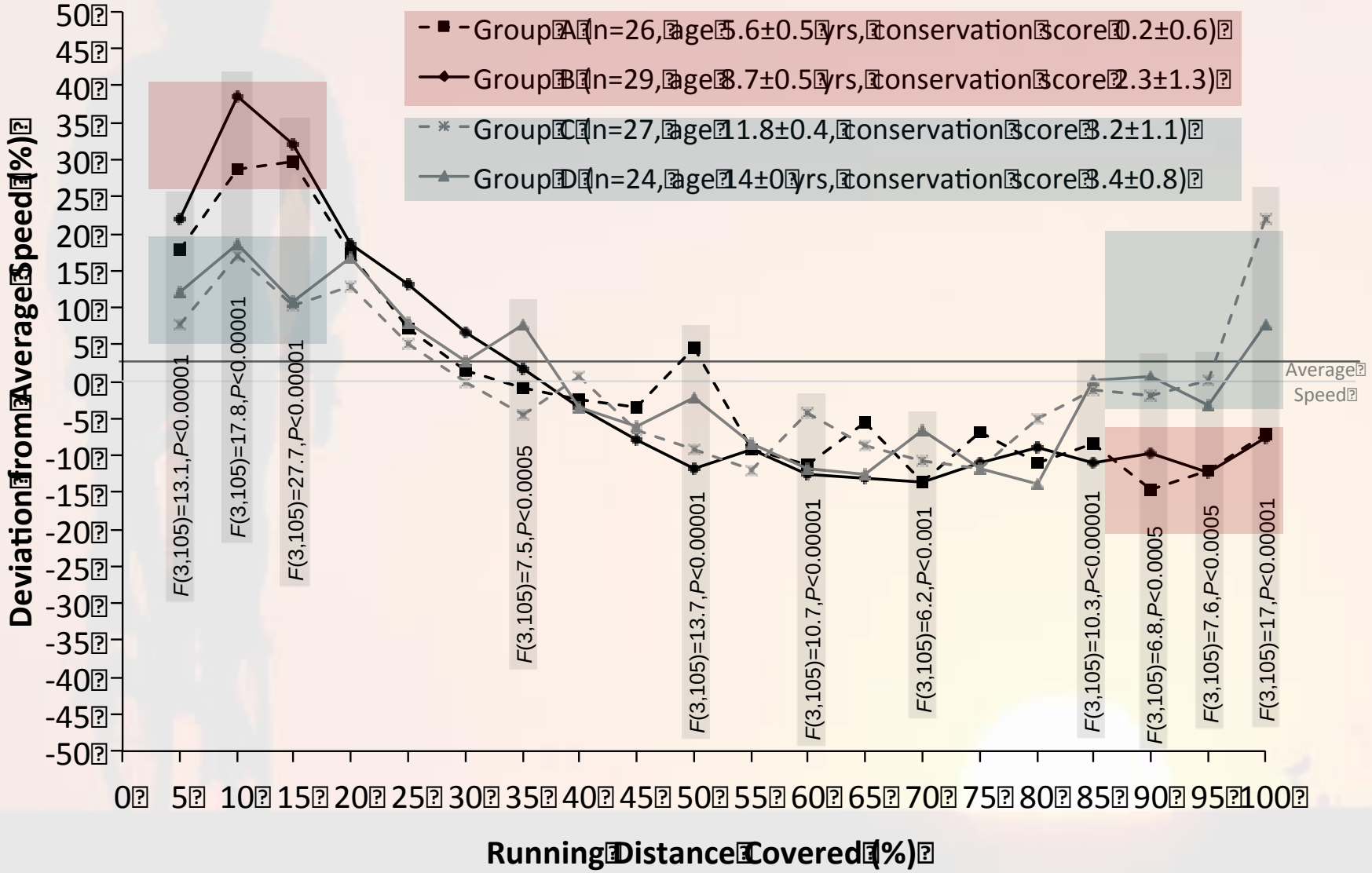
# **Fig 8.** Example Piagetian conservation task

Micklewright et al. (2012) *Med Sci Sports Ex.* 44(2), 362-369



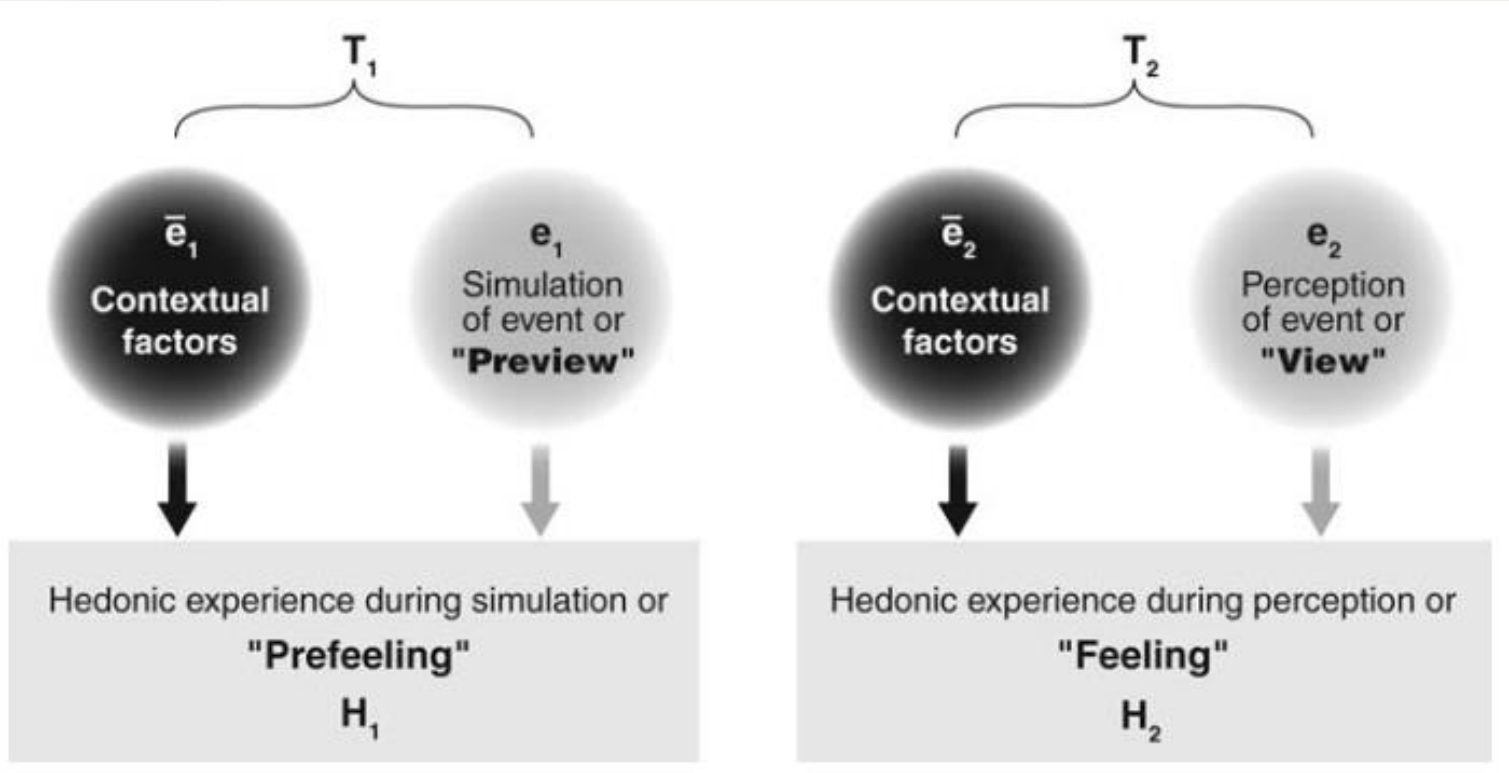
# **Fig 9.** Interaction between age group and pacing

Micklewright et al. (2012) *Med Sci Sports Ex.* 44(2), 362-369



# **Fig 10.** Prospective simulation is imperfect

(Adapted from Gilbert & Wilson, 2007. *Science)*




$H_1=H_2$ if $e_1=e_2$ & $\bar{e}_1=\bar{e}_2$

$H_1 \neq H_2$ if $e_1 \neq e_2$ and/or $\bar{e}_1 \neq \bar{e}_2$

Sports Med
DOI 10.1007/s40279-013-0107-0

REVIEW ARTICLE

# Application of Decision-Making Theory to the Regulation of Muscular Work Rate during Self-Paced Competitive Endurance Activity

**Andrew Renfree · Louise Martin · Dominic Micklewright · Alan St Clair Gibson**

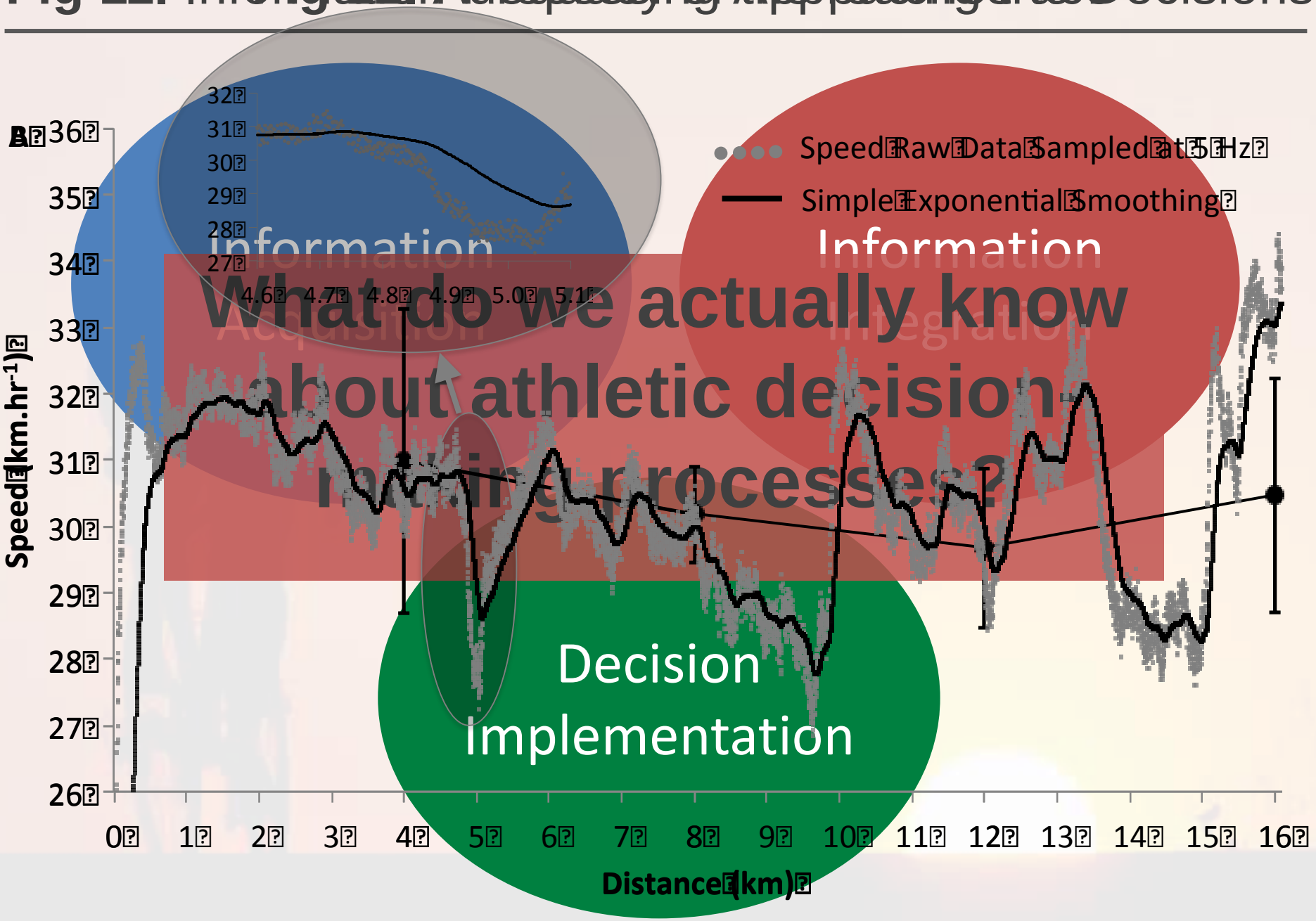


**Abstract** Successful participation in competitive endurance activities requires continual regulation of muscular work rate in order to maximise physiological performance

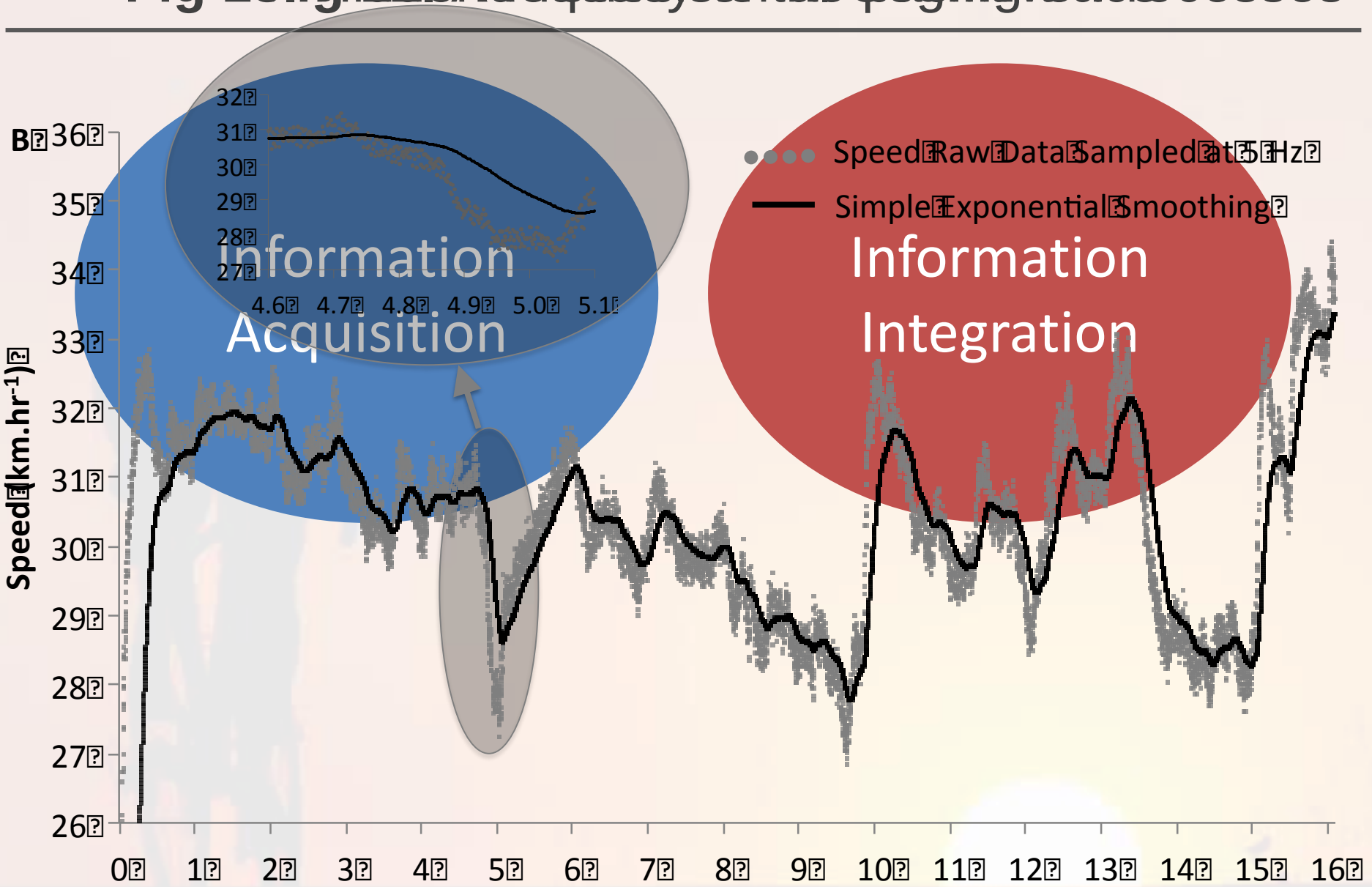
that effective rational decision-making
ever, at present, many proposed models
process share similarities with rational m

# **Fig 11.** Information Processing Approaches to Decisions

# Fig 11. Information Processing of Approaching Decisions



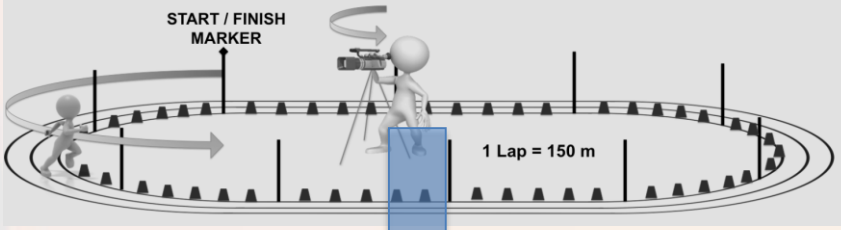
# Fig 13. Adequacy of the Cognitive Processes



# **Fig 14.** Information seeking in children during a self-paced run

Chinnasamy, Parry, St Clair Gibson & Micklewright, 2012. *MSSE*

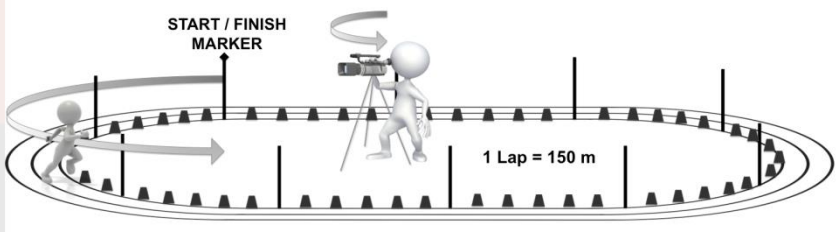
Control Run (N=38, Age 12 yrs)
Best 750 m Performance ($t_1$)



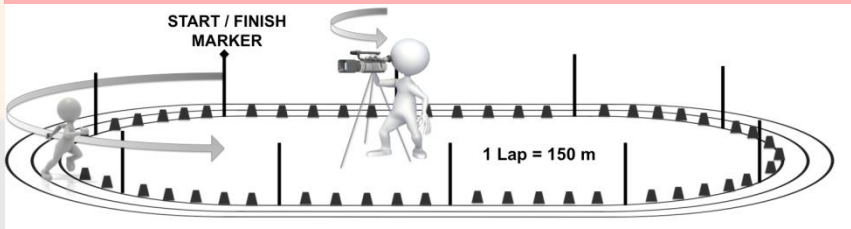

Split into two groups:
Matched for gender, conservation score and performance

Spatial Feedback Group

Repeat 750 m Run

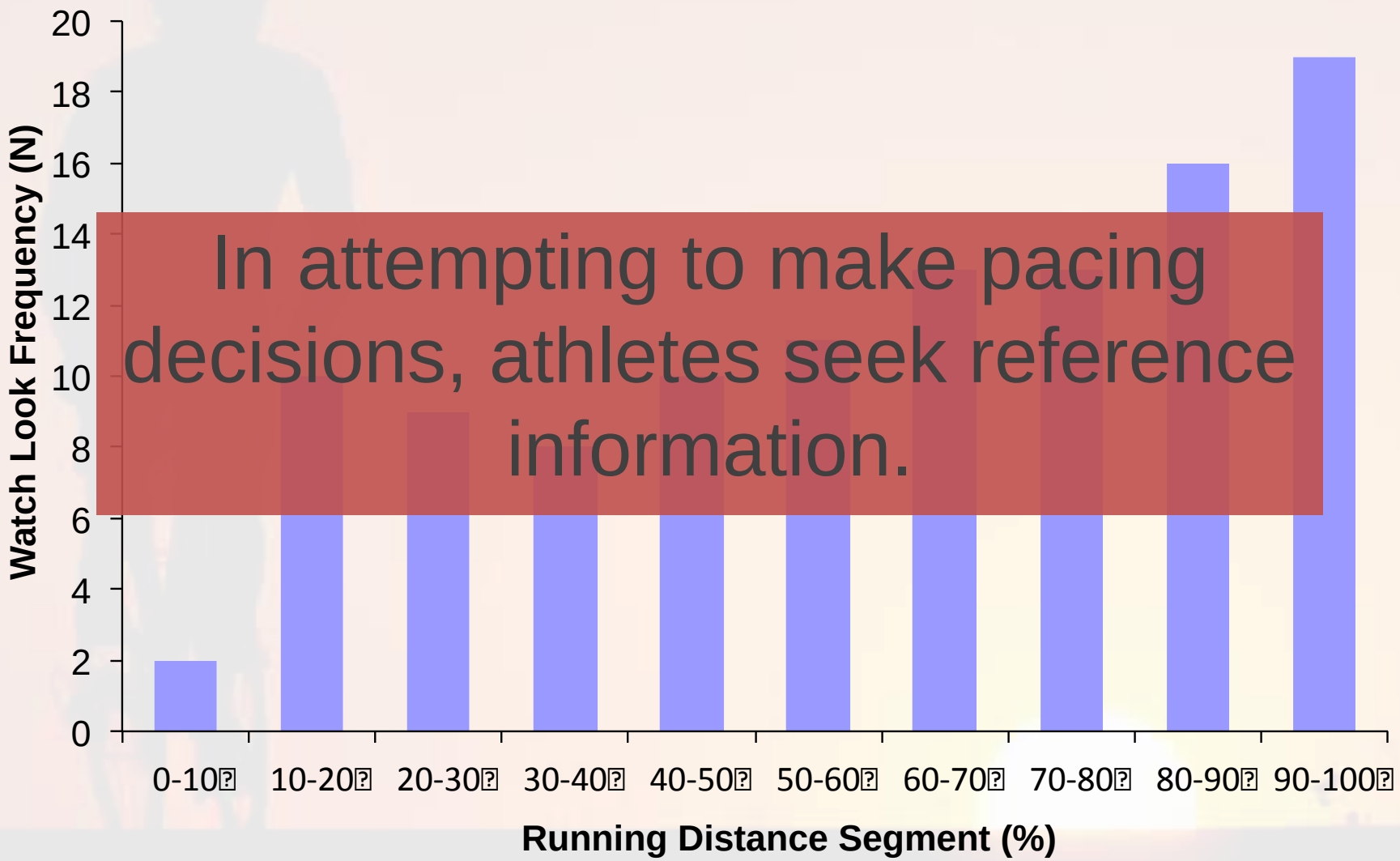



Temporal Feedback Group
Run to time picked from hat
(all matched to $t_1$ - deception)



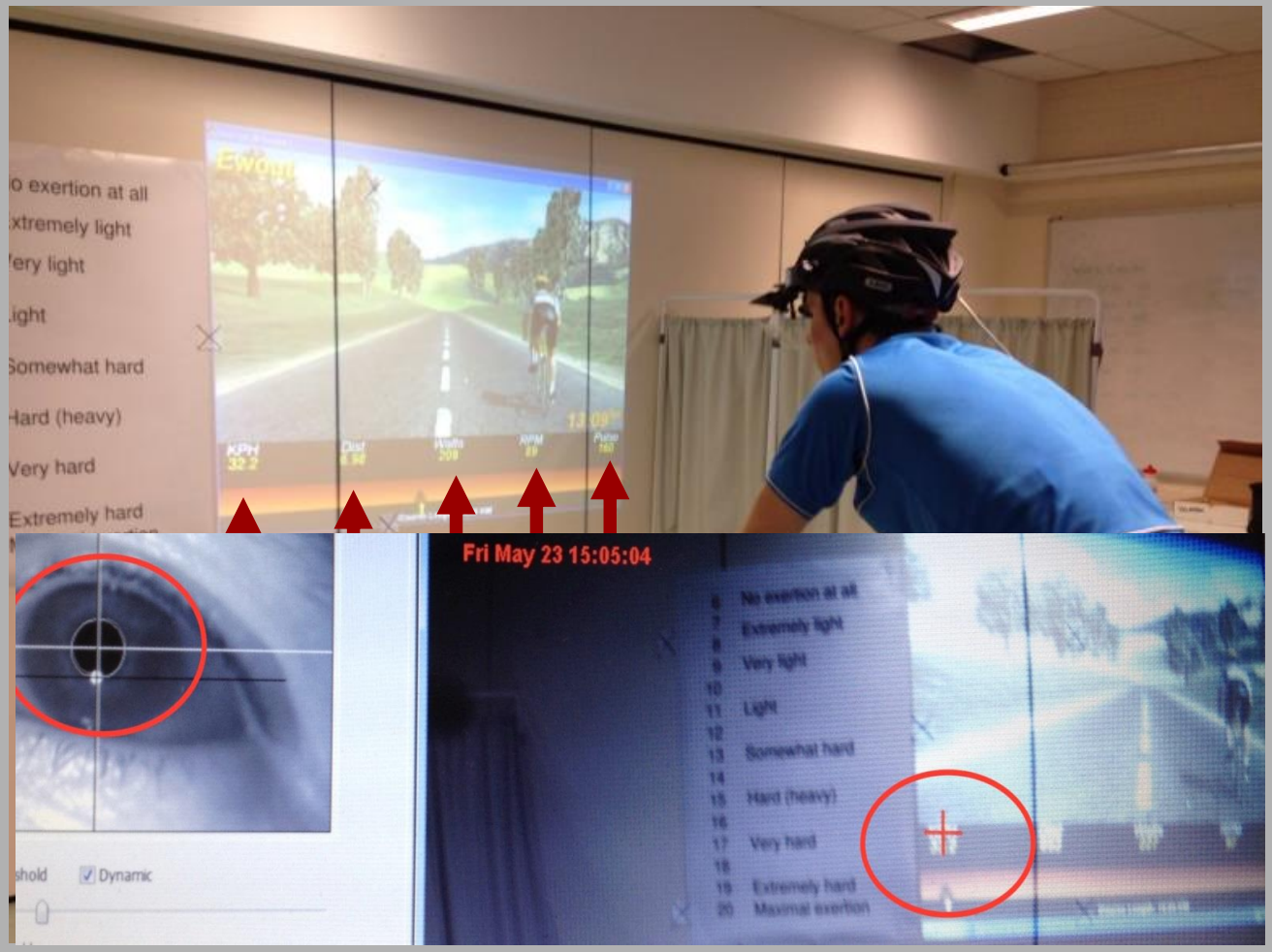
# **Fig 15.** Information Acquisition in Schoolchildren

Chinnasamy, Parry, St Clair Gibson & Micklewright, 2012. *MSSE*



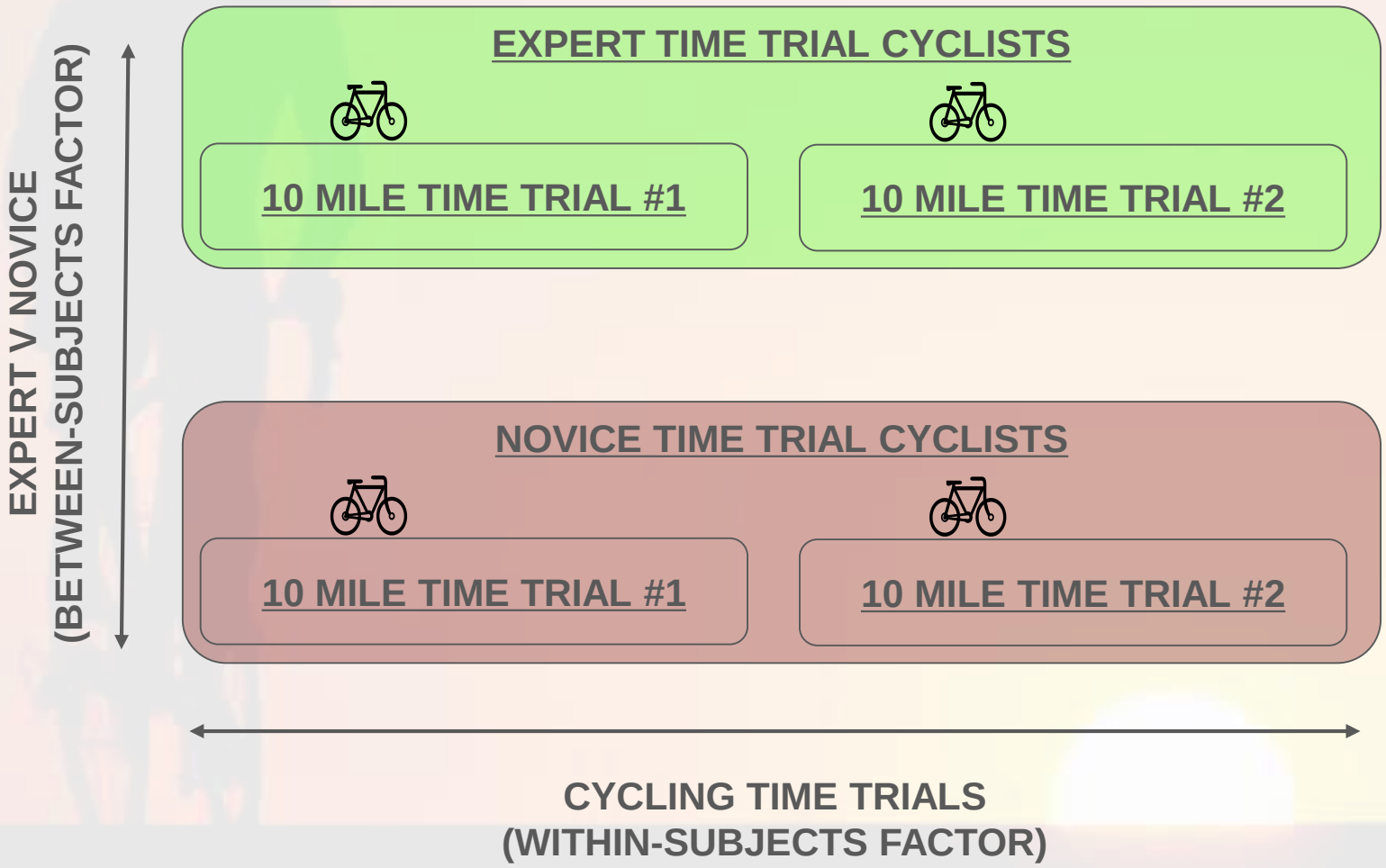

In attempting to make pacing decisions, athletes seek reference information.

# Eye-tracking methods



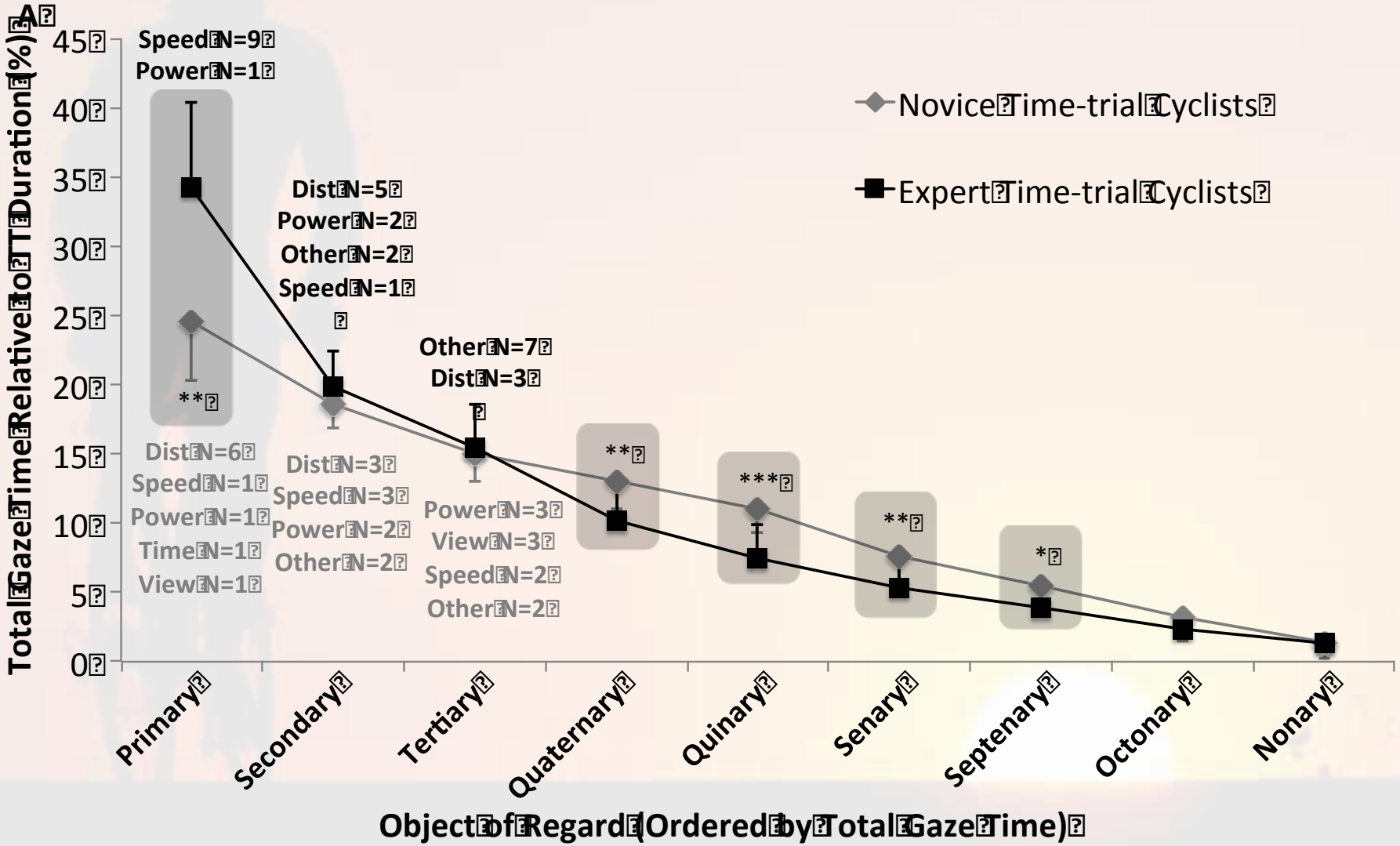

# **Fig 16.** Design Eye-tracking Time Trial Study Design

Boya et al. 2015, J. Sci. Cycling 4(2) - Abstract



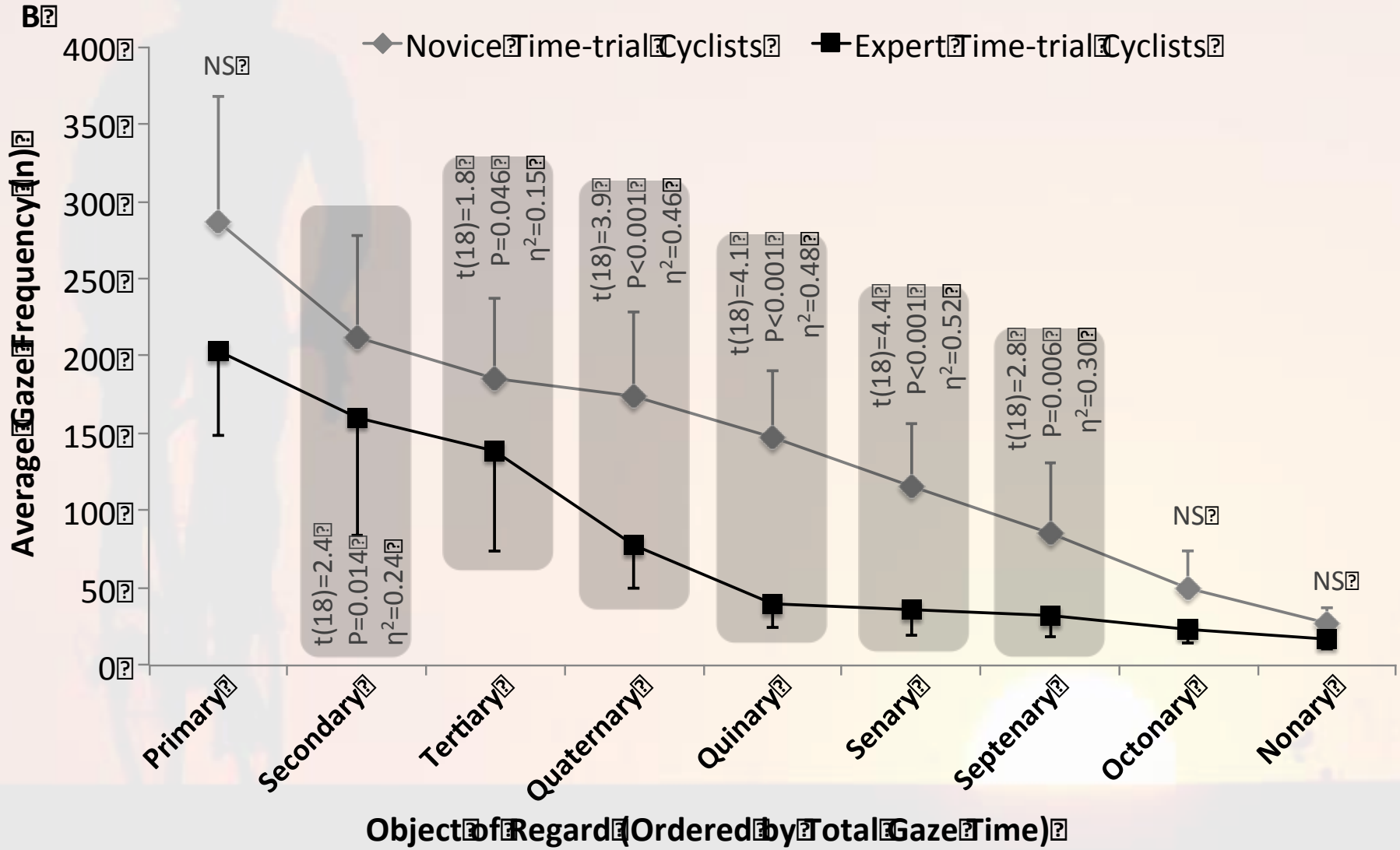
# **Fig 17.** Gaze fixation between experts and novices

Boya et al. 2015, J. Sci. Cycling 4(2) - Abstract



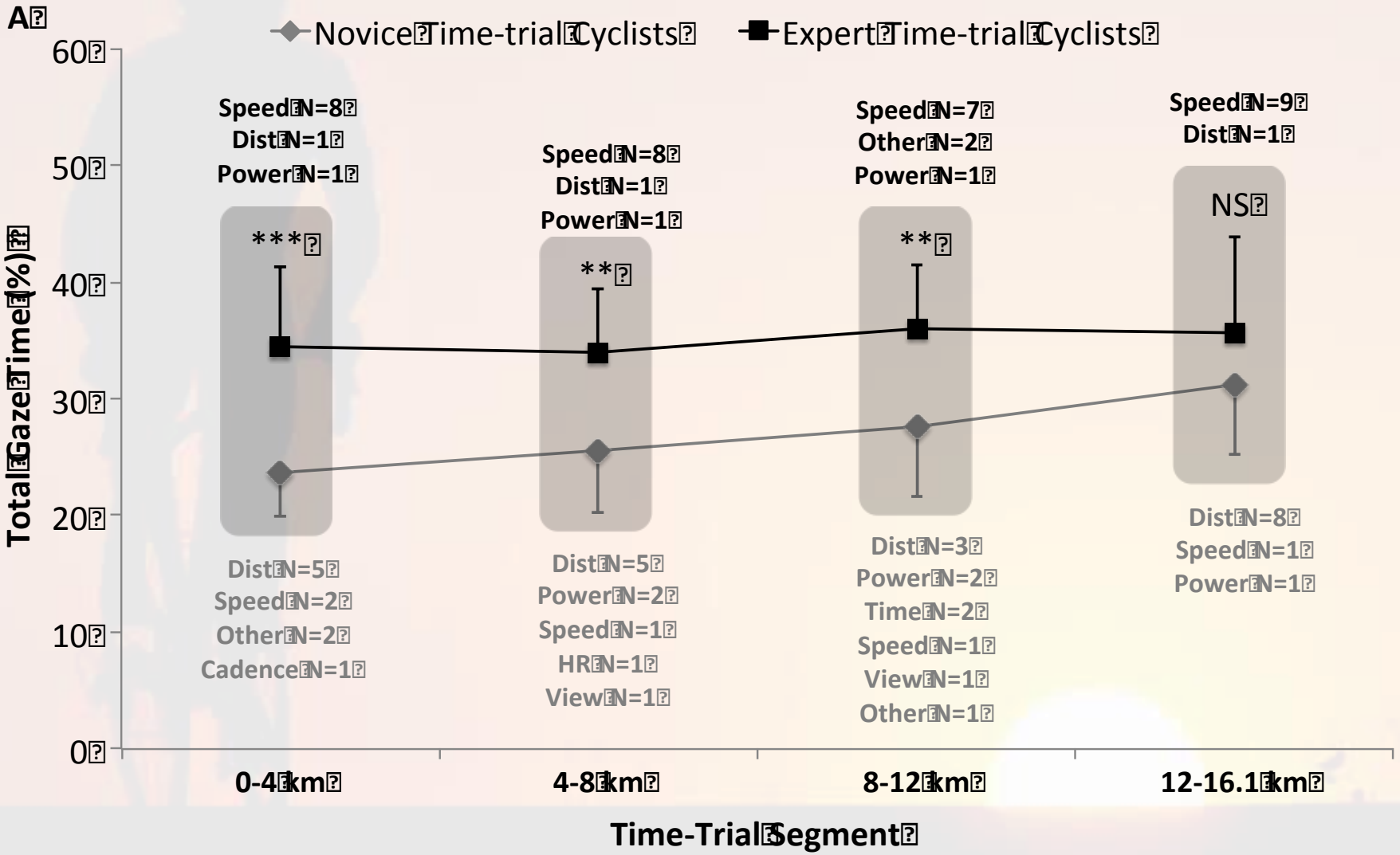
# **Fig 18.** Gaze frequency between experts and novices

Boya et al. 2015, J. Sci. Cycling 4(2) - Abstract



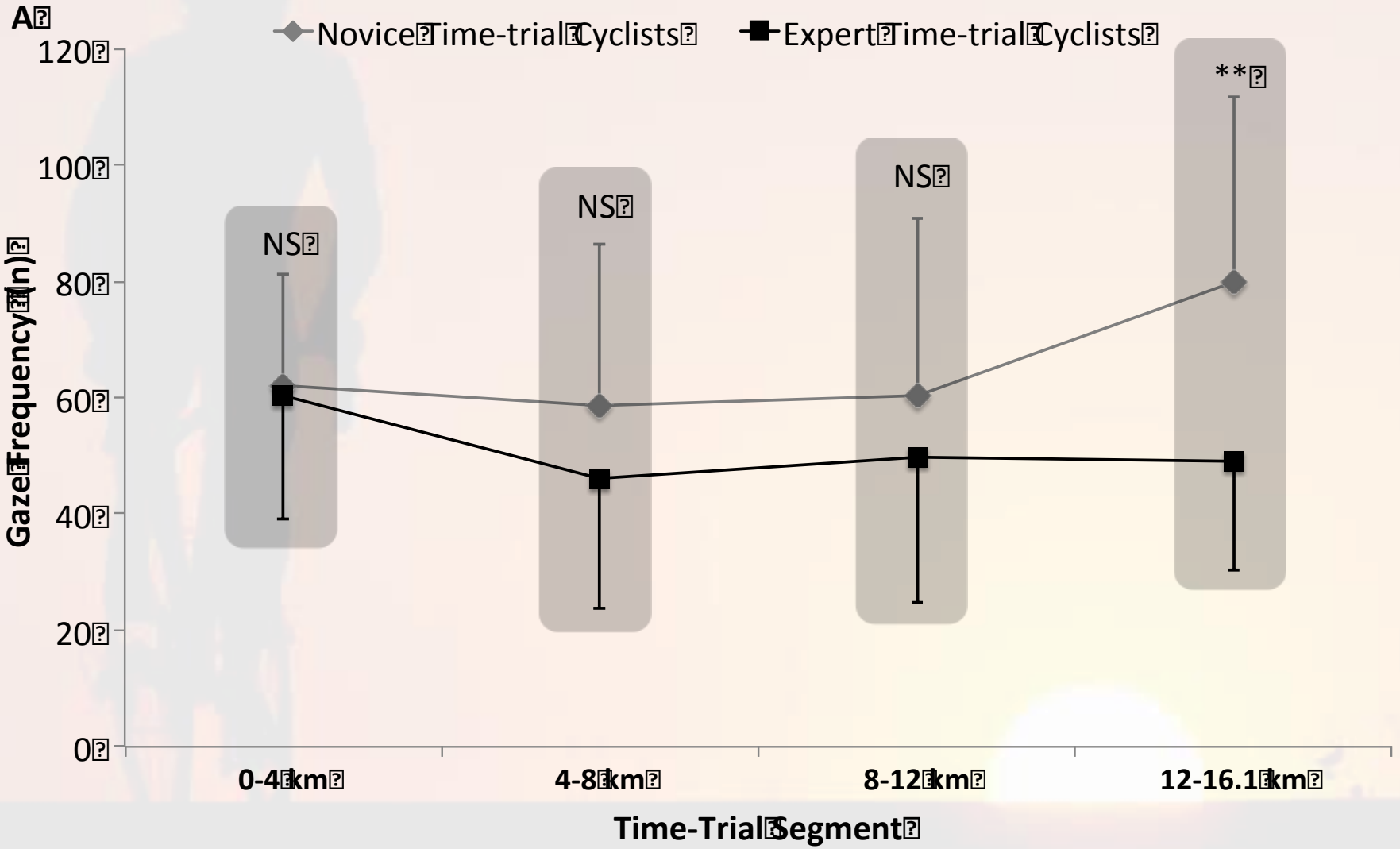
# **Fig 19.** Segment differences primary information fixation

Boya et al. 2015, J. Sci. Cycling 4(2) - Abstract



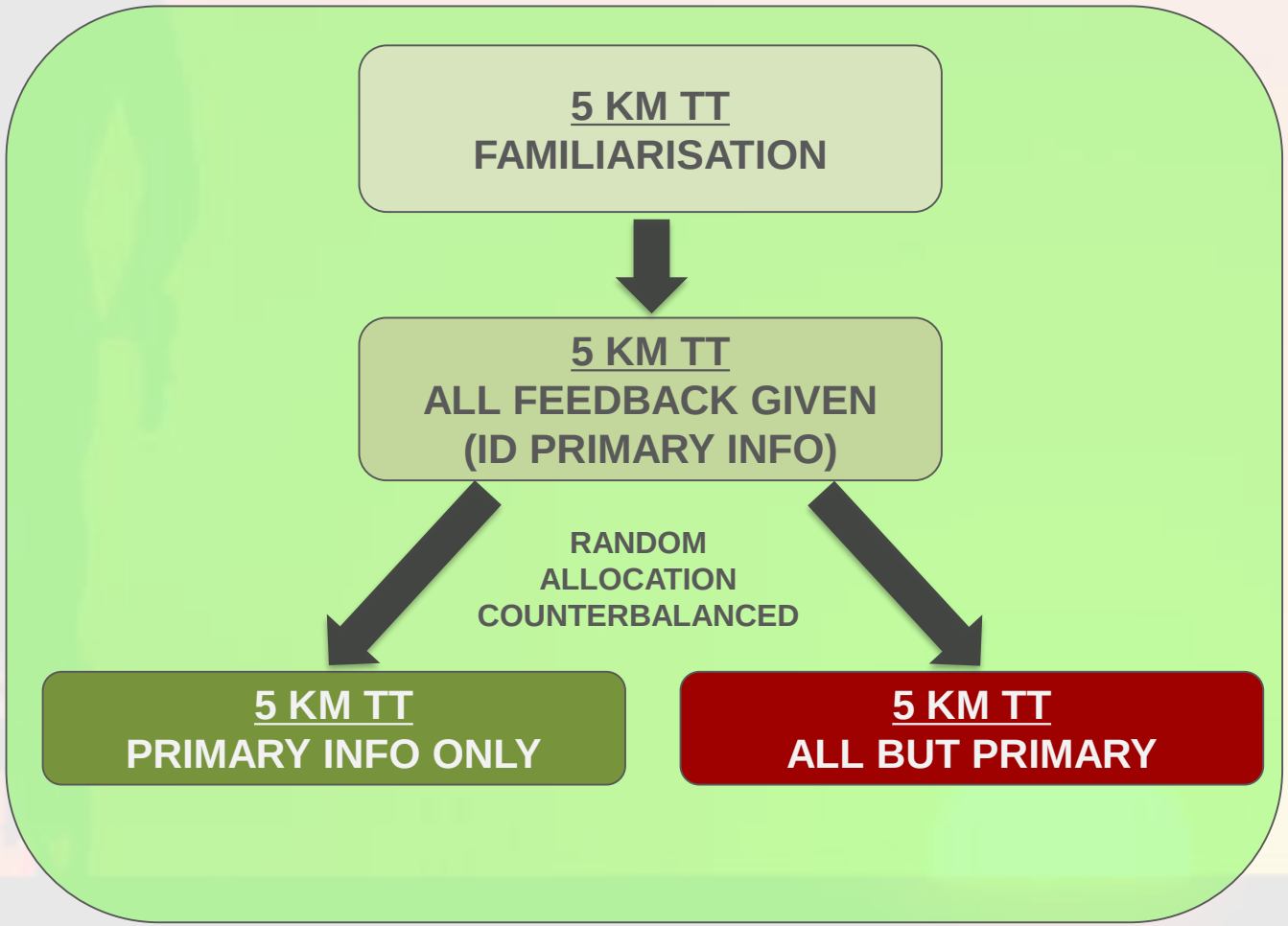
# **Fig 20.** Segment differences primary information frequency

Boya et al. 2015, J. Sci. Cycling 4(2) - Abstract



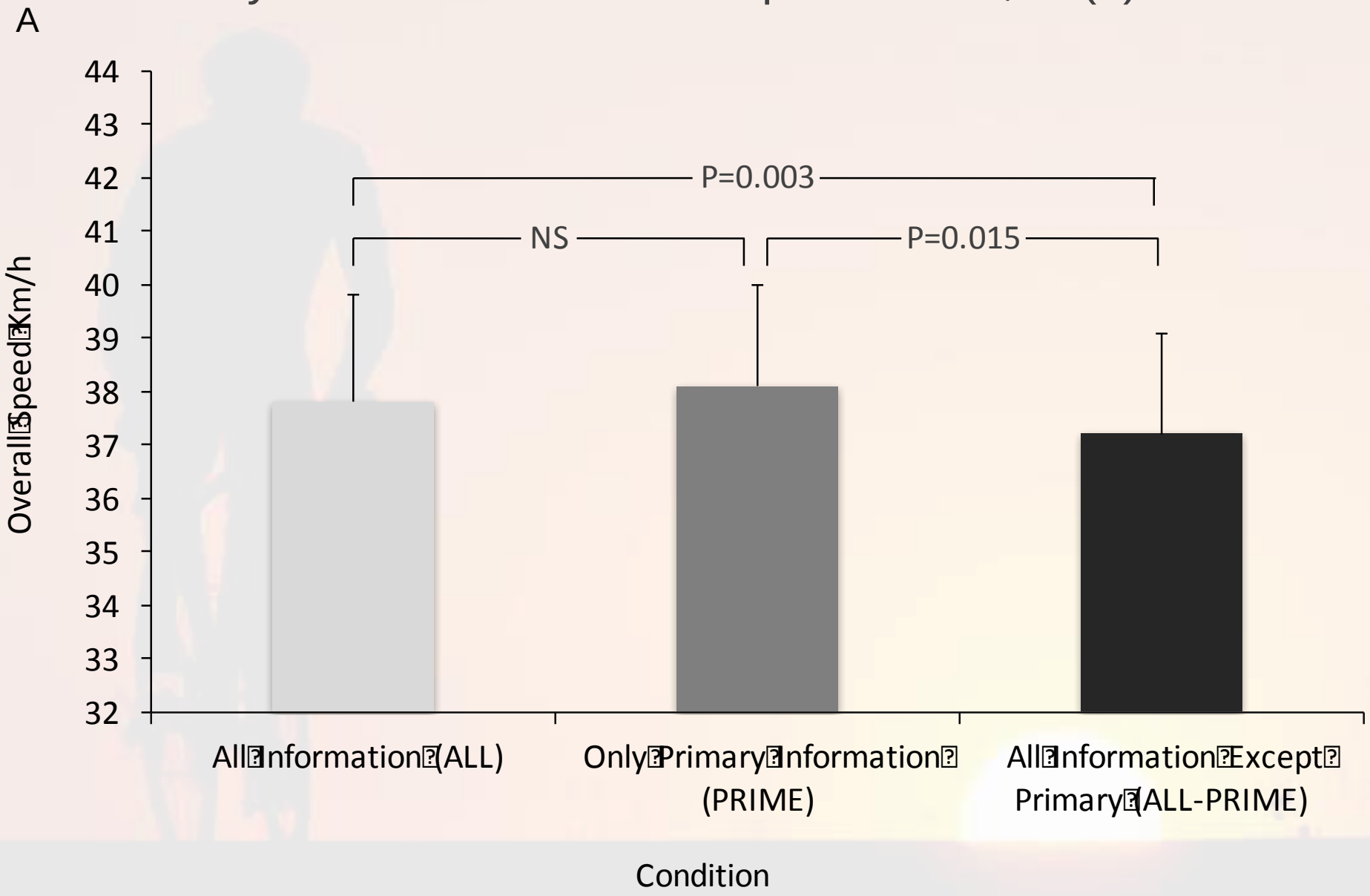
# **Fig 21.** Design – How Much Information?

Boya et al. 2016 Med Sci Sports Exerc, 48(5) S1



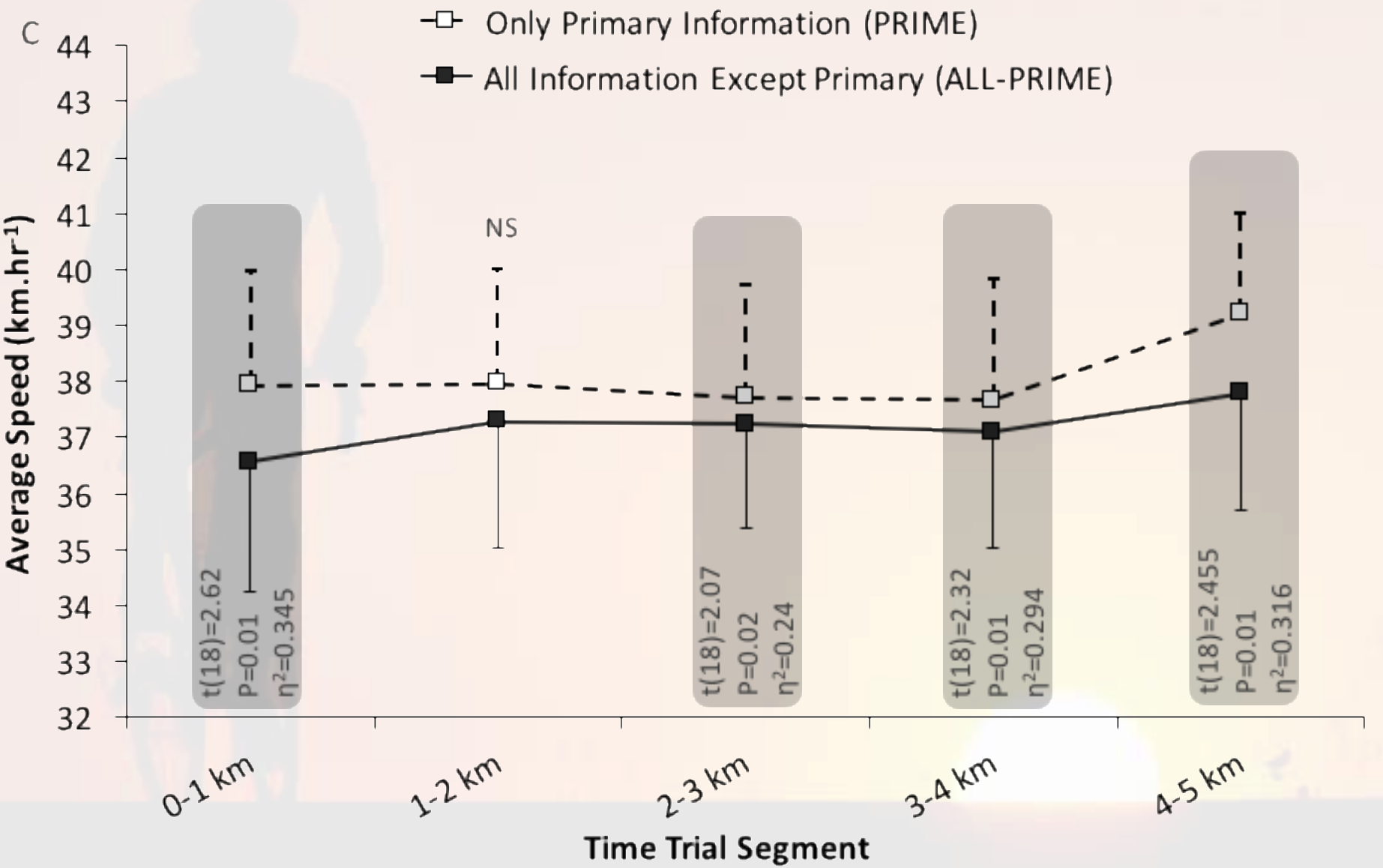
# **Fig 22.** Condition Difference in Performance

Boya et al. 2016 Med Sci Sports Exerc, 48(5) S1



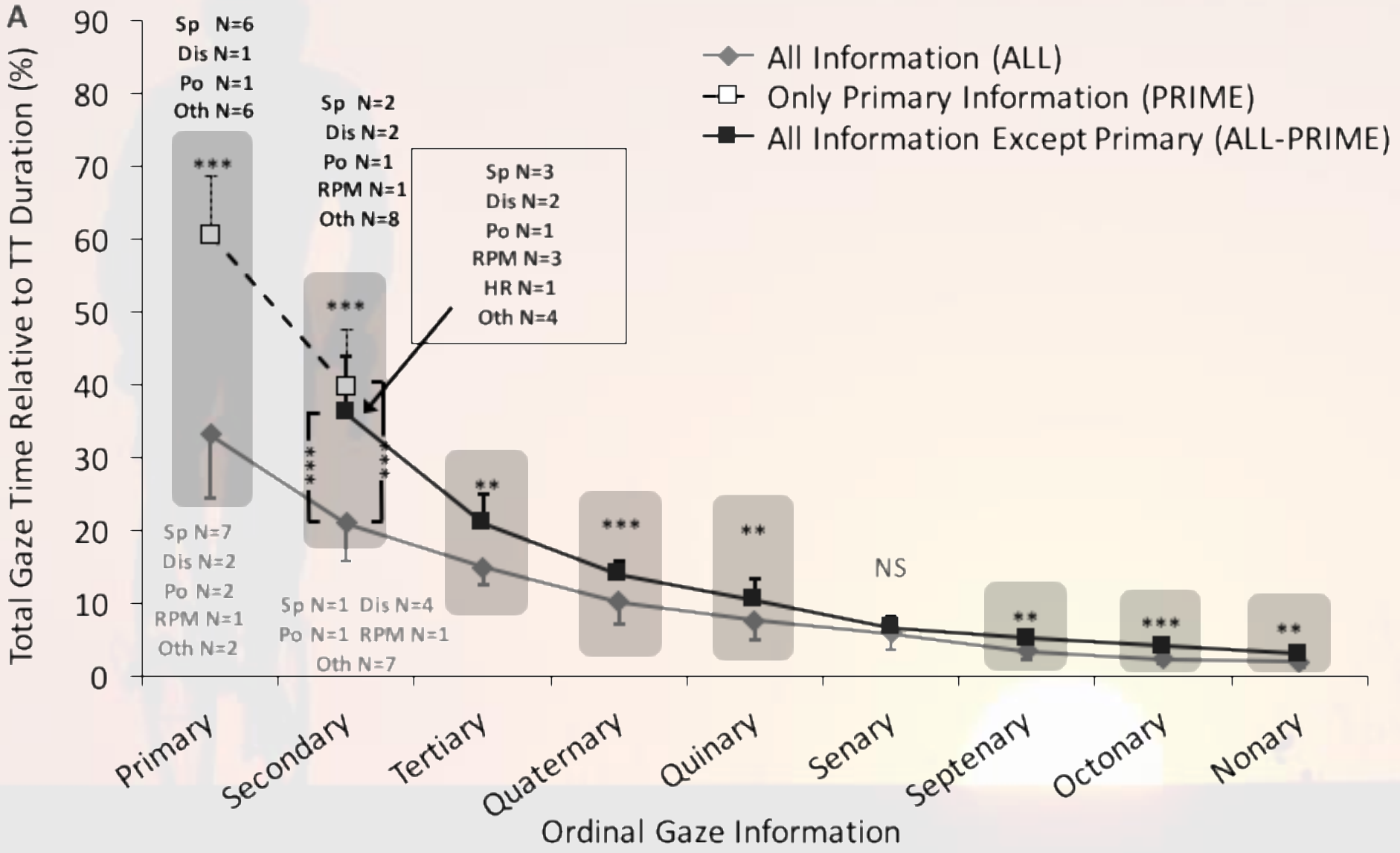
# **Fig 23.** Pacing Differences Prime vs All-Prime

Boya et al. 2016 Med Sci Sports Exerc, 48(5) S1



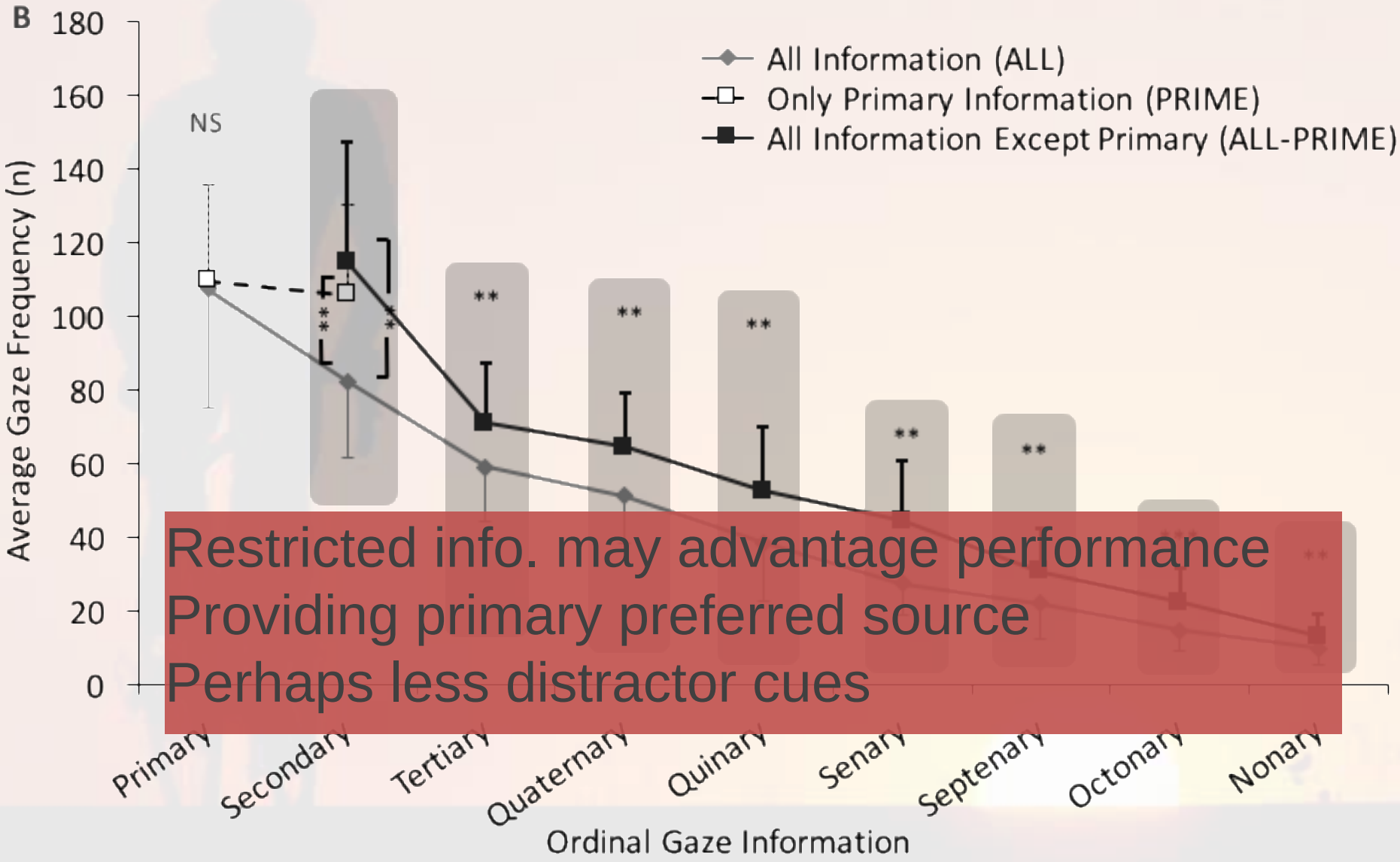
# **Fig 24.** Condition Differences in Gaze Fixation

Boya et al. 2016 Med Sci Sports Exerc, 48(5) S1



# **Fig 25.** Condition Differences in Gaze Frequency

Boya et al. 2016 Med Sci Sports Exerc, 48(5) S1



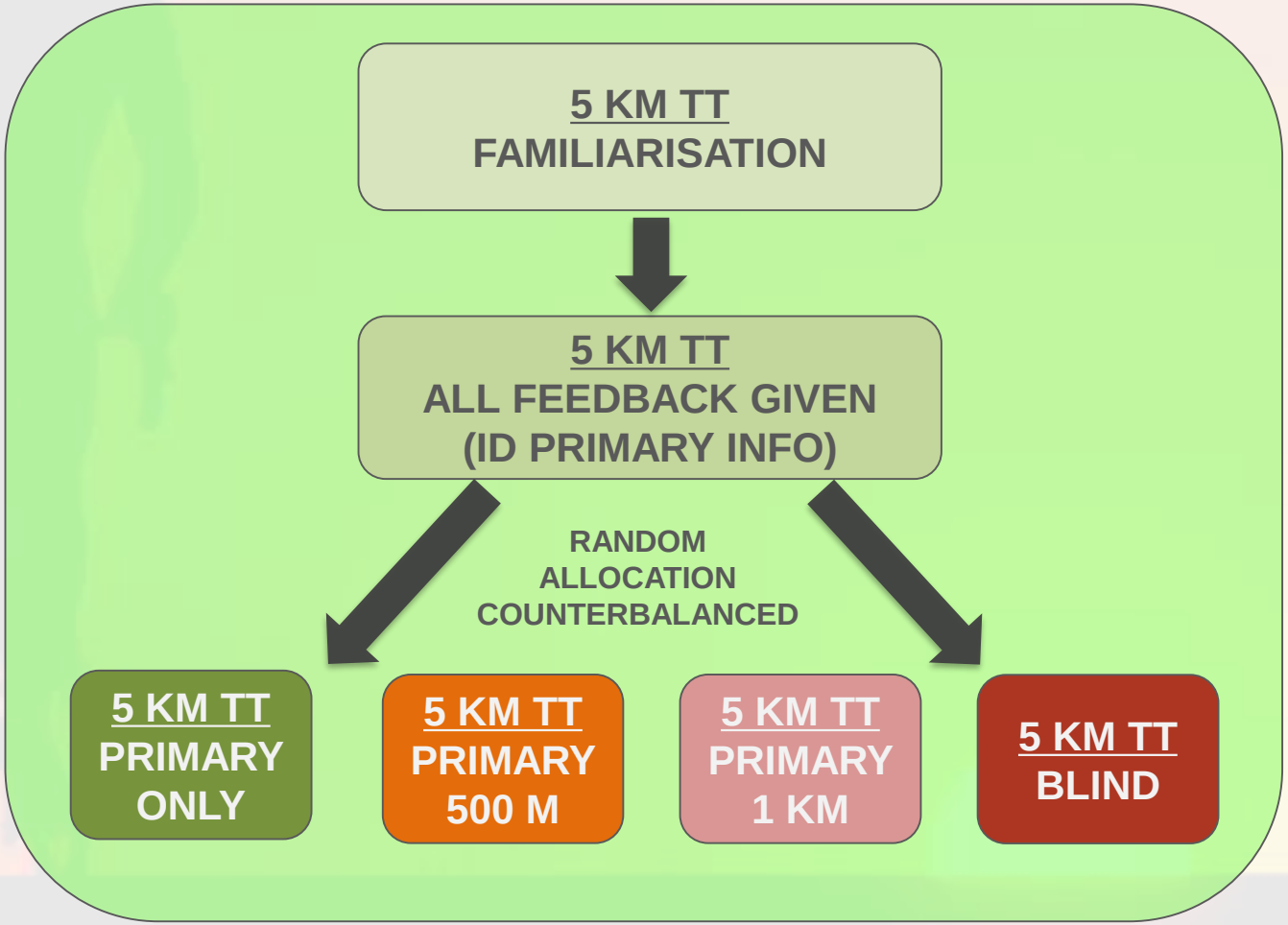

Restricted info. may advantage performance

Providing primary preferred source

Perhaps less distractor cues

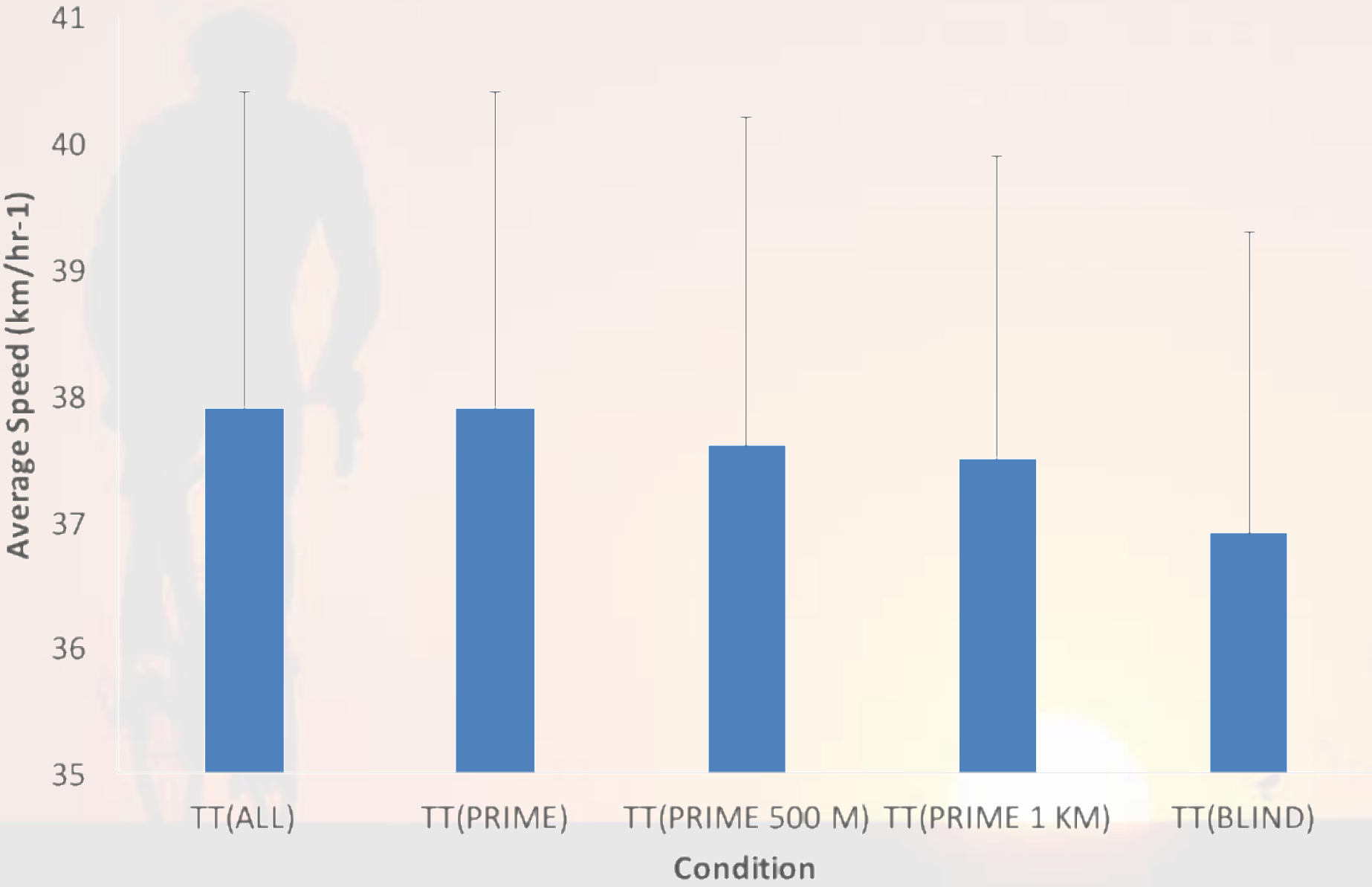
# **Fig 26.** Design – Information Exposure Length?

Unpublished



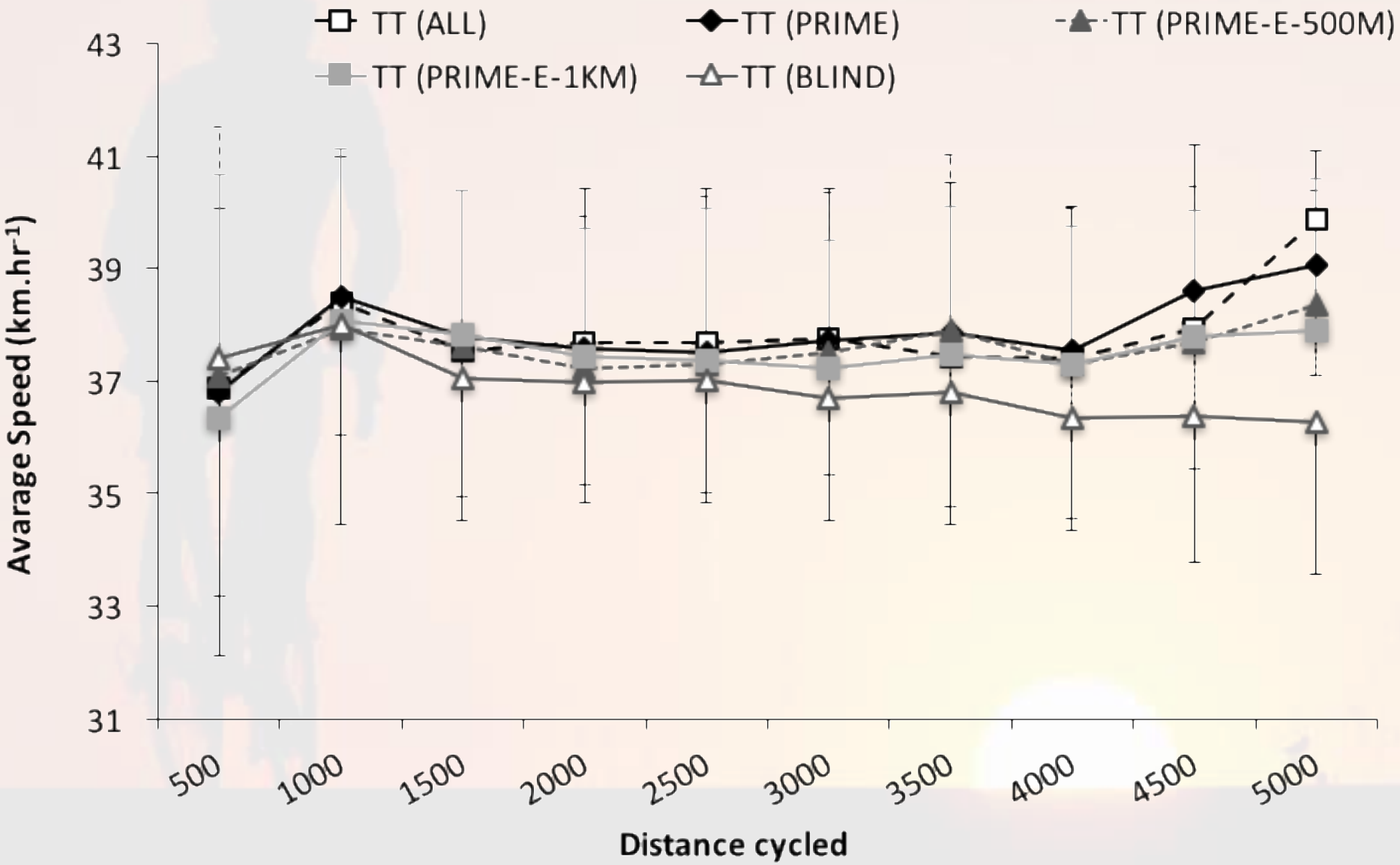
# **Fig 27.** Condition Difference in Performance

Unpublished



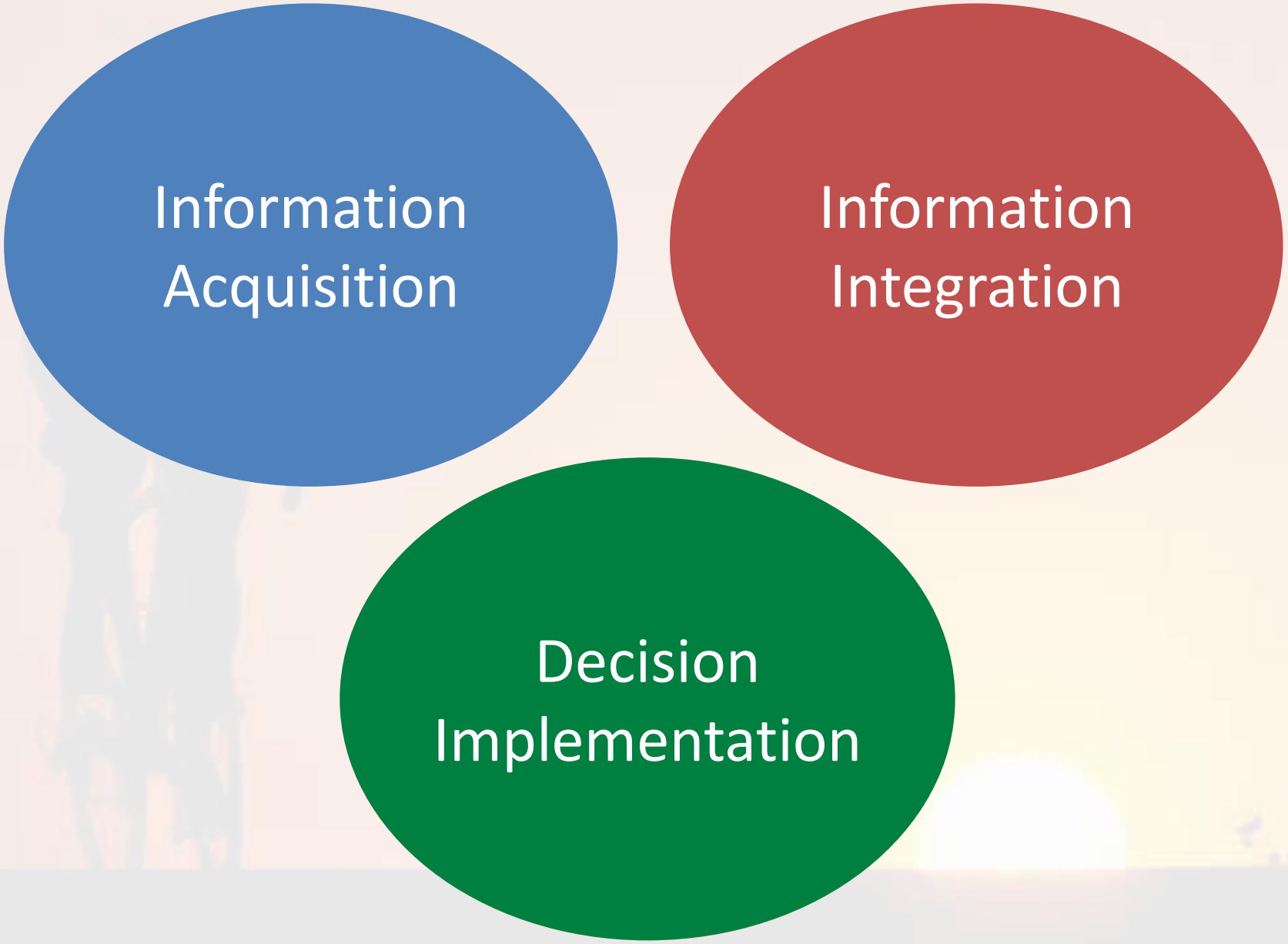
# **Fig 28.** Condition Difference in Pacing

Unpublished

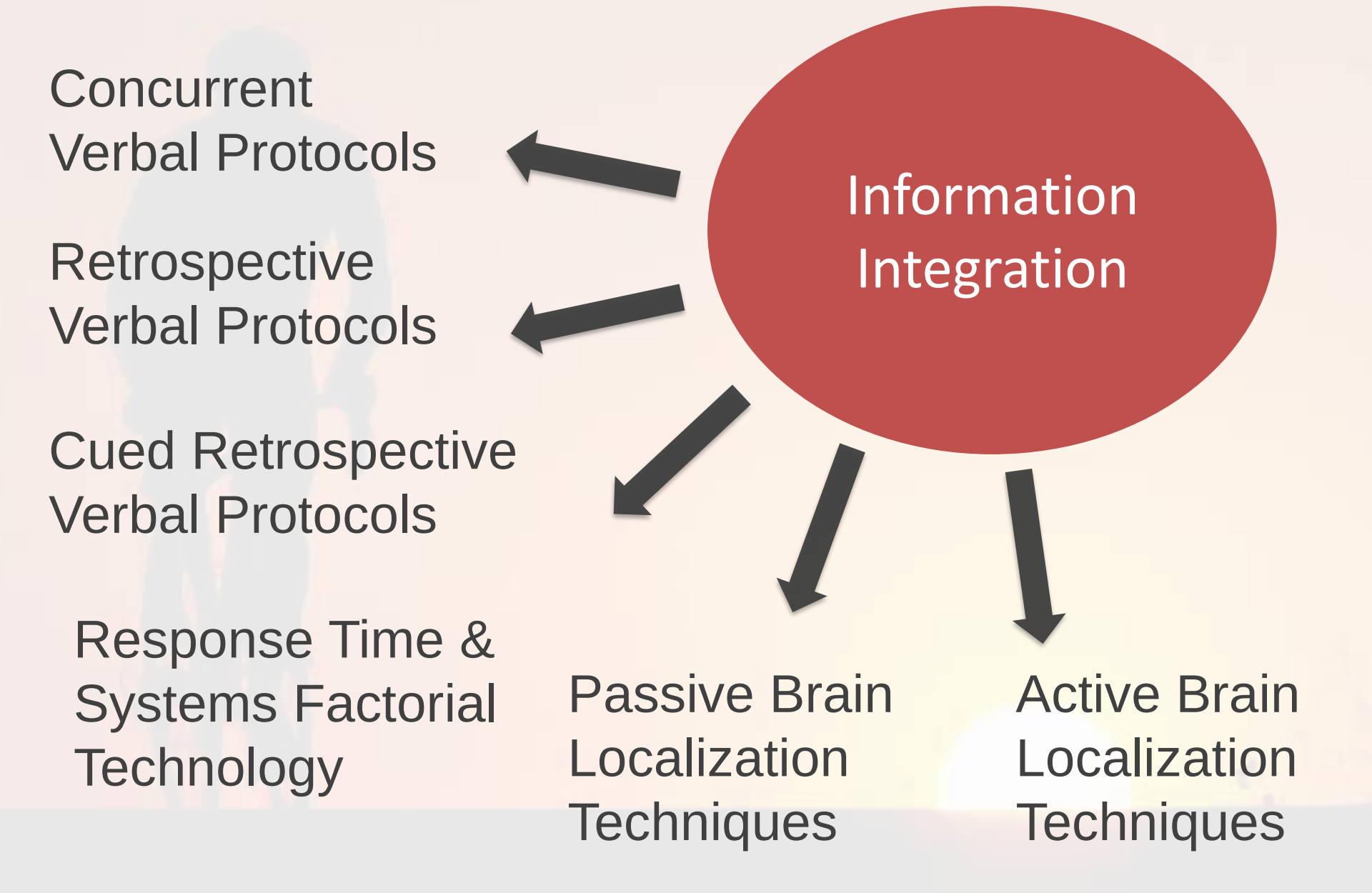


# Taking it in the field…


# **Fig 11.** Information Processing Approaches to Decisions



# **Fig 29.** Process Tracing Methods and Dual Processes



# Summary Points

Pacing models are helpful but mechanisms still light

Conscious-subconscious debate, although interesting, won't get us far

Dual process thinking models provide useful insights about how pacing decisions are made

Pacing trace reflects decision outcomes not processes

Hidden pre-decisional information acquisition and integtration processes demand special process tracing methods

Early information acquisition work with eye-trackers suggests information is used is a much more adaptive way that suggested by previous models

Future work must focus on understanding predecisional information processes, ideally in naturalistic settings

# The Conscious-Subconscious Pacing Quagmire! New Opportunities in Dual Process Theory and Process Tracing Methods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University of Essex