TMS METHODS

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TMS METHODS AND THINGS I WISH I KNEW BEFORE I STARTED DOING TMS RESEARCH

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TMS METHODS AND THINGS I WISH I REALLY LISTENED AND PAID DUE ATTENTION TO BEFORE I STARTED DOING TMS RESEARCH

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TMS METHODS (AND MORE)

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TMS RECAP

- Non-invasive, temporary, safe way to interfere with brain function.
- Direct experimental manipulation allows causal inference.
- Macroscopic / network level effects.
- Exact mechanism of effect unknown.

OVERVIEW

- METHODS
  - Key parameters
  - Online
  - Offline
  - 'Advanced'
- PRACTICAL CONSIDERATIONS
  - Safety & Screening
  - TMS artefact
  - Variability
  - An example study
  - Key decisions

DISCLAIMER

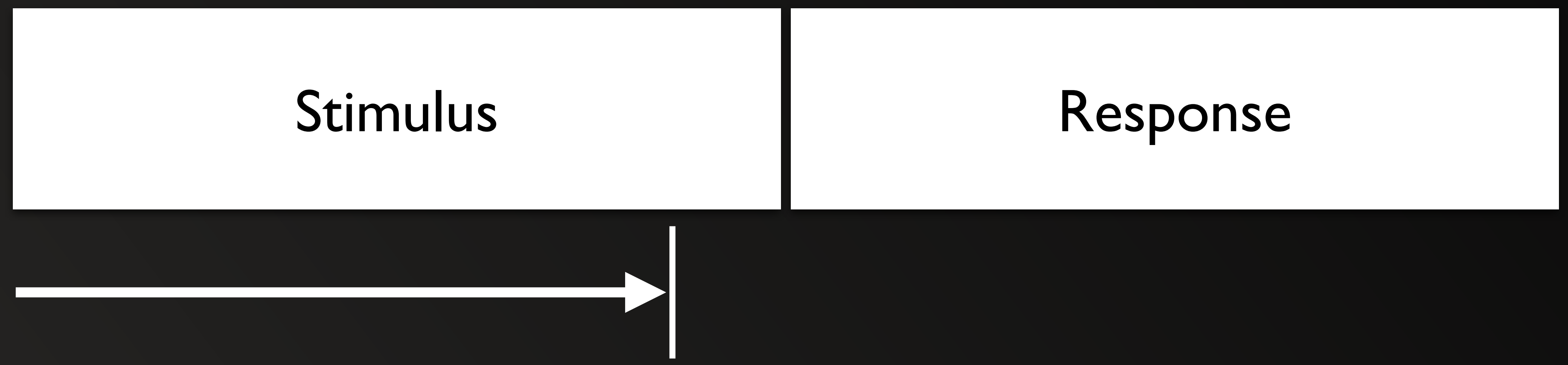
- Versatile technique with wide range of applications.
- Wide range of interests and expertise present.
- General introduction & ‘horoscopic’ recommendations.
- Examples are usually from ‘psychological’ context, i.e., we want to understand some behaviour/task process with TMS.
    - This is definitely not the only way TMS can be used!

KEY PARAMETERS

- Site and orientation of stimulation
- Intensity
- Number of pulses
- Frequency or pattern of pulses

ONLINE

- Single pulse, event-related TMS.
- Single pulse TMS can be delivered at specific time points.
- Varying this timepoint informs us *when* a brain area is involved.

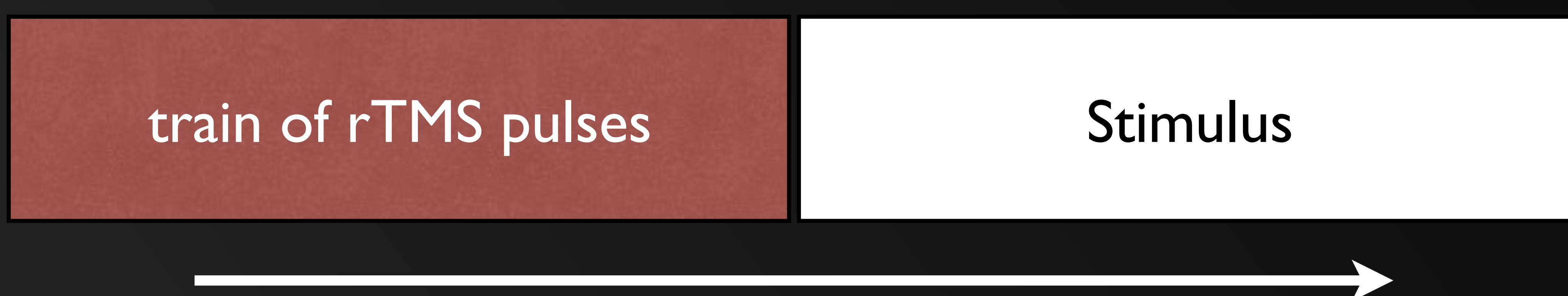


ONLINE

- Repetitive pulse, event-related TMS.
- Tells us if an area is required over a longer period.
- Helpful if precise neural timecourse is unknown.

OFFLINE

- Trains of rTMS pulses cause an aftereffect when behaviour can be tested.
- Repetitive TMS (rTMS)
  - low frequency
  - high frequency
  - theta burst (intermittent, continuous) Huang et al., 2005



- Low frequency TMS (<2 Hz) typically suppresses neural activity.
- High frequency TMS (>10 Hz) typically facilitates neural activity.
- Affects neural plasticity: LTD-like and LTP-like effects

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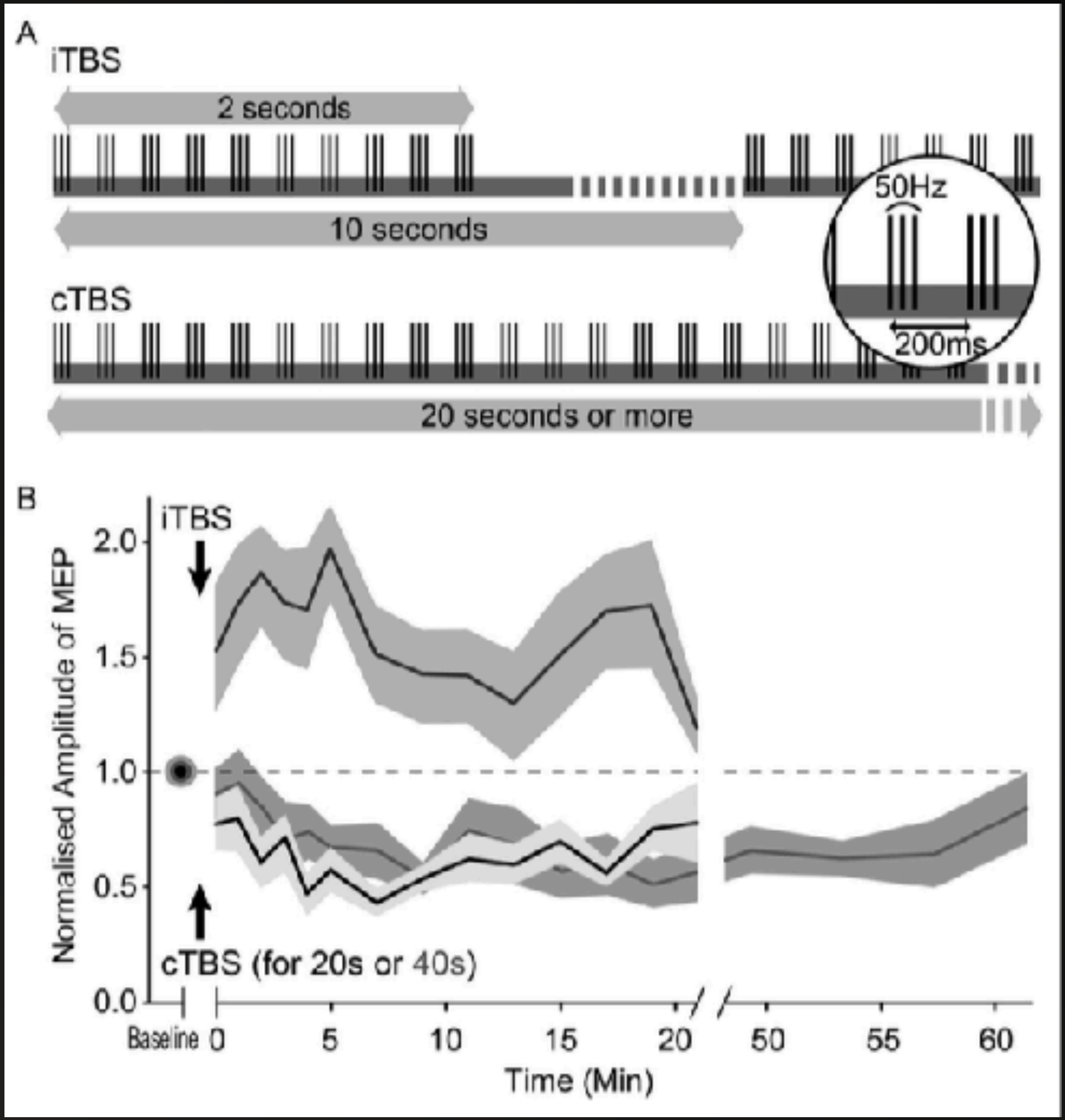
- CAVEAT: simplification - methods developed in M1.

- cTBS suppresses neural activity
- iTBS facilitates neural activity.



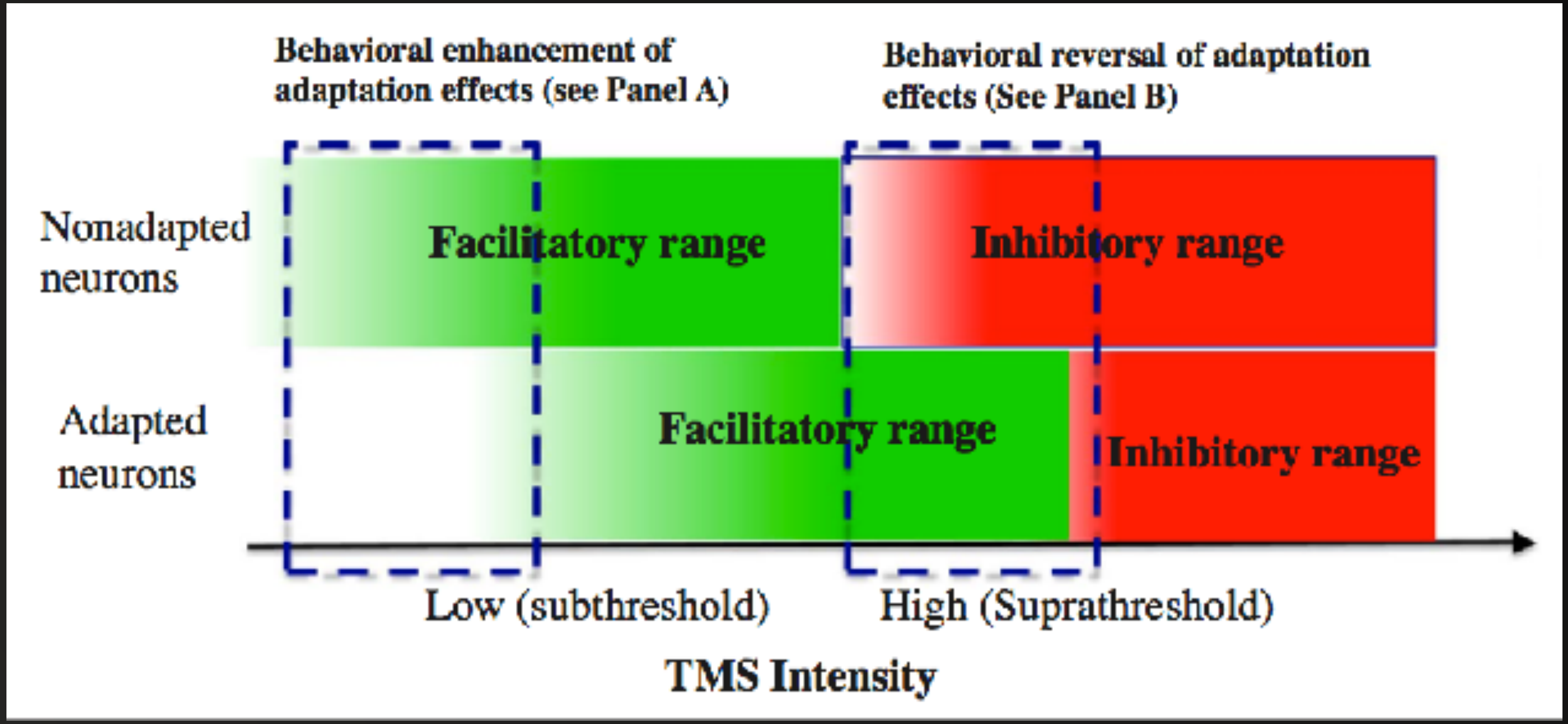
Suppa et al., 2016

'ADVANCED'

- State-dependent TMS
- Information-based and closed-loop approaches

STATE-DEPENDENT

- Underlying state of the cortex changes the effect of TMS.
- Can lead to 'paradoxical' facilitations of behaviour.
- This can be manipulated, i.e. through selective adaptation.



Silvanto & Cattaneo, 2017

INFORMATION-BASED

- Measured neural activity used to influence a stimulation parameter.
- Can be used to ‘close the loop’ e.g. EEG activity can influence stimulation timing or tACS frequency.
- Romei et al., 2016, Bergmann et al., 2016, Thut et al., 2017

PRACTICAL CONSIDERATIONS

- Safety and Screening
- TMS discharge artefact
- Variability
- An example study
- Key decisions

SAFETY AND SCREENING

- TMS is safe and well tolerated but some crucial considerations.
- Some populations can't have TMS.
- Minor adverse effects ~5% (Maizey, 2013)
- Seizure induction after screening ~0.0001%
- Rossi et al., 2009; Wassermann et al., 1998; Oberman et al., 2012

TMS DISCHARGE ARTEFACT

- Auditory and cutaneous artefact on each TMS pulse.
- A good control condition is essential for correct inference.
- Sham TMS is commonly used but ‘best’ sham varies.
    - Sham coil
    - Control site (commonly vertex)
- There is no perfect sham TMS!

VARIABILITY

- TMS can be highly variable intra- and inter-individually.
- Even with well-established effects in motor regions (Suppa, 2016).
- Aim to minimise this where possible, e.g. within subject design.
- Responders & non-responders (be aware).
- Consider what could contribute to this in your domain.

AN EXAMPLE STUDY

- 2 x behavioural sessions (psychophysical threshold estimation)
- fMRI localiser
- 6 x TMS session (3 sites and 2 experimental conditions)
  - sham, left hemisphere and right hemisphere

KEY DECISIONS

- What population(s) are you interested in?
- Where to stimulate?
  - Neuronavigation ([f]MRI, MNI or manual)?
- When to stimulate (online/offline)?
  - Which TMS pulse protocol?
- Outcome measure?

KEY DECISIONS (SIMPLIFIED)

- WHO to stimulate?
- WHERE to stimulate and HOW to ensure accuracy?
- WHEN to stimulate and HOW to do it?
- WHAT to measure and HOW?

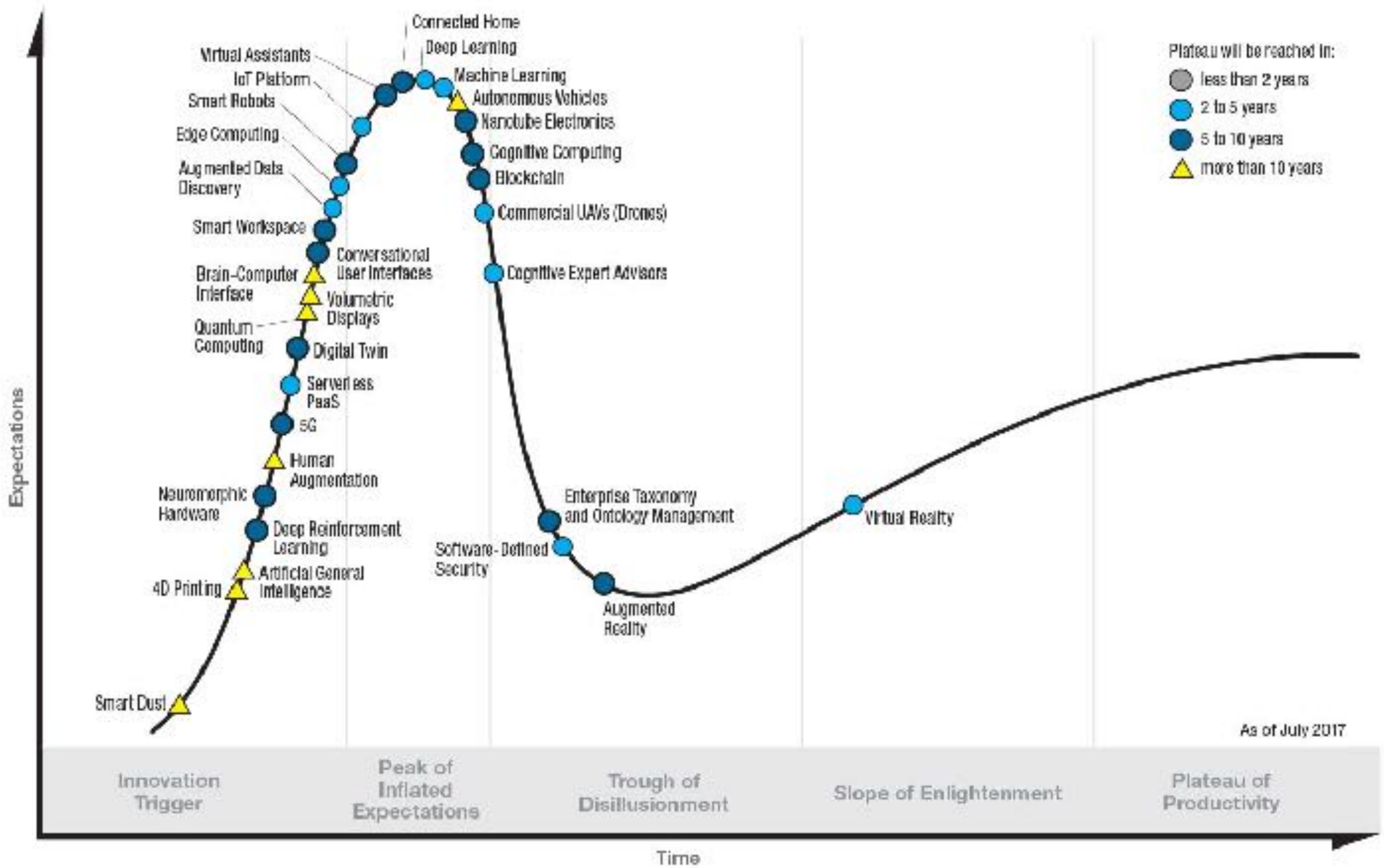
KEY DECISIONS (SIMPLIFIED)

- WHO to stimulate?
- WHERE to stimulate and HOW to ensure accuracy?
- WHEN to stimulate and HOW to do it?
- WHAT to measure and HOW?
- WHY?

WHY TMS?

- Unique insights into brain-behaviour link - new source of evidence.
- Relatively novel technique (modern TMS: 1985).
- Relatively simple data analysis.
- Low study conversion costs (behavioural).
- Established SOPs, training and ethics applications.
- Low actual costs

Gartner Hype Cycle for Emerging Technologies, 2017



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