



Impulsivity

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Syllabus

- ▶ What is impulsivity?
- ▶ Impulsivity in clinical context, motivation
- ▶ Subtypes of impulsive behaviour
- ▶ Impulsivity as a personal dimension
- ▶ Behavioural models of impulsivity
- ▶ Behavioural tasks
- ▶ Neurobiology of impulsivity
- ▶ Treatment

What is impulsivity?

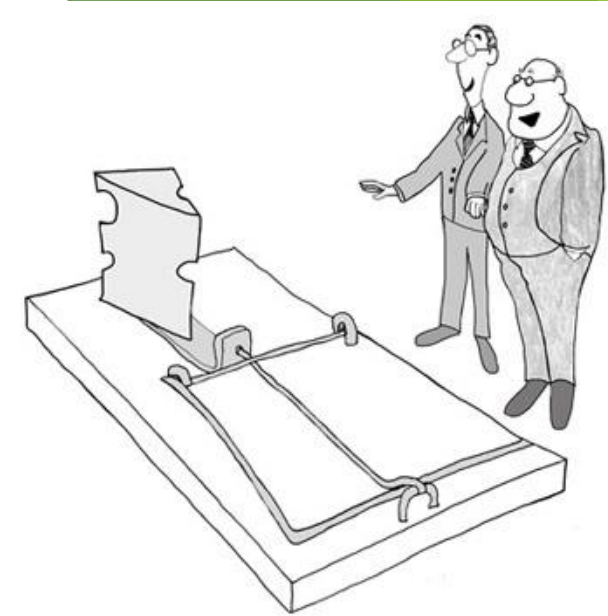
The background of the slide is white with abstract green geometric shapes on the right side. These shapes include overlapping triangles and polygons in various shades of green, from light lime to dark forest green. A thin, light gray line runs diagonally across the white space, intersecting the green shapes.

What is impulsivity?

- ▶ Heterogenous concept - consists of several dimensions?
- ▶ A tendency to act without thinking
- ▶ Acting without evaluation of consequences
- ▶ Inability to suppress irrelevant or unfavourable behaviour
- ▶ Impulsivity manifests in personality traits, cognitive and emotional processes or behaviour control
- ▶ Personality traits: high sensation seeking, lack of perseverance, positive and negative urgency, high reward sensitivity

Impulsivity in clinical context

- ▶ Disruptive forms of behaviour
- ▶ Aggressive behaviour, self-destructive behaviour, binge eating, suicide, drug abuse, alcoholism, gambling, risk sexual behaviour, property destruction
- ▶ High negative impact on life
- ▶ ADHD, borderline personality disorder, mania, substance use disorders, kleptomania, Parkinson disease, bulimia
- ▶ Inhibitory control deficit present in the close relatives of patients - ? Inheritable



"This is tempting, but it may come back to bite us."



Motivation for research

- Impulsivity is present in many neuropsychiatric disorders,
 - Significant negative influence on patient's life,
 - No effective treatment,
 - Inconsistent terminology.
-
- After subjective distress, impulsivity is the most common diagnostic criteria in the DSM-IV.
-
- Prevention, prediction (addiction) - identification of the risk factors,
 - Treatment,
 - Improving the quality of life,
 - Better diagnostics,
 - Better description, improving of terminology,..



- ▶ Impulsivity as a personality dimension
- ▶ Impulsivity as a consequence of some neurobiological impairment



Impulsivity as a personality dimension

- ▶ Buss and Plomin (1975): temperament dimension (impulsivity, emotionality, activity, sociability)
 - inhibitory control, decision time, persistence, sensation seeking
- ▶ Eysenck - venturesomeness (aware risky behaviour)
- ▶ Cloninger (1991) - impulsivity as an aspect of novelty seeking (terms related to thrill seeking and acting on feelings of the moment without regard for rules and regulations.)
- ▶ Zuckerman (1991) - impulsive sensation seeking (a lack of planning and the tendency to act impulsively, experience seeking, or willingness to take risks for the sake of excitement or novel experiences)

Impulsivity as a personality dimension

- ▶ Measured by self-assessment questionnaires
- ▶ **Barrat scale** (Patton, Stanford and Barrat, 1995) -
3 factors - attentional impulsiveness, motor impulsiveness, non-planning impulsiveness
- ▶ **UPPS-P** (Whiteside and Lynam, 2001, Cyders and Smith, 2007) -
negative and positive urgency, lack of premeditation, lack of perseverance, sensation seeking
 - based on previous questionnaires and concepts
 - Includes aspect of **emotional impulsivity**



Behavioural impulsivity models

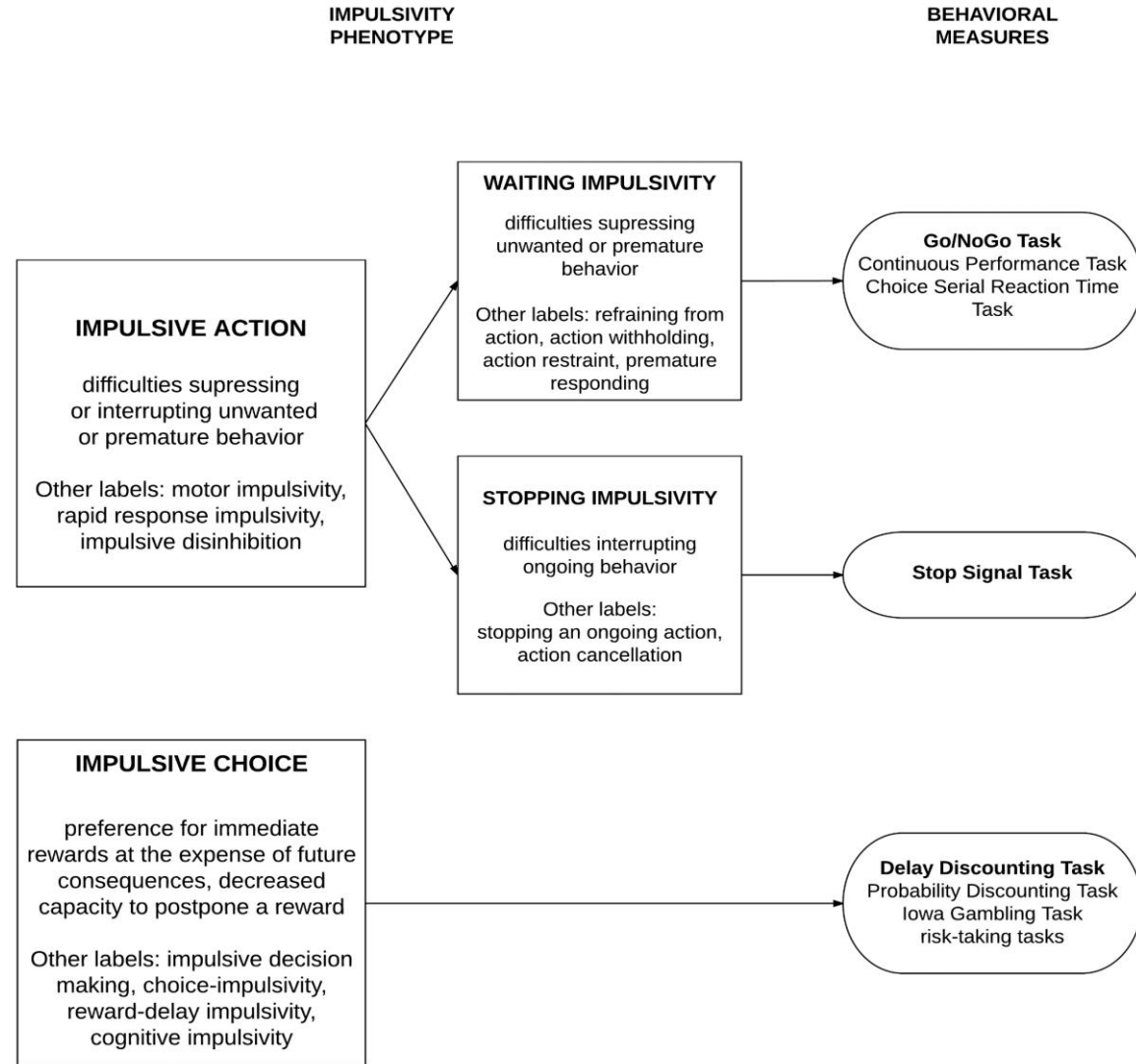
- ▶ Impulsivity as a consequence of abnormal functions of neural system
- ▶ Measured by behavioural tasks

- ▶ **Motor impulsivity**
 - waiting impulsivity
 - stopping impulsivity

- ▶ **Impulsive decision making**

- ▶ Nigg's taxonomy (2000)
- ▶ Behavioural inhibition: **prepotent response inhibition, interference control** (distractibility)

Behavioural impulsivity models



Motor impulsivity

- ▶ Ability to inhibit preplanned, dominant or unwanted action (waiting impulsivity).
- ▶ Ability to stop ongoing action (Stopping impulsivity)

- ▶ Measured by choice reaction time tasks
- ▶ Tasks: Go/No-Go task, Stop signal task, Continuous performance task

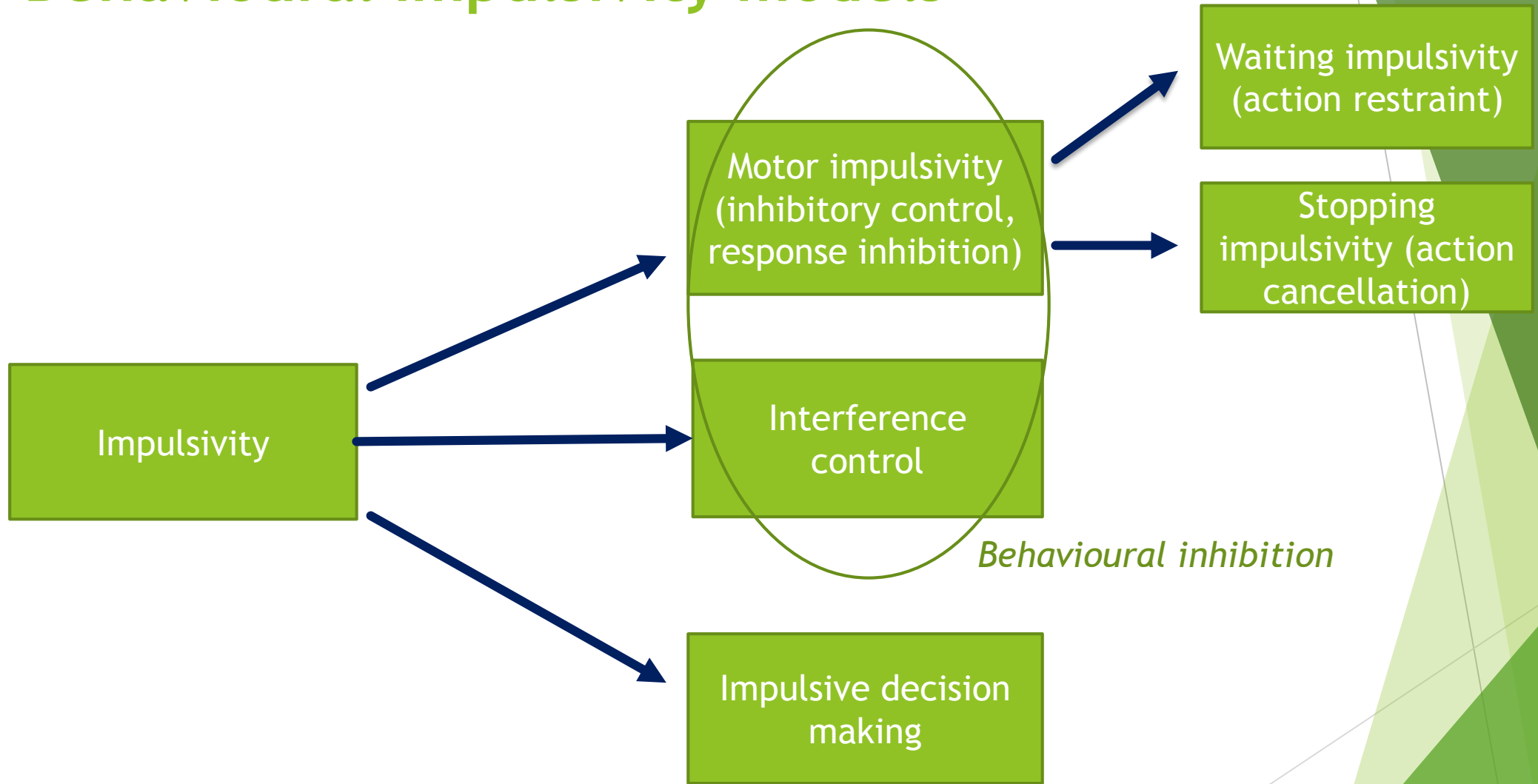
Impulsive decision making

- ▶ ...preference for smaller, more immediate rewards over larger, more delayed rewards
- ▶ The value of delayed reward is discounted in inverse proportion to its delay.
- ▶ Tasks: delay discounting, probability discounting, Iowa gambling task

Interference control

- ▶ ...ability to ignore irrelevant information while processing the target stimulus.
- ▶ In the interference control tasks, a person has to react quickly to the stimulus ignoring distractors presented at the same time.
- ▶ Tasks: Stroop Color-Word test, Flanker task, Simon test, the Opposite World task,...

Behavioural impulsivity models



Impulsivity tasks

Go/No-Go task

- ▶ Measures the ability to inhibit preplanned, dominant or unwanted action.

Go stimulus - target → react

No-Go stimulus - inhibition → don't react

Go: No-Go ratio 50:50 or less No-Go stimuli

- ▶ Variables - reaction time, accuracy - commission errors, omission errors

Slow reaction time + more commission errors - impulsivity

vs. Fast RT + more omission errors - attention problems

Continuous performance task

- ▶ The GNG task with a predominance of No-Go stimuli - sustained attention

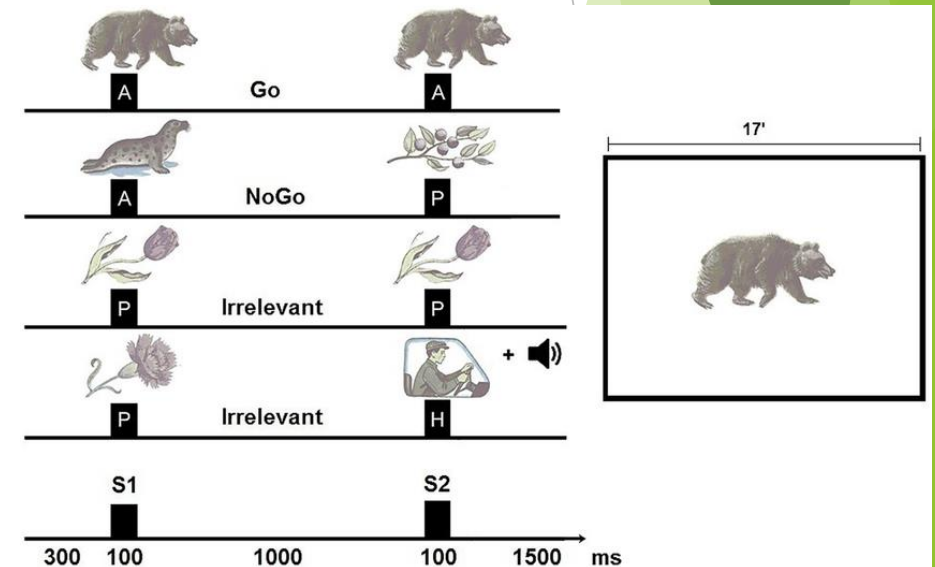
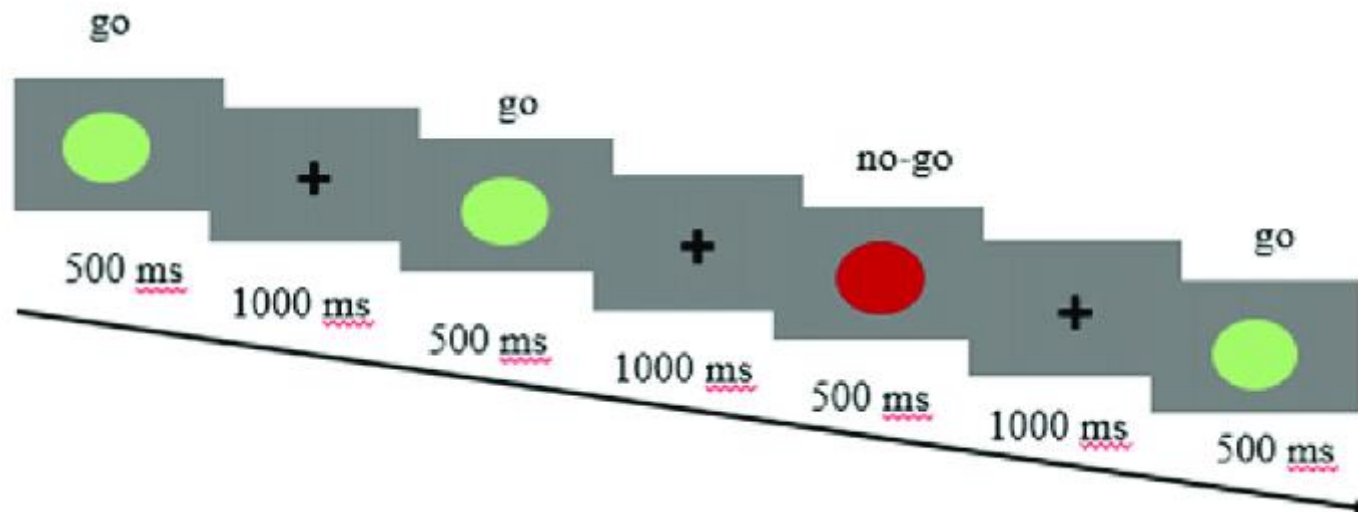
Impulsivity tasks - Go/No-Go task

- ▶ Simple GNG tasks
- ▶ Complex GNG tasks (more types of No-Go stimuli, variable No-Go stimuli,..)
- ▶ Modifications: Stimuli - letters, pictures, symbols,..
Emotional GNG tasks



Impulsivity tasks - Go/No-Go task

- Behavioural version low frequency of No-Go stimuli - high inhibitory load
- fMRI - low cognitive load, low working memory demands
 - equal Go:No-Go ratio is better. Unequal Go:No-Go ratio makes interpretation difficult



Impulsivity tasks

Stop signal task

- ▶ Ability to stop an ongoing action

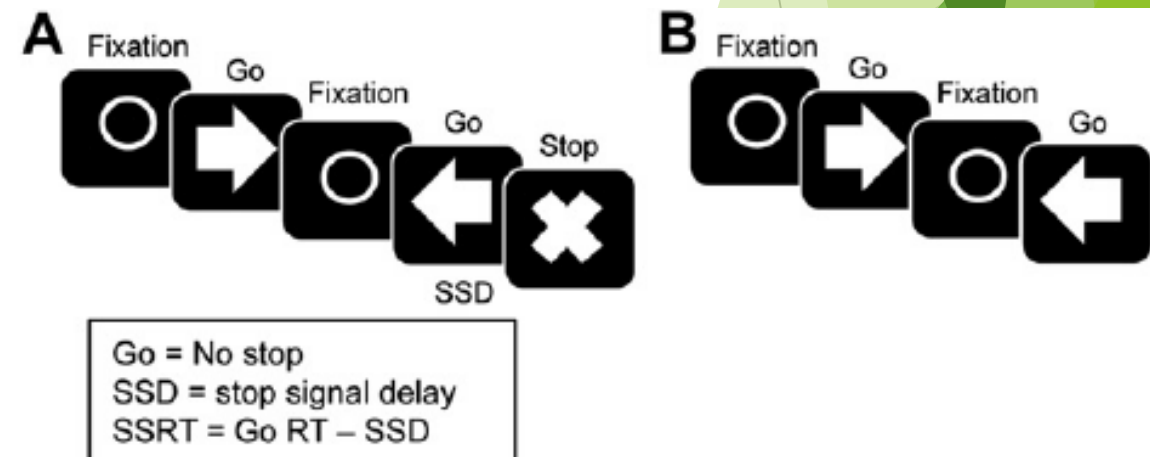
Go-stimulus

No-Go signal (visual or acoustic) - after this signal Go stimulus turns to No-Go, subject has to cancel his reaction

- ▶ Variables - SST reaction time - time needed to stop reaction

Longer SSRT = inhibitory problems

- accuracy, reaction time



Impulsivity tasks - Stop signal task

- ▶ Stop signal delay = delay between the onset of Go stimulus and the stop signal
 - Fixed or variable delay
 - Variable delay → high inhibitory load
- ▶ Stop signal reaction time can not be measured directly
- ▶ Estimated from reaction time and stop signal delay and probability of making error after the stop signal

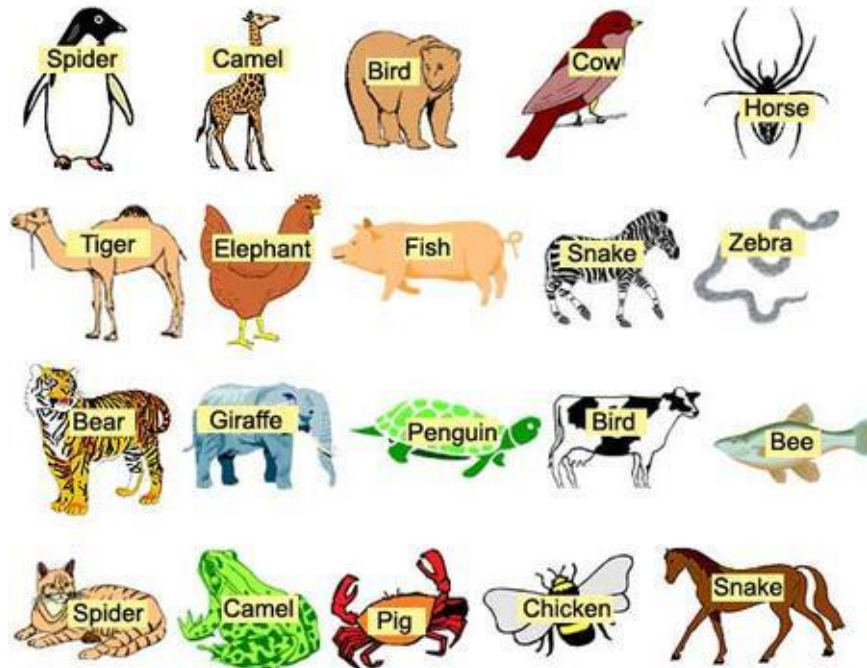
Impulsivity tasks

Stroop Color-Word test

- ▶ Variables - Interference score, number of items made in time, number of errors, time needed to complete condition
- ▶ Variants - picture, wrapped words, emotional

Stroop Effect

YELLOW BLUE ORANGE
 BLACK RED GREEN
 PURPLE YELLOW RED
 ORANGE GREEN BLUE
 BLUE RED PURPLE
 YELLOW RED GREEN

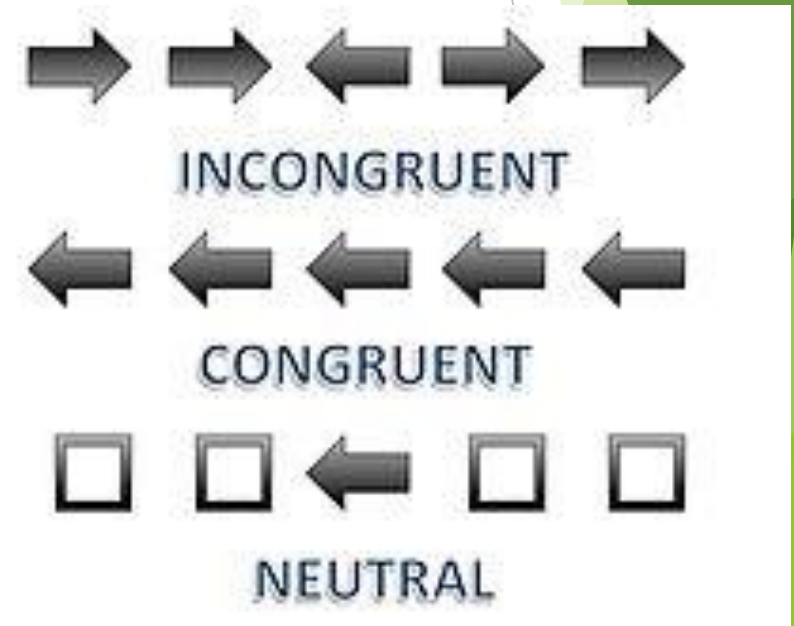


紅	黑	綠	藍
黃	橙	黑	棕
紫	黃	藍	黃
綠	棕	紅	紫

Impulsivity tasks

Flanker task

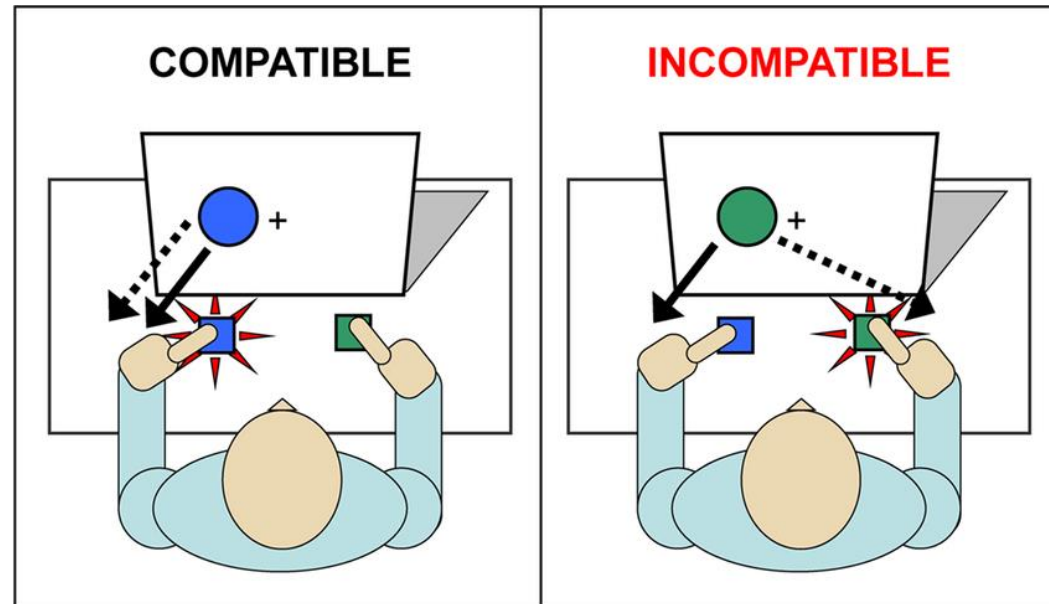
- ▶ Target stimulus - arrow pointing to the left or right
- ▶ Incongruent stimuli
- ▶ Congruent stimuli
- ▶ Neutral stimuli
- ▶ Variables - number of errors, reaction time



Impulsivity tasks

Simon task

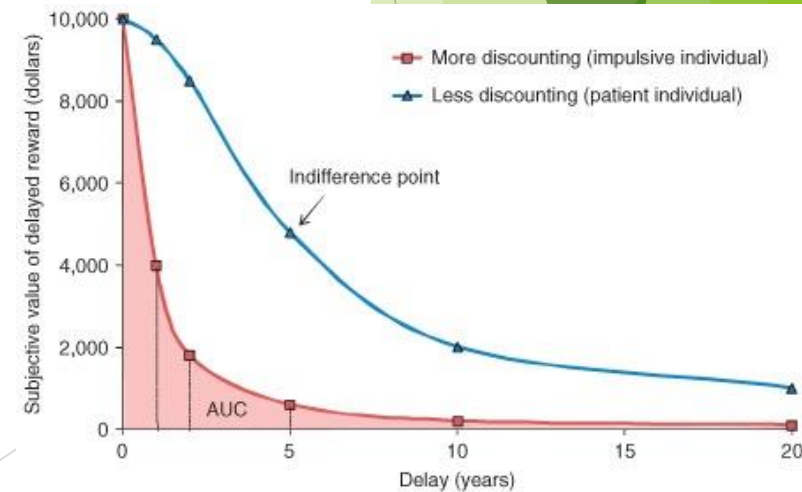
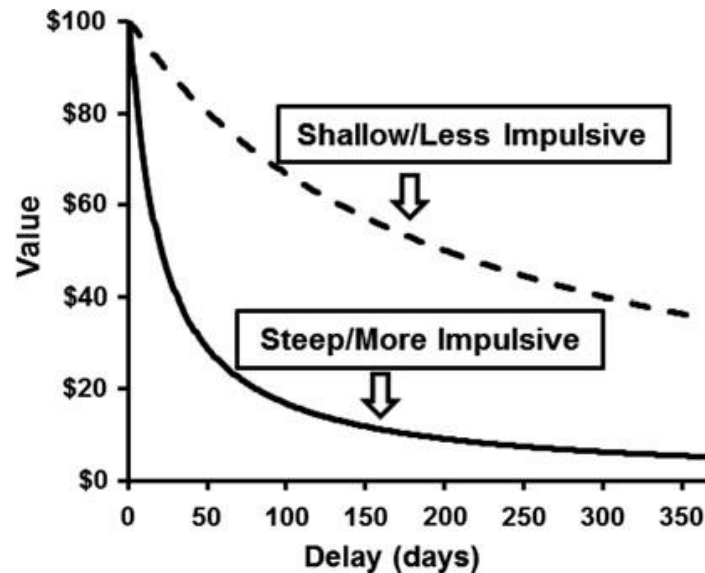
- ▶ Central fixation point
- ▶ Target stimulus in some position from the central fixation point
- ▶ React according to the type of stimulus, ignore the position of the stimulus



Impulsivity tasks

Delay discounting

- ▶ Choice - two options - smaller immediate reward or bigger but delayed reward
- ▶ How fast declines the worth of money in time?
- ▶ As the delay of a reward increases, the subjective value of this delayed reward decreases.



Impulsivity tasks - Delay discounting

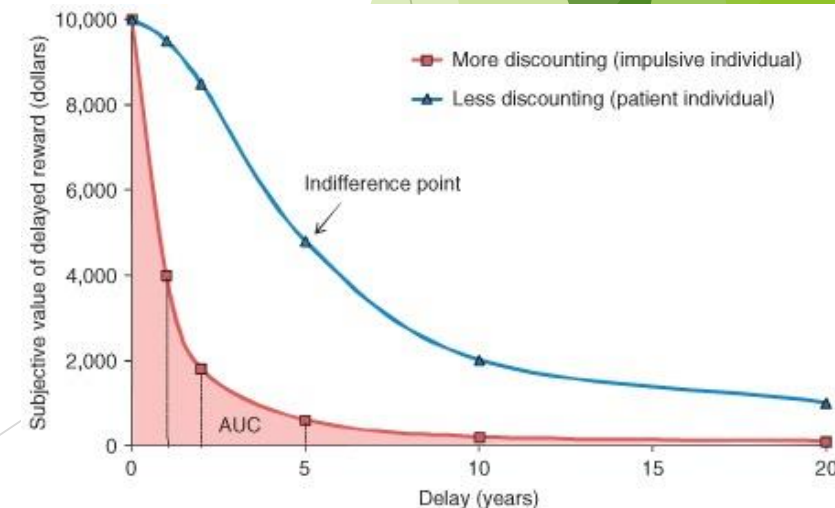
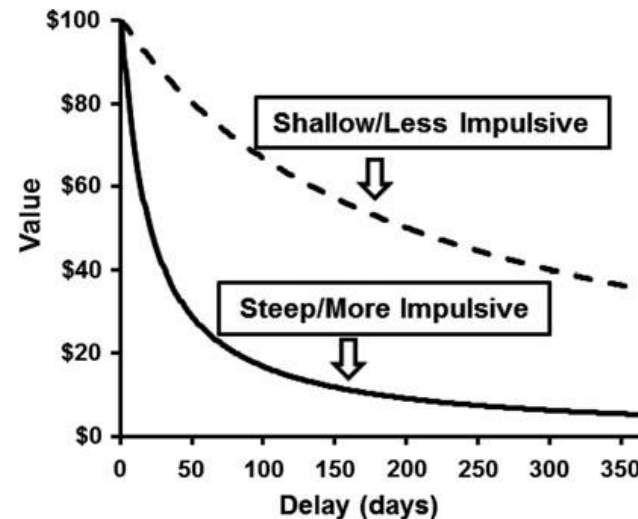
indifference points - subjective value for immediate and delayed reward is the same.

$$\text{value} = A / (1 + k * D)$$

- ▶ A is the amount of the reward, D is the delay to reward, and k is a free parameter (discounting parameter).
- ▶ Larger values of k indicate steeper decline of subjective value (=steeper curve in graph) → greater impulsivity.

- ▶ Variables - k ,
 AUC (area under curve).

- ▶ Impulsive = big k , small AUC



Impulsivity tasks - Delay discounting

- ▶ Variants: different time delays (days →decades), commodity (money, drugs, alcohol,..), immediate rewards decline (regular, random).
- ▶ Value of money is more stable than other commodities
- ▶ Good marker for addiction risk

Impulsivity tasks

Probability discounting task

Immediate reward \times bigger probabilistic reward

As the probability of receiving a specific gain decreases, the subjective value of that gain decreases.

The value of a probabilistic reward decreases as its probability decreases, so it becomes less likely that the probabilistic gain will be chosen from among alternatives

Indifference points $\rightarrow k$

A **lower** degree of probability discounting (higher subjective values) is associated with risk-seeking choices. When the degree of discounting is steeper than the expected value, data points fall below the EV line. A higher degree of probability discounting (lower subjective values) \rightarrow risk-averse choices.

Probabilistic losses: Someone who is risk-seeking is more likely to choose the possibility of losing nothing, while taking the risk of possibly losing the entire larger amount, rather than incur a smaller, certain loss.

Impulsivity tasks

Iowa gambling task

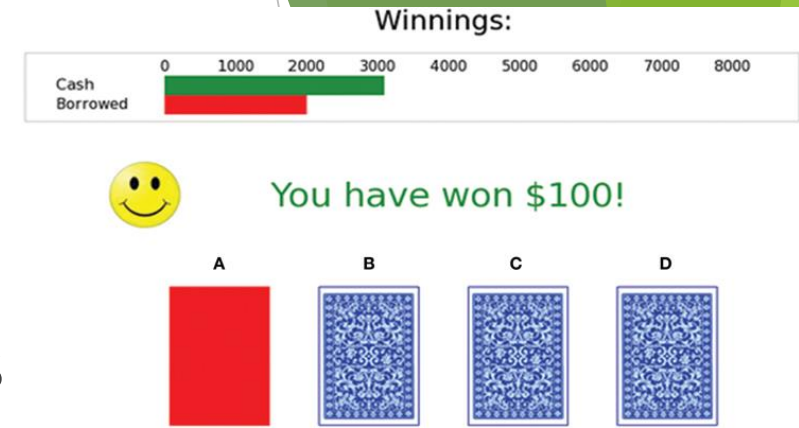
- ▶ 4 decks of cards containing winning and losing cards
- ▶ Good decks and bad decks
- ▶ IGT involves probabilistic learning via monetary rewards and punishments, where advantageous task performance requires subjects to forego potential large immediate rewards for small longer-term rewards to avoid larger losses.

A - bad deck, high immediate rewards, frequent losses

B - bad deck, high immediate rewards, infrequent but very high losses

C - good deck, small immediate rewards, frequent but low losses

D - good deck, small immediate rewards, infrequent losses



Impulsivity tasks - Iowa gambling task

- ▶ Impulsive people prefer large immediate rewards with risk of large losses in the future
- ▶ or prefer low probable but large losses over certain but small losses.
- ▶ Brain activity - ventromedial prefrontal cortex, orbitofrontal cortex dysfunctions

Neural substrates of impulsivity

Neurotransmitter systems

- ▶ Dopaminergic, serotonergic and noradrenergic systems
- ▶ Specific reactions during tasks - for example gamblers
dopamine IGT

Treatment

Bari and Robbins (2013):

- ▶ Prefrontal noradrenergic neurotransmission - important for stopping impulsivity
- ▶ Dopamine - motor readiness for inhibition and activation in striatum
- ▶ Norepinephrine and dopamine - error monitoring
- ▶ 5HT - more affective forms of inhibition and waiting inhibition



Treatment

- ▶ SSRI (Lieb et al., 2010)
- ▶ Mood stabilizers (Huband et al., 2010)
- ▶ Olanzapine (Lieb et al., 2010), quetiapine 5HT_{2A} receptor (Van de Eynde et al., 2008), aripiprazole and lamotrigine (Lieb et al., 2010).
- ▶ ADHD - stimulants (Moeller et al., 2010)
- ▶ Mechanism is not well understood yet.
- ▶ **Different drugs improve performance in different impulsivity tasks.**
- ▶ **Different groups of patients/patients have problems in different tasks.**



Brain structures involved in inhibition

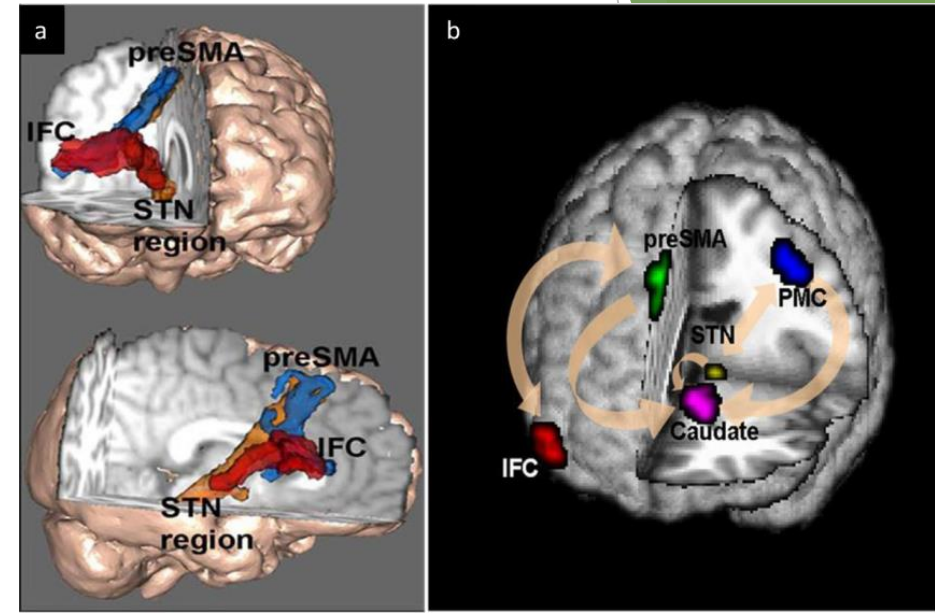
- ▶ ACC, insula, preSMA, SMA, pre-motor cortex, parietal cortex, inferior frontal gyrus, subcortical structures
- ▶ Most important - prefrontal and pre-motor areas

Brain structures involved in inhibition

- ▶ Inferior frontal gyrus (IFG) - most important for response inhibition
- ▶ Pre-motor region - controls motor excitability
- ▶ SMA - stopping response, more active in people with fast SSRT
 - response initiation, selection
- ▶ Parietal cortex - visuospatial attention?
- ▶ DLPFC - working memory, task rules maintaining, executive control in motivational and emotional behaviours
- ▶ ACC - response selection, conflict monitoring, error detection, working memory

Brain structures involved in inhibition

- ▶ Subcortical structures: Thalamus, Basal ganglia
- ▶ **Fronto-striatal network - indirect pathway**
 - Proactive inhibition, selective inhibition
- ▶ **Hyperdirect pathway**
 - Cortical regions (stop command) → basal ganglia
 - pre-SMA and inferior frontal gyrus- subthalamic nucleus (STN)- Globus pallidus
 - Fast inhibition of ongoing actions



a) Aron et al. 2007, b) Poldrack et al. 2011

Selective x non-selective inhibition in fMRI

Control condition - after green cross
- only Go stimulus follows



No inhibition

Go/No-Go condition - after red cross
can appear both Go and No-Go stimulus

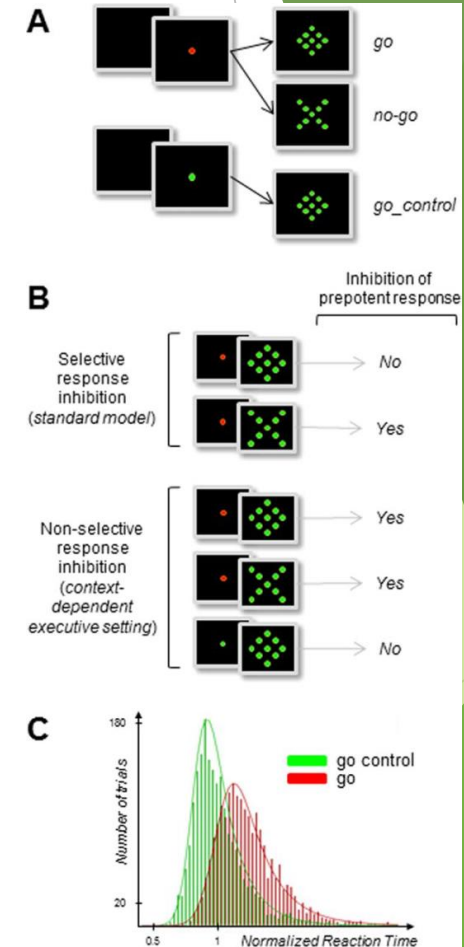


Inhibition after
both stimuli

Is inhibitory activity present in GNG task selective (present only when No-Go stimulus appears)?

Vs.

Is inhibition context-dependent and present during the whole GNG condition (after red cross)?



Albares et al. 2014

Thank you for your attention



Literature

- ▶ Bari A, Robbins T. 2013. Inhibition and impulsivity: behavioral and neural basis of response control. *Prog Neurobiol.* 108:44-79.
- ▶ Brevers, D., Bechara, A., Cleeremans, A., & Noël, X. 2013. Iowa Gambling Task (IGT): twenty years after-gambling disorder and IGT. *Frontiers in psychology.* 4, 665.
- ▶ MacKillop, J., Amlung, M. T., Few, L. R., Ray, L. A., Sweet, L. H., & Munafò, M. R. 2011. Delayed reward discounting and addictive behavior: a meta-analysis. *Psychopharmacology.* 216(3): 305-321.
- ▶ Nieuwenhuis S, Yeung N, Van Den Wildenberg W, et al. 2003. Electrophysiological correlates of anterior cingulate function in a go/no-go task: effects of response conflict and trial type frequency. *Cogn Affect Behav Neurosci.* 3(1): 17-26.
- ▶ Stahl C, Voss A, Schmitz F, et al. 2014. Behavioral components of impulsivity. *J Exp Psychol Gen.* 143(2): 850.