

UNIVERSITÄT
DUISBURG
ESSEN

Open-Minded

***Psychological and neurobiological
mechanisms of behavioral addictions***

Matthias Brand



General
Psychology:
Cognition



CeBAR
Center for Behavioral
Addiction Research



ERWIN L. HAHN
INSTITUTE
FOR
MAGNETIC
RESONANCE
IMAGING

Conflict of Interest Disclosure Declaration

I declare that I have no conflict of interests in the context of this presentation.

I receive funding (to University of Duisburg-Essen)
for my research from the German Research Foundation
(*Deutsche Forschungsgemeinschaft, DFG*)

and I am the spokesperson of the
DFG-Research Unit FOR 2974 ACSID (Pr.-Nr.: 411232260).

1

Introduction



ICD-11



Further potential behavioral addictions:



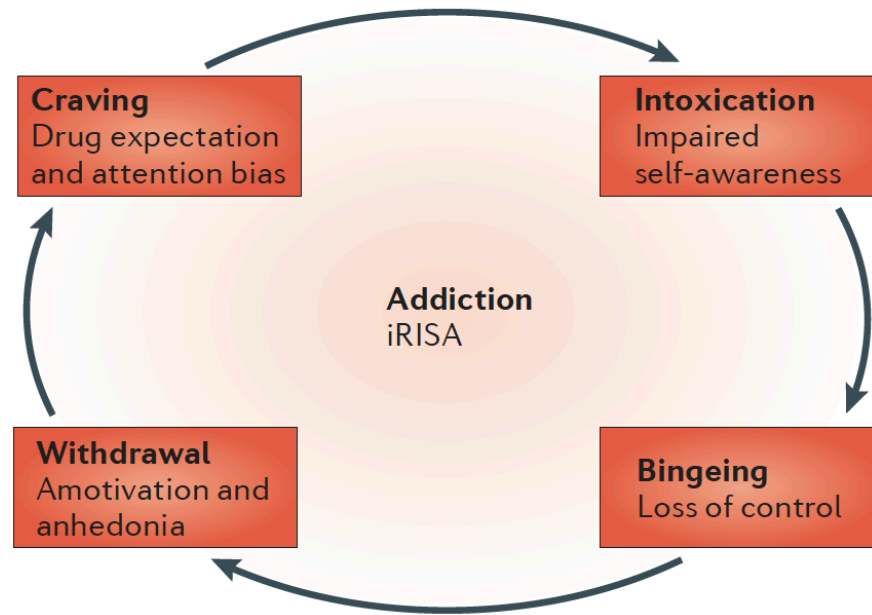
Estimated prevalence rates: 1-5%



Theory and evidence

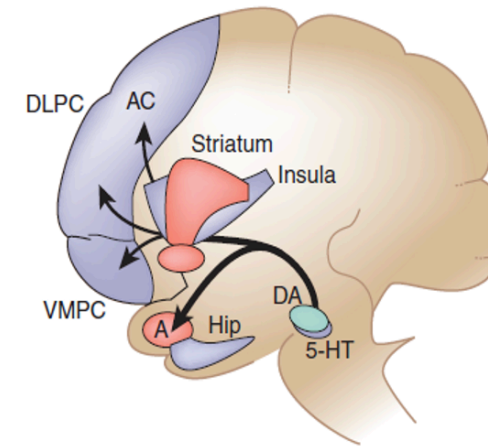
iRISA model

by Rita Z. Goldstein & Nora D. Volkow (2011)



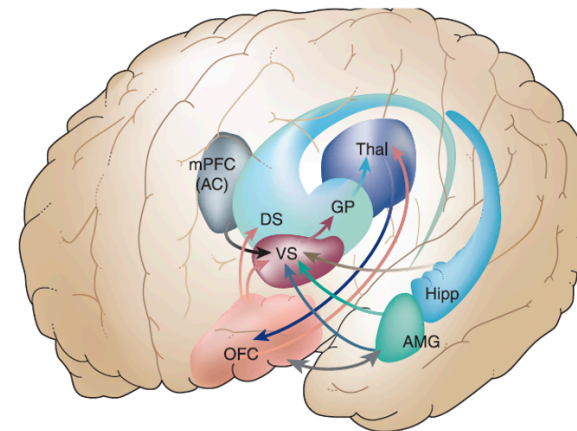
Loss of willpower to resist drugs

by Antoine Bechara (2005)



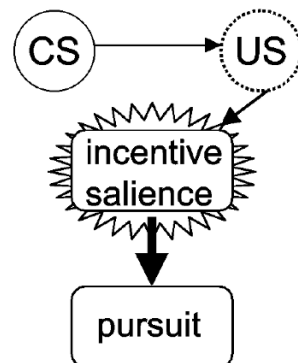
From actions to habits to compulsions

by Barry J. Everitt & Trevor W. Robbins (2005, 2016)



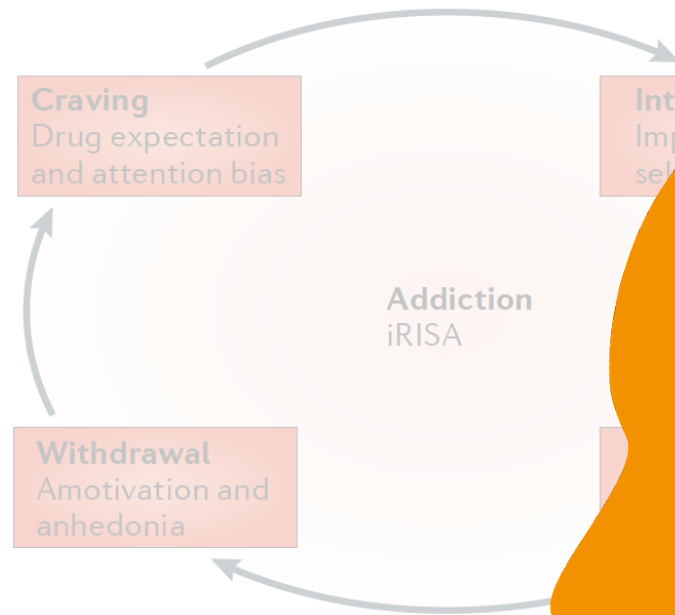
Incentive-sensitization theory

by Terry E. Robinson & Kent C. Berridge (2003)



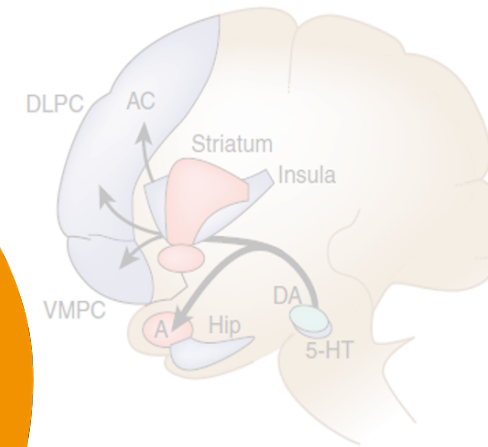
iRISA model

by Rita Z. Goldstein & Nora D. Volkow (2011)



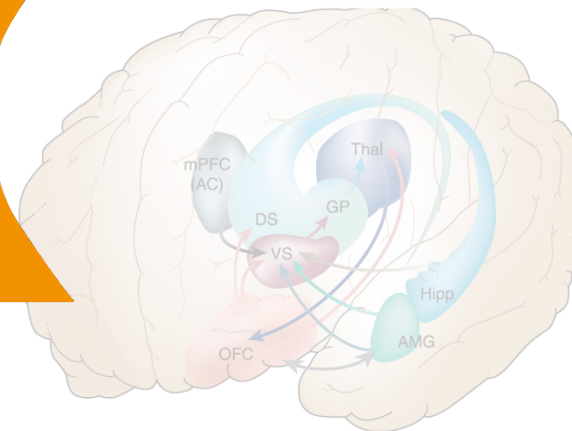
Loss of willpower to resist drugs

by Antoine Bechara (2005)



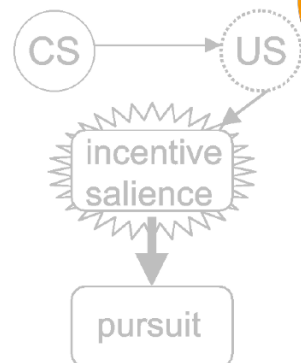
From actions to habits to compulsions

by B. J. Everitt & Trevor W. Robbins (2005, 2016)



Incentive-sensitization theory

by Terry E. Robinson & Kent E. Bickel (1986)



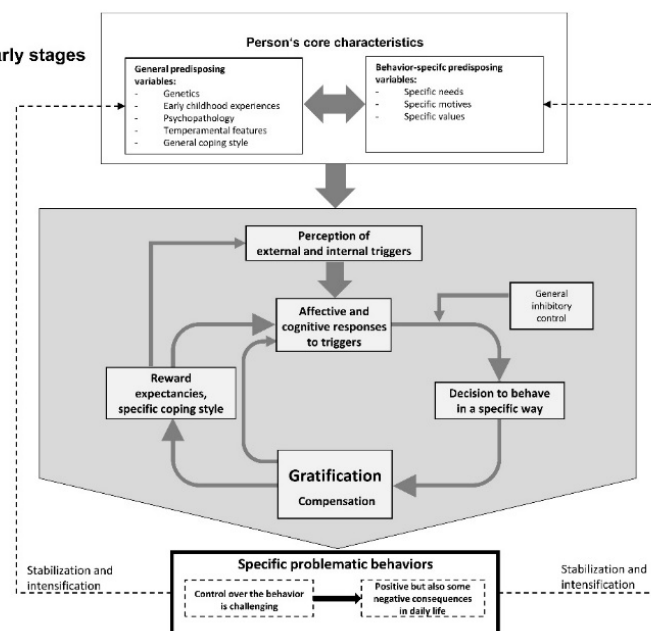
Review article

The Interaction of Person-Affect-Cognition-Execution (I-PACE) model for addictive behaviors: Update, generalization to addictive behaviors beyond internet-use disorders, and specification of the process character of addictive behaviors

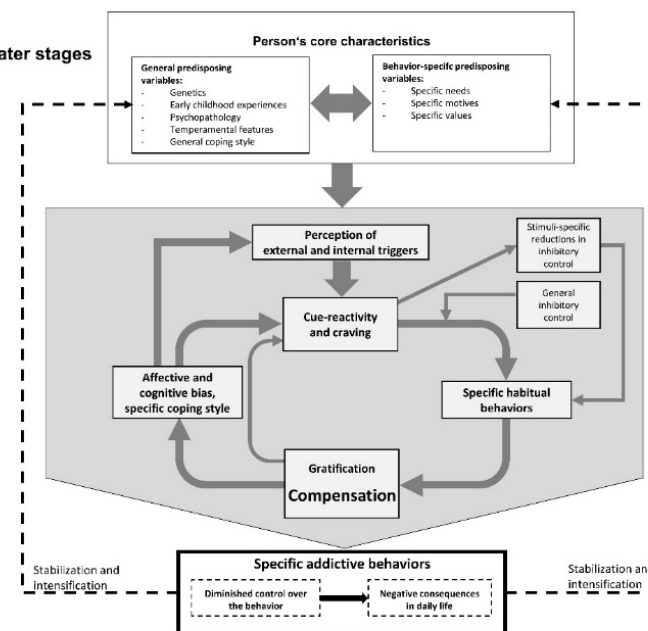


Matthias Brand^{a,b,*}, Elisa Wegmann^a, Rudolf Stark^{c,d}, Astrid Müller^e, Klaus Wölfling^f, Trevor W. Robbins^g, Marc N. Potenza^{h,i,j}

A: Early stages



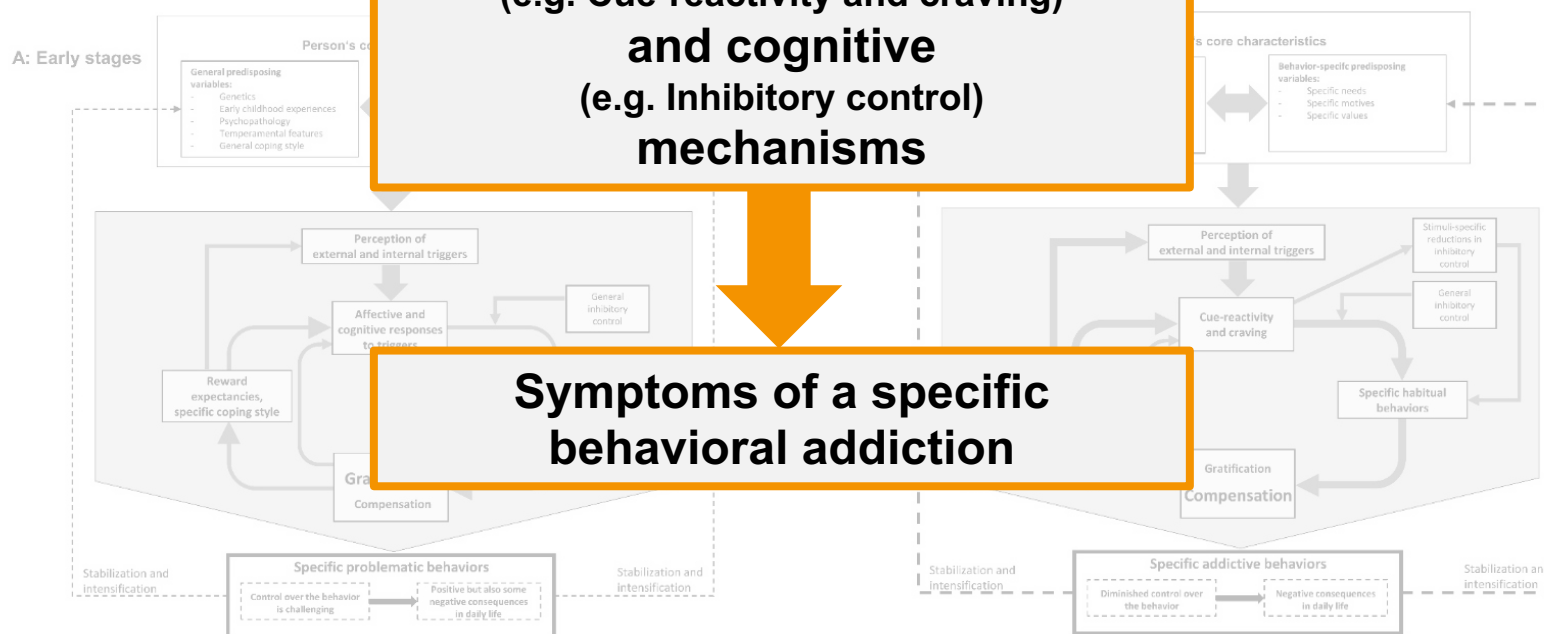
B: Later stages



Review article

The Interaction of Vulnerability Factors and Addictive Behaviors: A Model for the Development of Addictive Behaviors beyond internet-use disorders, and specification of the process character of addictive behaviors


Matthias Brand^{a,b,*}, Elisa Wegmann^a, Rudolf Stark^c, Astrid Müller^e, Klaus Wölfling^f, Trevor W. Robbins^g



Risk and protective factors of Internet gaming disorder among Chinese people: A meta-analysis

Yinan Ji , Margaret Xi Can Yin, Anna Yan Zhang, more...

[Show all authors](#) ▾

First Published July 10, 2021 | Review Article | [Find in PubMed](#) |  Check for updates
<https://doi.org/10.1177/00048674211025703>

High effect sizes:

Psychopathological characteristics
Personality traits
Emotion regulation style

Protective factor:

Self-control

[Meta-Analysis](#) > [Neuropsychol Rev.](#) 2019 Mar;29(1):14-26. doi: 10.1007/s11065-019-09402-x.

Epub 2019 Mar 30.

A Systematic Meta-Review of Impulsivity and Compulsivity in Addictive Behaviors

Rico S C Lee ^{1 2}, Sylco Hoppenbrouwers ^{3 4}, Ingmar Franken ³

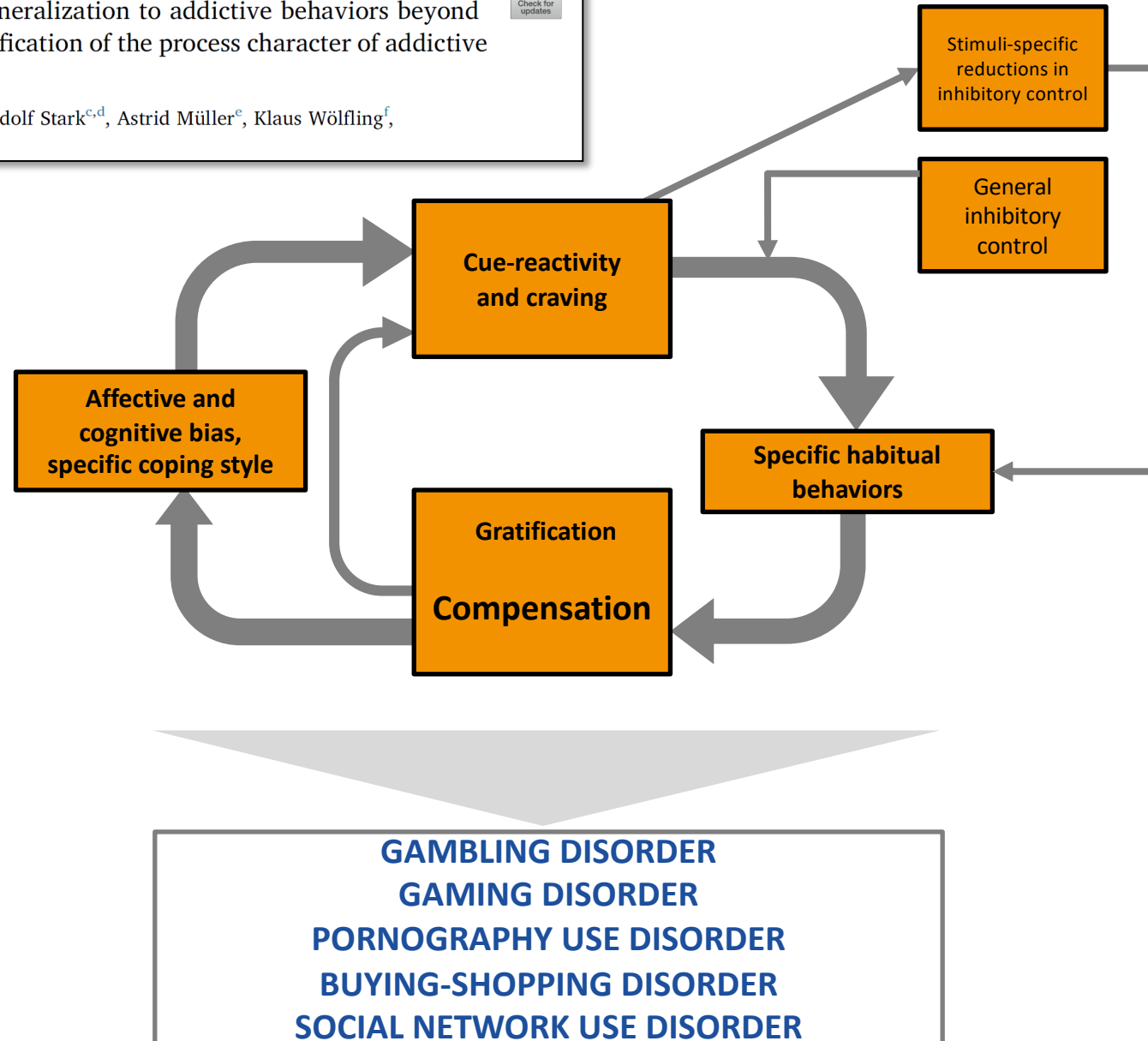
Impulsivity and *Compulsivity*

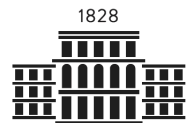
Central constructs related to addictive behaviors - not just secondary consequences

The Interaction of Person-Affect-Cognition-Execution (I-PACE) model for addictive behaviors: Update, generalization to addictive behaviors beyond internet-use disorders, and specification of the process character of addictive behaviors



Matthias Brand^{a,b,*}, Elisa Wegmann^a, Rudolf Stark^{c,d}, Astrid Müller^e, Klaus Wölfling^f, Trevor W. Robbins^g, Marc N. Potenza^{h,i,j}





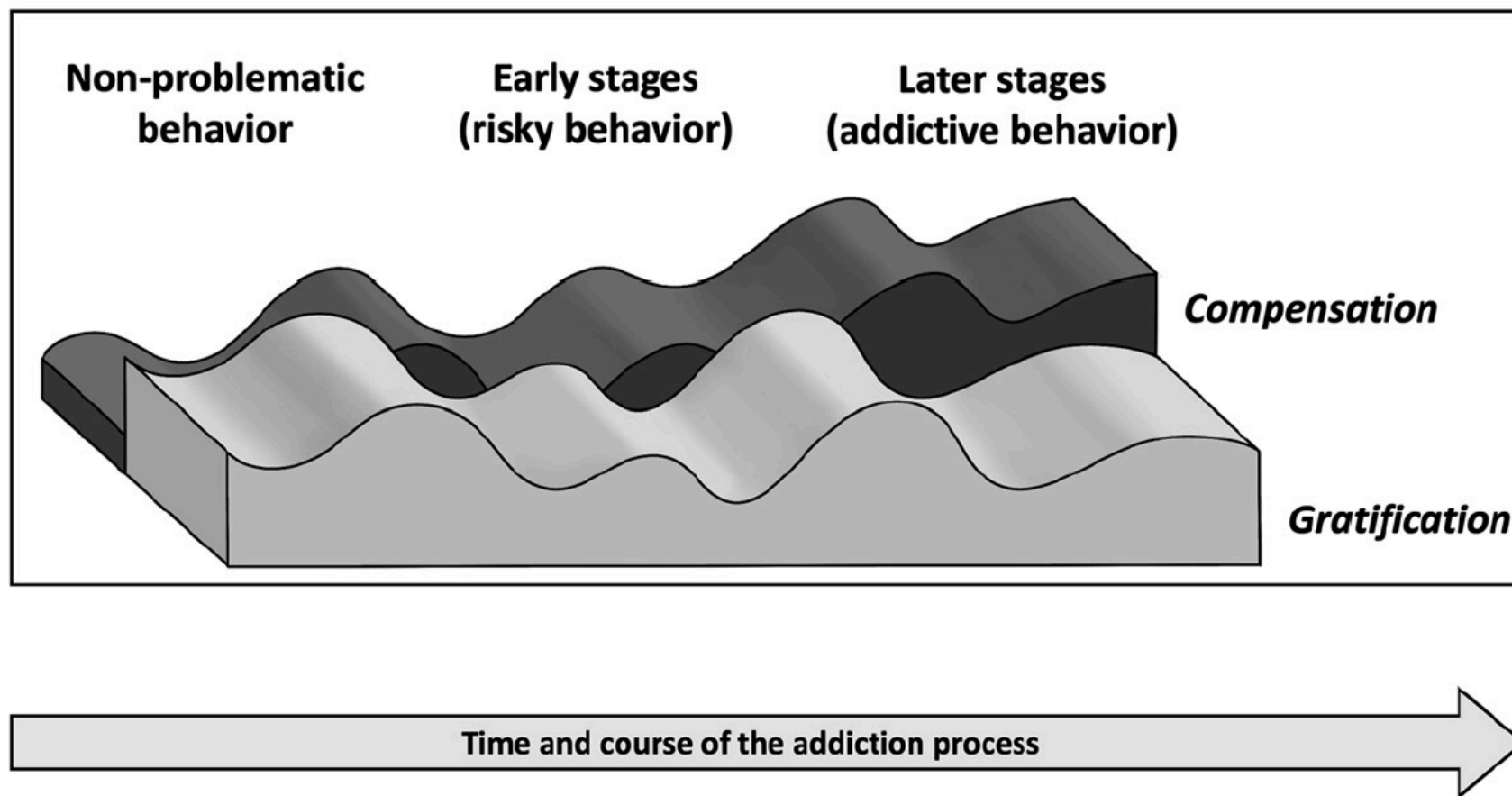
AKADÉMIAI KIADÓ

14 (2025) 1, 1-17

Journal of Behavioral
Addictions

Current interpretations of the I-PACE model of behavioral addictions

MATTHIAS BRAND^{1,2,3*}, ASTRID MÜLLER⁴,
ELISA WEGMANN^{1,2}, STEPHANIE ANTONS^{1,2,3},
ANNIKA BRANDTNER^{1,2}, SILKE M. MÜLLER^{1,2,3},
RUDOLF STARK^{5,6,7}, SABINE STEINS-LOEBER⁸ and
MARC N. POTENZA^{9,10,11,12}

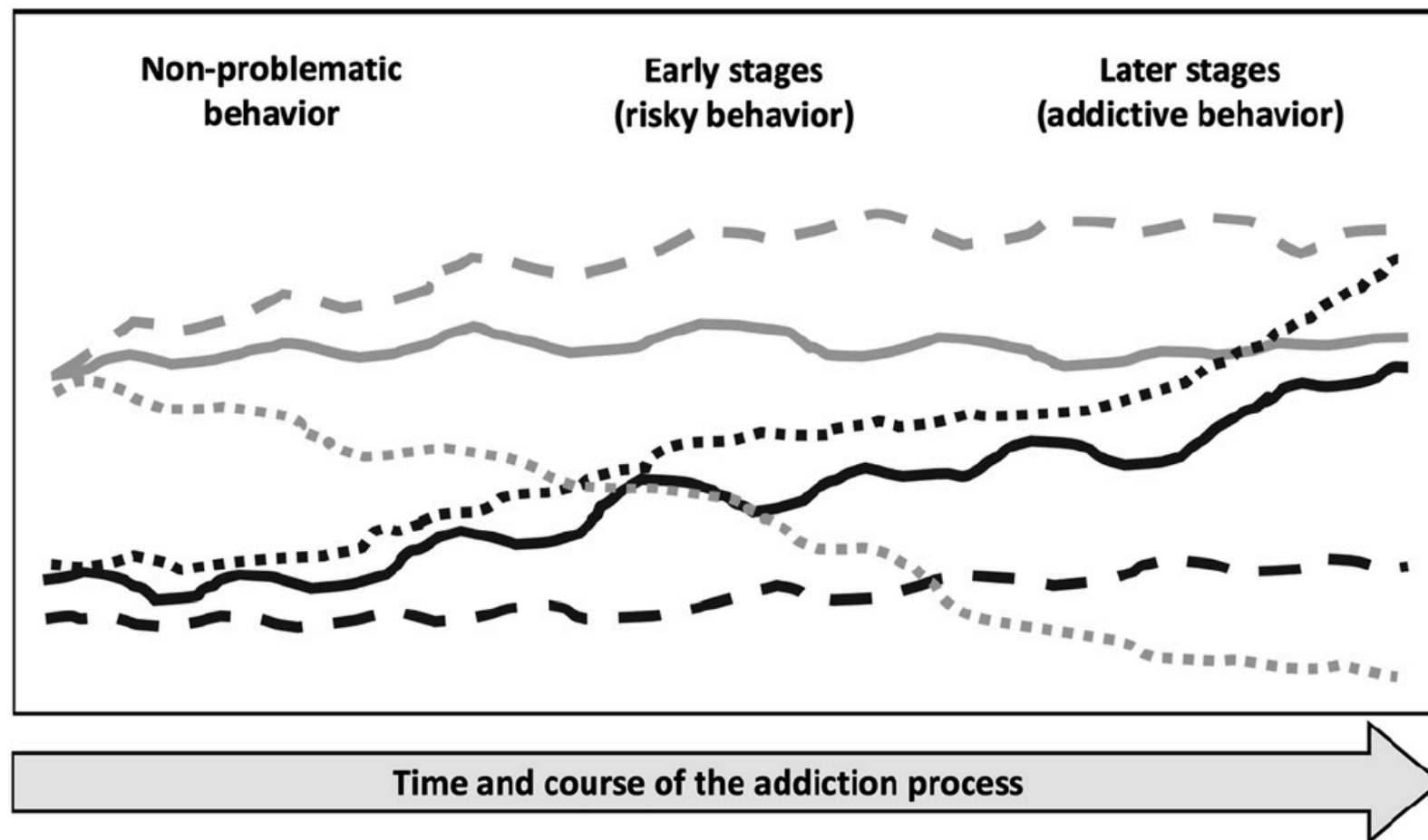


Current interpretations of the I-PACE model of behavioral addictions

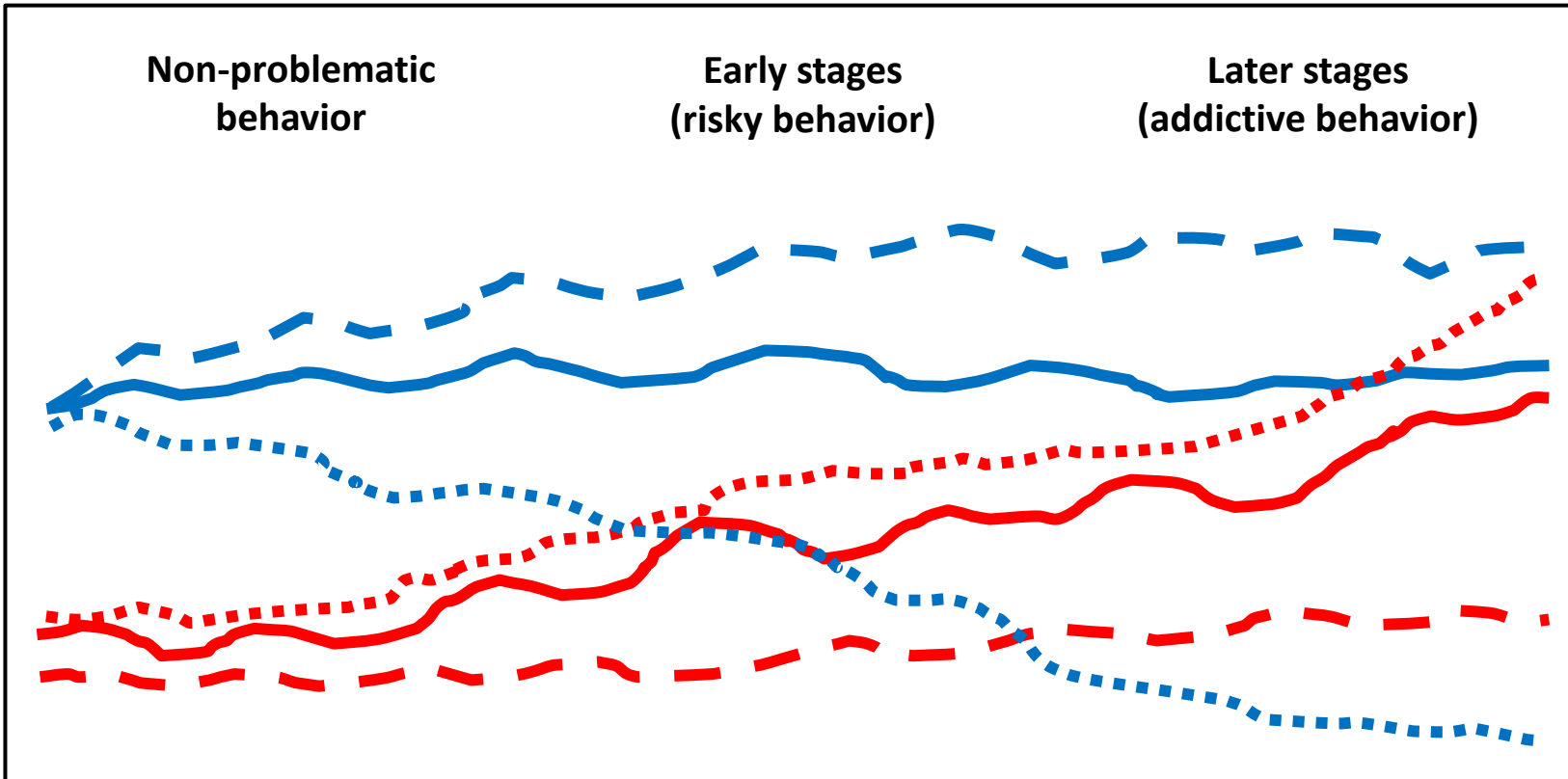
14 (2025) 1, 1-17

Journal of Behavioral Addictions

MATTHIAS BRAND^{1,2,3*}, ASTRID MÜLLER⁴,
ELISA WEGMANN^{1,2}, STEPHANIE ANTONS^{1,2,3},
ANNIKA BRANDTNER^{1,2}, SILKE M. MÜLLER^{1,2,3},
RUDOLF STARK^{5,6,7}, SABINE STEINS-LOEBER⁸ and
MARC N. POTENZA^{9,10,11,12}



- Experienced negative consequences
- - - Anticipated negative consequences
- ... Anticipated negative consequences of not behaving specifically
- Experienced positive consequences
- - - Anticipated positive consequences
- ... Anticipated positive consequences of not behaving specifically



Positive Consequences of Behavior

- Experienced positive consequences
- - Anticipated positive consequences

Negative Consequences of Behavior

- Experienced negative consequences
- - Anticipated negative consequences

Consequences of not behaving

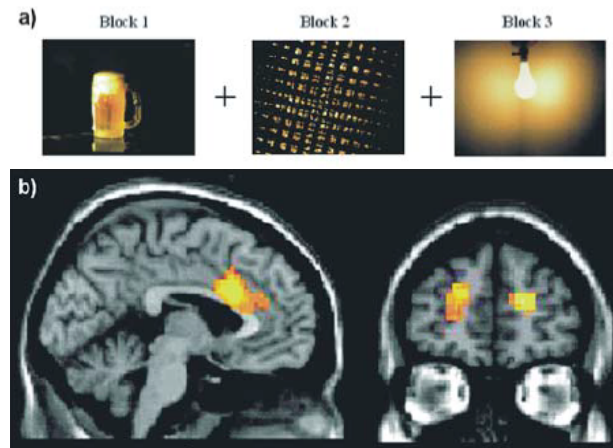
- Anticipated positive consequences of not behaving specifically
- Anticipated negative consequences of not behaving specifically

Time and course of the addiction process

Continuation despite negative consequences

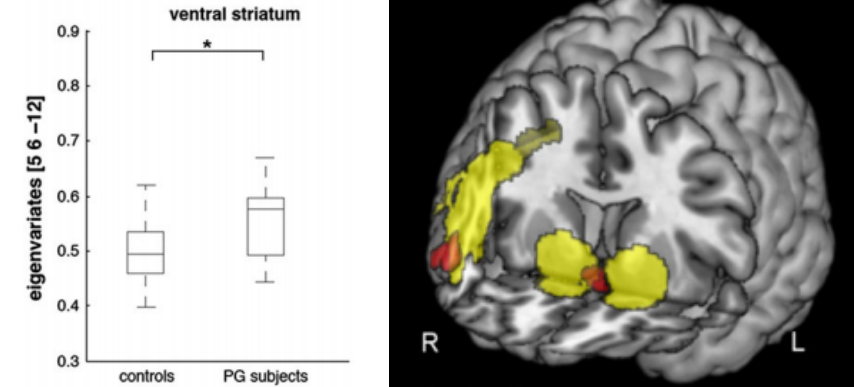
Neural Correlates: Cue reactivity and Craving

...Alcohol use disorder



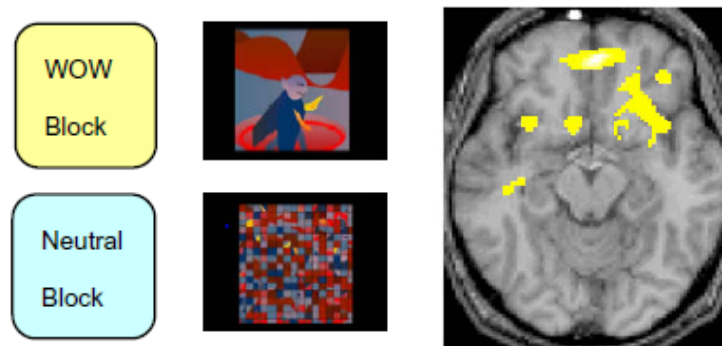
(Grüsser et al., 2004)

...Gambling disorder



(Koehler et al., 2013)

...Gaming disorder



(Ko et al., 2009)

→ ventral striatum

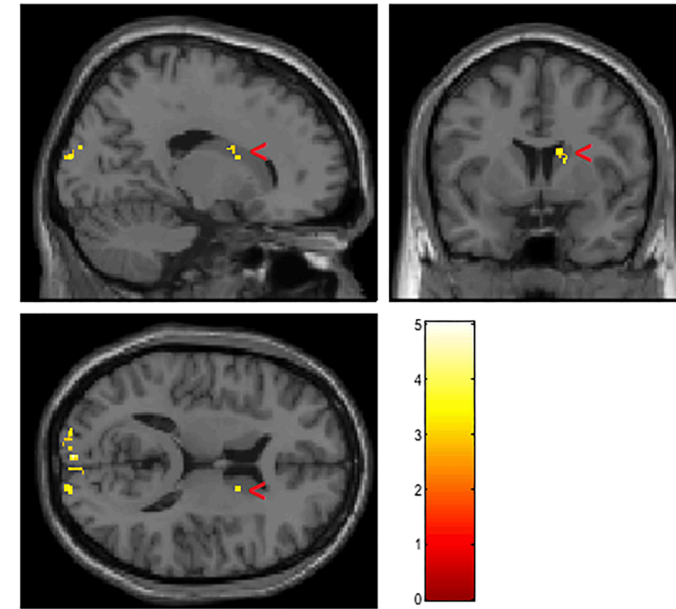
= „Reward system“

Dorsal and ventral striatum activity in individuals with buying-shopping disorder during cue-exposure: A functional magnetic resonance imaging study

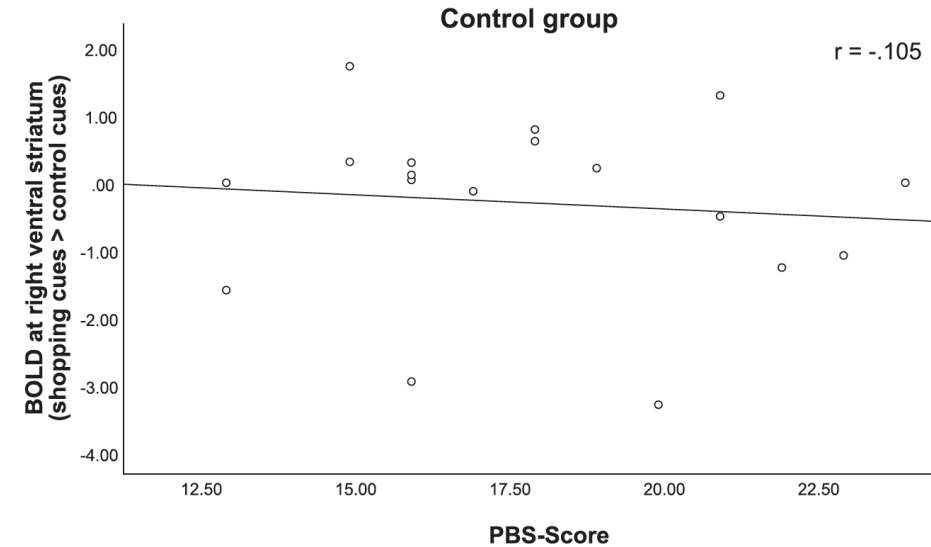
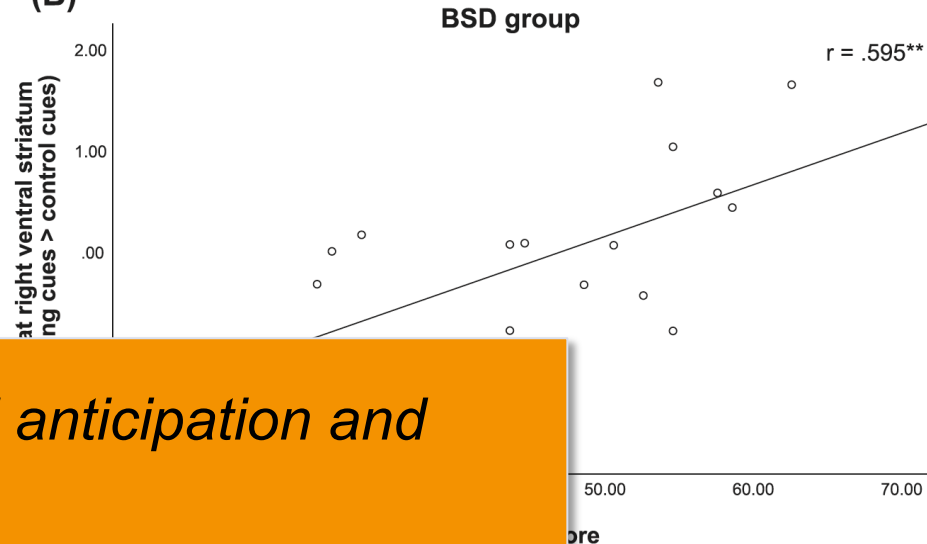
Patrick Trotzke^{1,2,3} | Katrin Starcke⁴ | Anya Pedersen⁵ | Matthias Brand^{1,2}

Compulsive tendencies

Activity in dorsal striatum
Patients > Control group



(B) Correlation symptom severity – Activity in ventral striatum



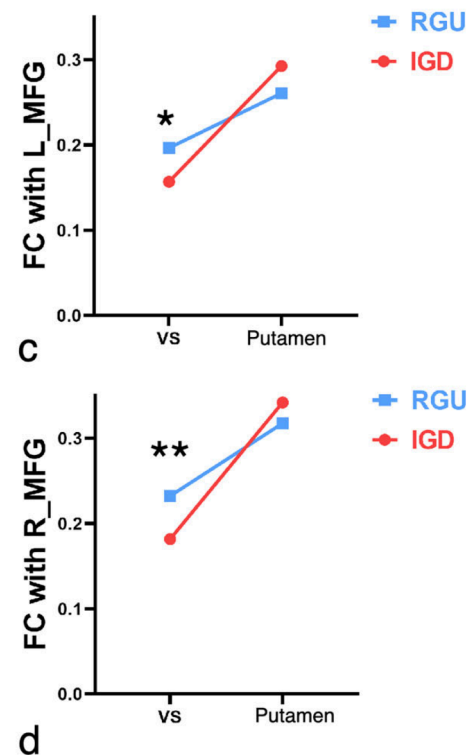
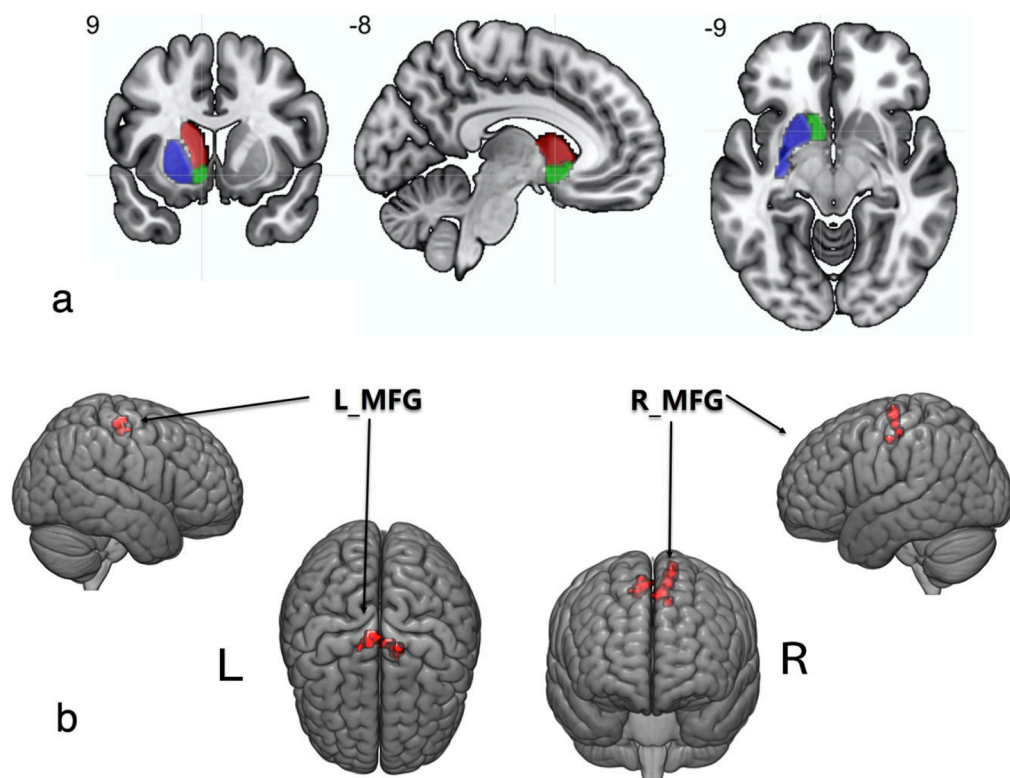
Reward anticipation and craving

Dorsal and ventral striatal functional connectivity shifts play a potential role in internet gaming disorder

Guang-Heng Dong^{1,2,3}, Haohao Dong⁴, Min Wang^{1,2}, Jialin Zhang⁵, Weiran Zhou², Xiaoxia Du⁶ & Marc N. Potenza^{7,8,9}

Activation of the ventral and dorsal striatum during cue reactivity in Internet gaming disorder*

Lu Liu, Sarah W. Yip, Jin-Tao Zhang, Ling-Jiao Wang, Zi-Jiao Shen, Ben Liu, Shan-Shan Ma, Yuan-Wei Yao, Xiao-Yi Fang



Sexual incentive delay in the scanner: Sexual cue and reward processing, and links to problematic porn consumption and sexual motivation

Journal of Behavioral Addictions

10 (2021) 1, 65–76

CHARLOTTE MARKERT^{1,2,3*}, SANJA KLEIN^{1,2,3},
JANA STRAHLER^{1,2}, ONNO KRUSE^{1,2,4} and
RUDOLF STARK^{1,2,3}

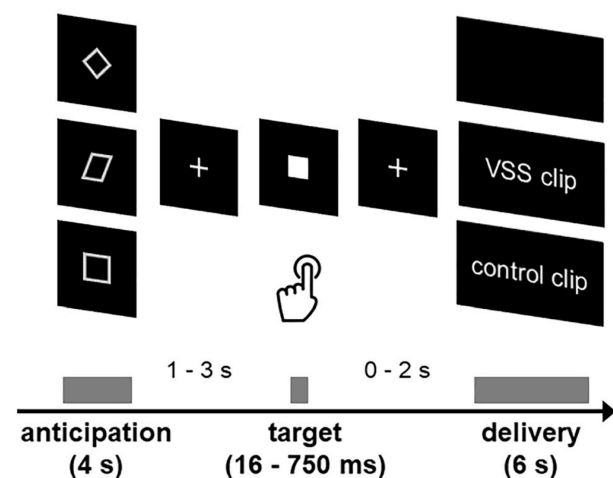
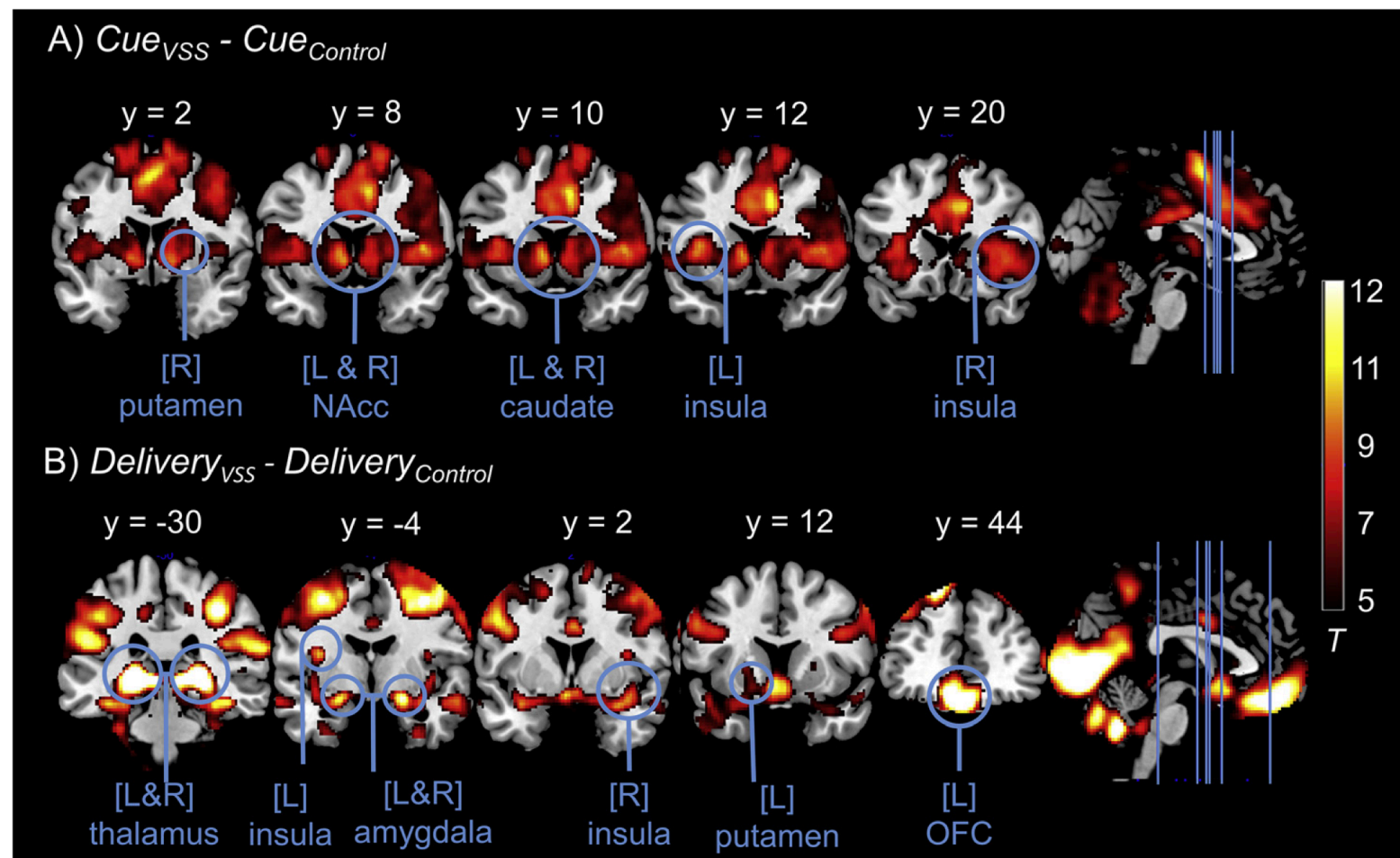


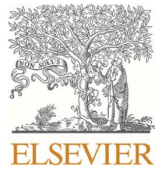
Fig. 1. Sexual Incentive Delay Task. During the anticipation phase, the participants saw a cue (geometric figure). Following a variable time interval, a target was presented for a short time, to which the participants were asked to react as quickly as possible by pressing a button. If the cue in the anticipation phase was a Cue_{VSS} or a Cue_{Control}, a corresponding video could be obtained by reacting quickly to the target (see also Klein et al., 2020)



Cognitive deficits in problematic internet use: meta-analysis of 40 studies

The British Journal of Psychiatry (2019)

Konstantinos Ioannidis, Roxanne Hook, Anna E. Goudriaan, Simon Vlies, Naomi A. Fineberg, Jon E. Grant and Samuel R. Chamberlain



Contents lists available at [ScienceDirect](#)

Neuroscience and Biobehavioral Reviews

journal homepage: www.elsevier.com/locate/neubiorev

A systematic review and meta-analysis of risky decision-making in specific domains of problematic use of the internet: Evidence across different decision-making tasks

Silke M. Müller^{a,b,*}, Stephanie Antons^{a,b}, Elisa Wegmann^a, Konstantinos Ioannidis^{c,d}, Daniel L. King^e, Marc N. Potenza^{f,g,h,i}, Samuel R. Chamberlain^{c,d}, Matthias Brand^{a,b}

Neuropsychopharmacology

At the intersection of brain, behavior, and therapeutics

Article | **OPEN** | Published: 16 April 2019

Impulsivity in Gambling Disorder and problem gambling: a meta-analysis

Konstantinos Ioannidis, Roxanne Hook, Katie Wickham, Jon E. Grant & Samuel R. Chamberlain 

Role of decision making, inhibitory control, and other executive functions

=> Self-control

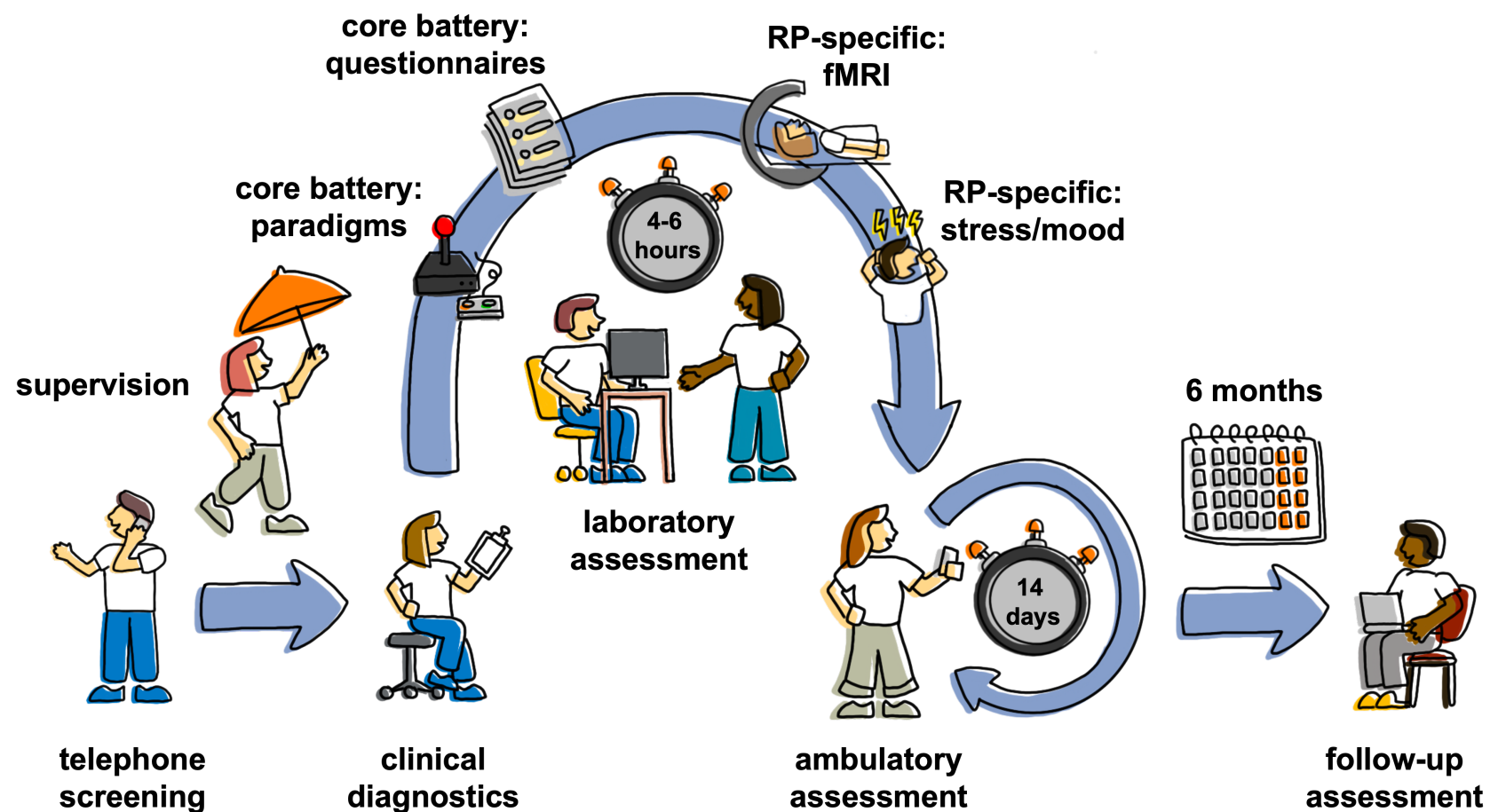


ACSID

Psychological and neurobiological processes
in the development and perpetuation
of addictive behaviour on the internet

Funded by
DFG Deutsche
Forschungsgemeinschaft
German Research Foundation

FOR2974



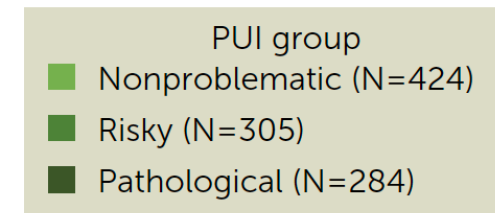
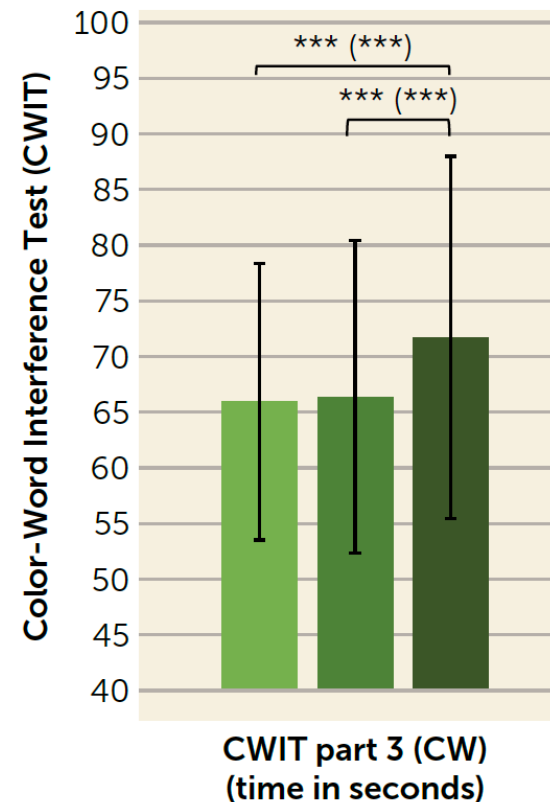
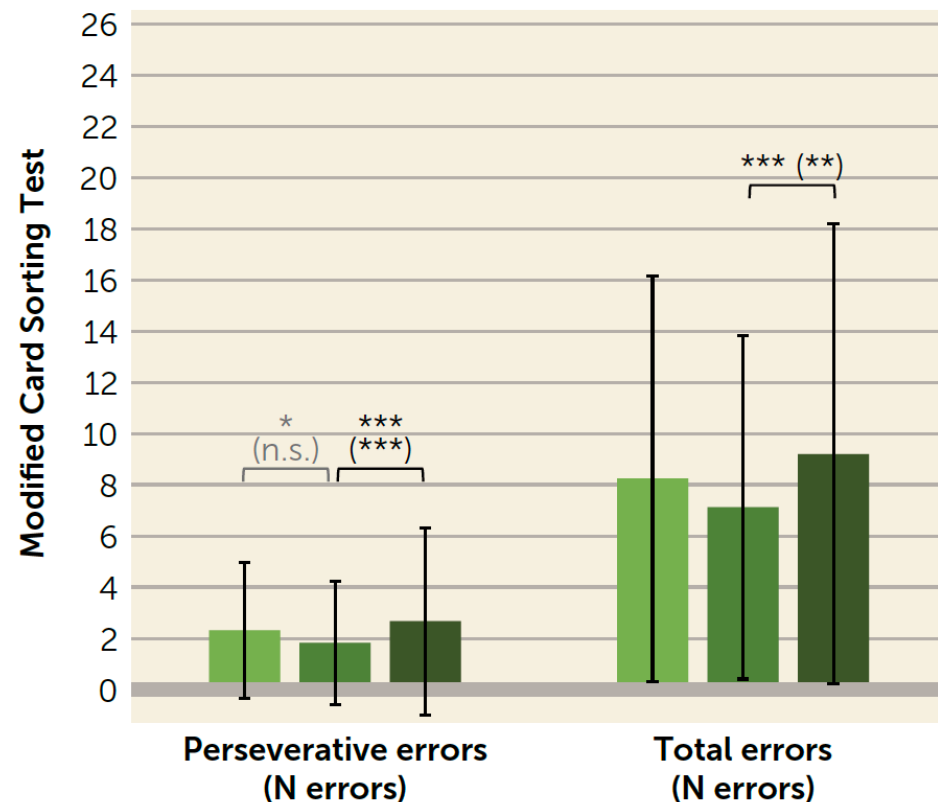
Self-Control Abilities in Specific Types of Problematic Usage of the Internet: Findings From Clinically Validated Samples With Neurocognitive Tasks

Silke M. Müller, Ph.D. , Stephanie Antons, Ph.D. , Anna M. Schmid, M.Sc., Tobias A. Thomas, M.Sc., Annica Kessling, M.Sc., Maithilee Joshi, M.Sc., Kseniya Krikova, M.Sc., Miriam Kampa, Ph.D., Lukas Mallon, M.Sc., Lasse David Schmidt, M.Sc., Lena Klein, M.Sc., Nanne Dominick, M.Sc., Kjell Büsche, M.Sc., Andreas Oelker, M.Sc., Annika Brandtner, Ph.D., Christian Montag, Ph.D., Klaus Wölfling, Ph.D., Oliver T. Wolf, Ph.D., Martin Diers, Ph.D., Tim Klucken, Ph.D., Hans-Jürgen Rumpf, Ph.D., Rudolf Stark, Ph.D., Astrid Müller, M.D., Ph.D. , Elisa Wegmann, Ph.D., Sabine Steins-Loeber, Ph.D., Matthias Brand, Ph.D. 



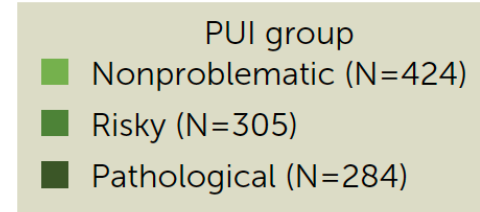
A. Behavioral Measures

General Executive Functions

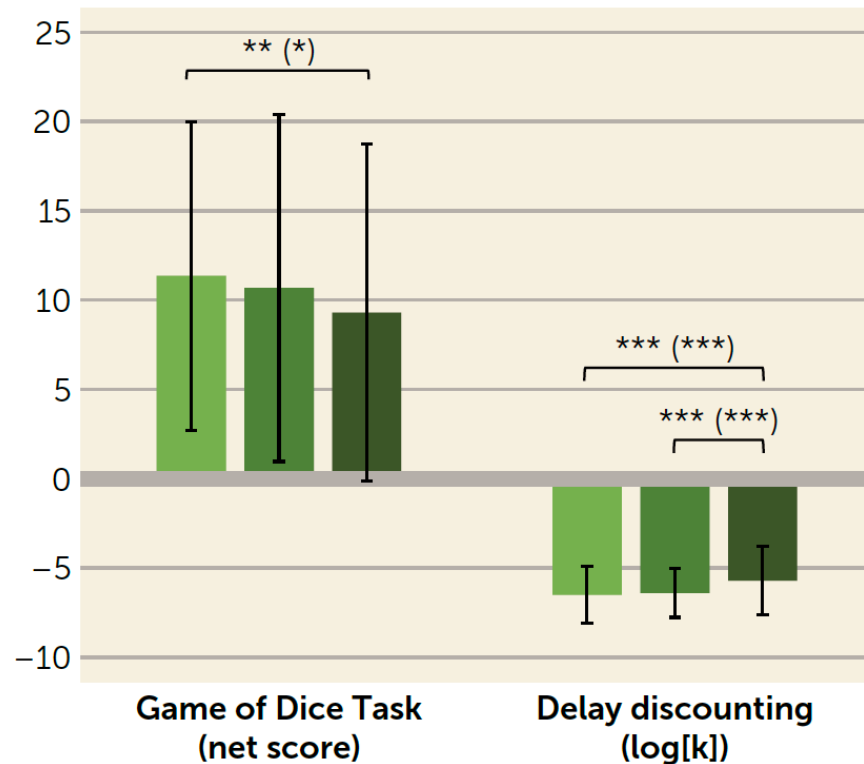


Self-Control Abilities in Specific Types of Problematic Usage of the Internet: Findings From Clinically Validated Samples With Neurocognitive Tasks

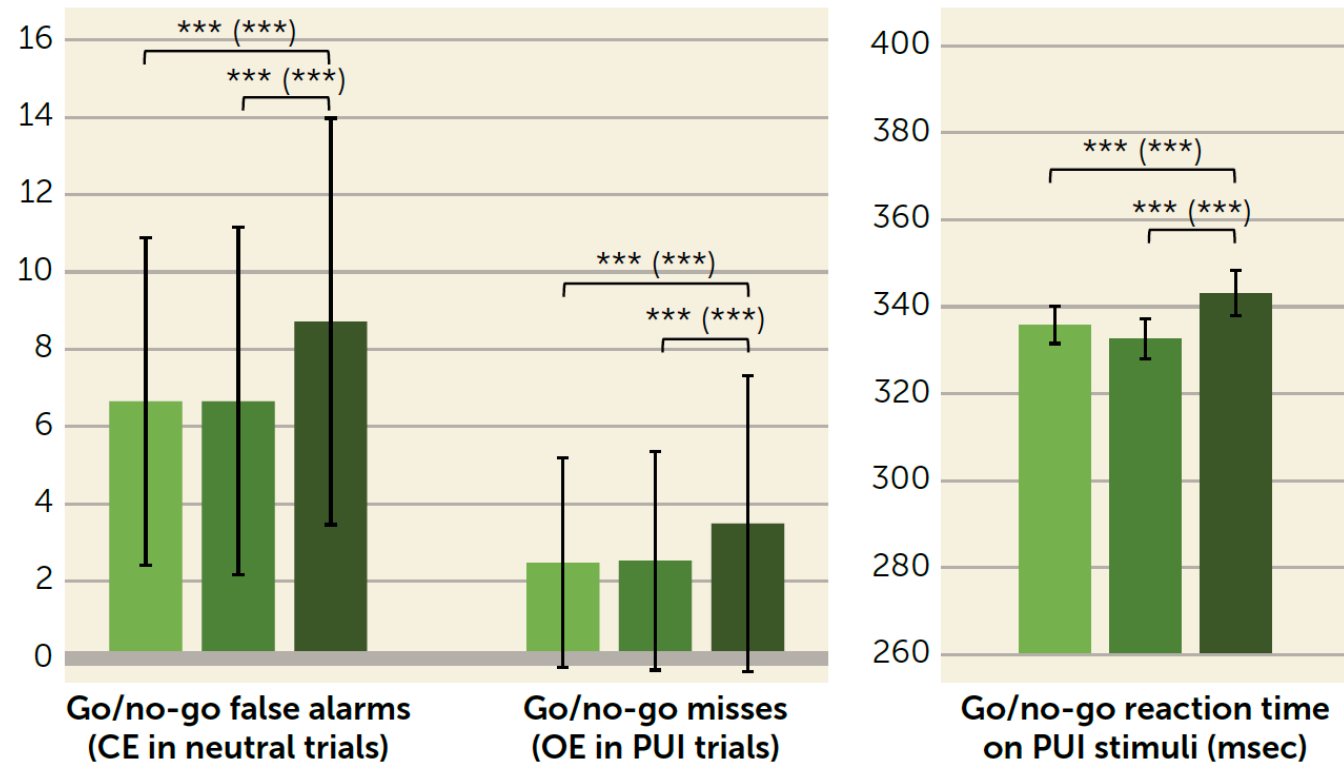
Silke M. Müller, Ph.D.,¹ Stephanie Antons, Ph.D.,² Anna M. Schmid, M.Sc.,³ Tobias A. Thomas, M.Sc.,⁴ Annica Kessling, M.Sc.,⁵ Maithilee Joshi, M.Sc.,⁶ Kseniya Krikova, M.Sc.,⁷ Miriam Kampa, Ph.D.,⁸ Lukas Mallon, M.Sc.,⁹ Lasse David Schmidt, M.Sc.,¹⁰ Lena Klein, M.Sc.,¹¹ Nanne Dominick, M.Sc.,¹² Kjell Büsche, M.Sc.,¹³ Andreas Oelker, M.Sc.,¹⁴ Annika Brandtner, Ph.D.,¹⁵ Christian Montag, Ph.D.,¹⁶ Klaus Wölfling, Ph.D.,¹⁷ Oliver T. Wolf, Ph.D.,¹⁸ Martin Diers, Ph.D.,¹⁹ Tim Klucken, Ph.D.,²⁰ Hans-Jürgen Rumpf, Ph.D.,²¹ Rudolf Stark, Ph.D.,²² Astrid Müller, M.D., Ph.D.,²³ Elisa Wegmann, Ph.D.,²⁴ Sabine Steins-Loeber, Ph.D.,²⁵ Matthias Brand, Ph.D.²⁶



Decision Making

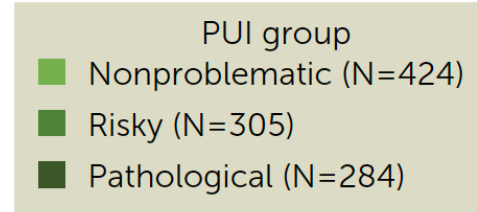


Stimulus-Specific Inhibitory Control

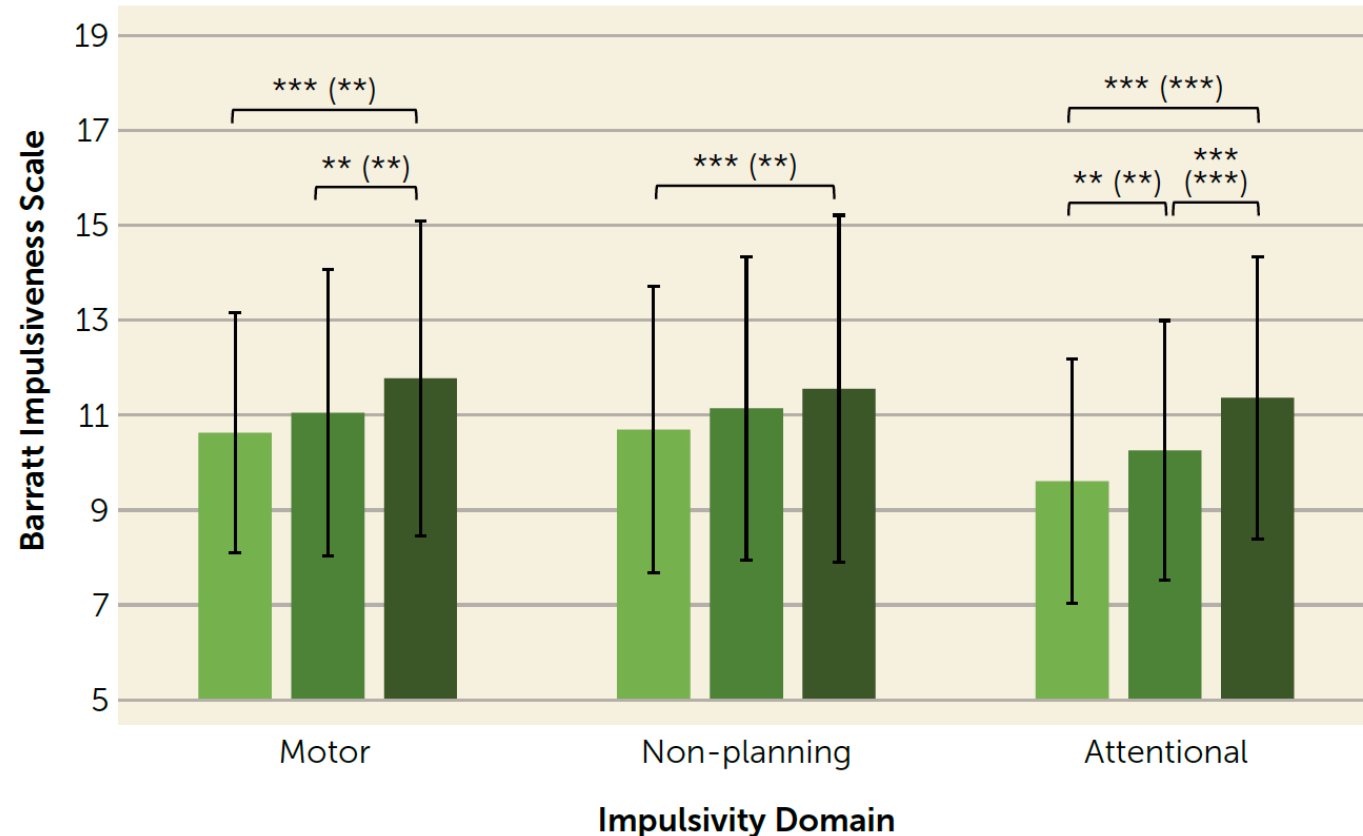
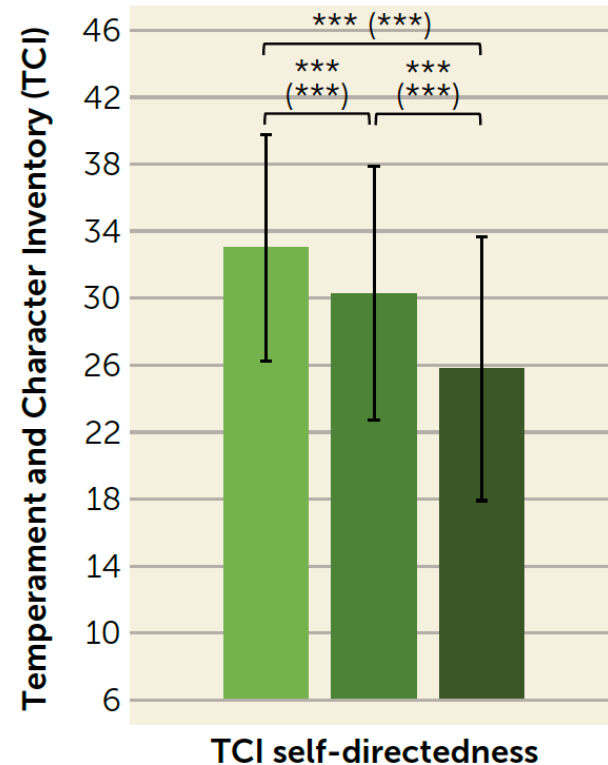


Self-Control Abilities in Specific Types of Problematic Usage of the Internet: Findings From Clinically Validated Samples With Neurocognitive Tasks

Silke M. Müller, Ph.D.,¹ Stephanie Antons, Ph.D.,² Anna M. Schmid, M.Sc.,³ Tobias A. Thomas, M.Sc.,⁴ Annica Kessling, M.Sc.,⁵ Maithilee Joshi, M.Sc.,⁶ Kseniya Krikova, M.Sc.,⁷ Miriam Kampa, Ph.D.,⁸ Lukas Mallon, M.Sc.,⁹ Lasse David Schmidt, M.Sc.,¹⁰ Lena Klein, M.Sc.,¹¹ Nanne Dominick, M.Sc.,¹² Kjell Büsche, M.Sc.,¹³ Andreas Oelker, M.Sc.,¹⁴ Annika Brandtner, Ph.D.,¹⁵ Christian Montag, Ph.D.,¹⁶ Klaus Wölfling, Ph.D.,¹⁷ Oliver T. Wolf, Ph.D.,¹⁸ Martin Diers, Ph.D.,¹⁹ Tim Klucken, Ph.D.,²⁰ Hans-Jürgen Rumpf, Ph.D.,²¹ Rudolf Stark, Ph.D.,²² Astrid Müller, M.D., Ph.D.,²³ Elisa Wegmann, Ph.D.,²⁴ Sabine Steins-Loeber, Ph.D.,²⁵ Matthias Brand, Ph.D.²⁶



B. Self-Report Measures





Conclusion

NEUROSCIENCE

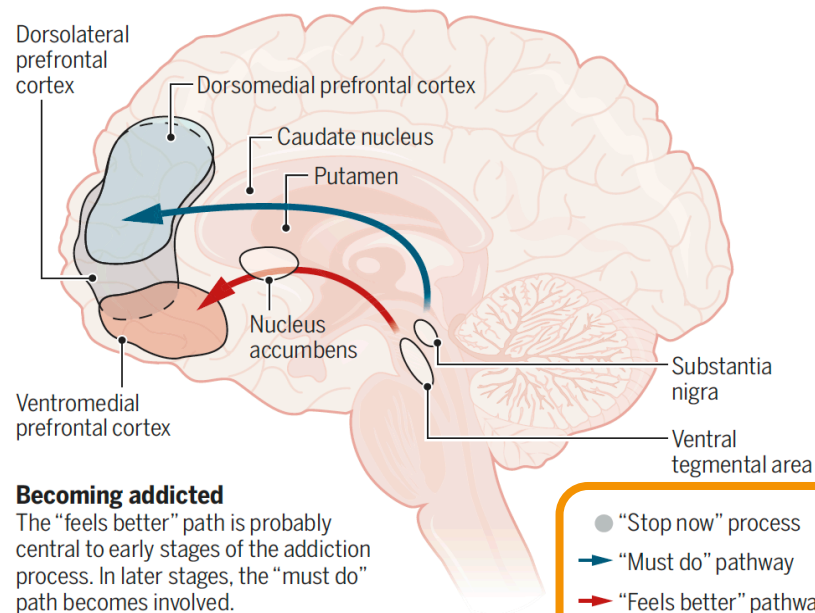
Can internet use become addictive?

Problematic internet use parallels drug addiction, but the mechanisms are not yet clear

By Matthias Brand^{1,2}

Neural pathways in addiction

The hypothesized main neural circuits in human addictive behaviors are shown. The “feels better” path includes positive and negative reinforcement experiences and involves the ventral striatum (nucleus accumbens), and the dorsal striatum in later stages. The “must do” path includes primarily compulsive behaviors, involving the dorsal striatum (putamen and caudate nucleus). The “stop now” self-control process mainly involves the dorsolateral prefrontal cortex.



➔ “Feels better” pathway

Positive and negative reinforcement

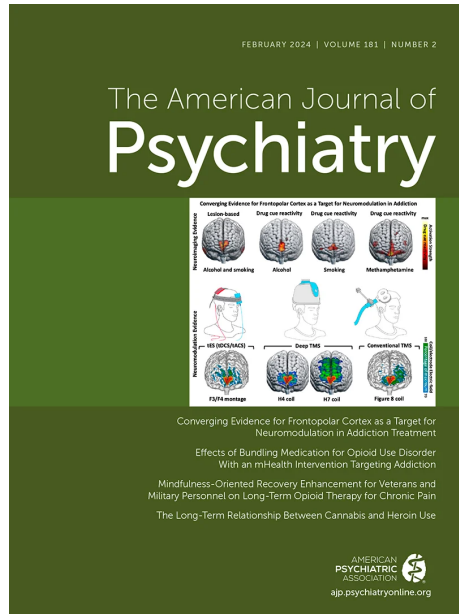
➔ “Must do” pathway

Seemingly habitual and compulsive behaviors

● “Stop now” process

Self-control

- “Stop now” process
- ➔ “Must do” pathway
- ➔ “Feels better” pathway



Current Advances in Behavioral Addictions: From Fundamental Research to Clinical Practice

Matthias Brand, Ph.D., Stephanie Antons, Ph.D., Beata Bóthe, Ph.D., Zsolt Demetrovics, Ph.D., Naomi A. Fineberg, M.A., M.B.B.S., Susana Jimenez-Murcia, Ph.D., Daniel L. King, Ph.D., Gemma Mestre-Bach, Ph.D., Tania Moretta, Ph.D., Astrid Müller, M.D., Ph.D., Elisa Wegmann, Ph.D., Marc N. Potenza, M.D., Ph.D.

Gambling disorder is the only behavioral addiction recognized as a clinical disorder in DSM-5, and Internet gaming disorder is included as a condition requiring further research. ICD-11 categorizes gambling and gaming disorders as disorders due to addictive behaviors. Additional behavioral addictions may include compulsive sexual behavior disorder, compulsive buying-shopping disorder, and problematic use of social media. This narrative review summarizes the current state of knowledge regarding these five (potential) disorders due to addictive behaviors. All five (potential) disorders are clinically relevant and prevalent. Behavioral addictions frequently co-occur with other mental and behavioral problems, such as depression, anxiety, and attention deficit hyperactivity disorder. Validated diagnostic instruments exist, with empirical support varying across conditions. No

medications have approved indications from regulatory bodies for behavioral addictions, and cognitive-behavioral therapy has the most empirical support for efficacious treatment. Given that behavioral addictions are prevalent, frequently co-occur with psychiatric disorders, may often go undiagnosed and untreated, and have been linked to poorer treatment outcomes, active screening and treatment are indicated. Public health considerations should be expanded, and impacts of modern technologies should be investigated more intensively. Treatment optimization involving pharmacotherapy, psychotherapy, neuromodulation, and their combination warrants additional investigation.

Am J Psychiatry 2025; 182:155–163; doi: 10.1176/appi.ajp.20240092

- **Vulnerability**
- **Causality**
- **Specificity**

Cascade model?



Baummapper@wikimedia

Thank you!

UNIVERSITÄT
DUISBURG
ESSEN

Open-Minded



General
Psychology:
Cognition



Funded by
DFG Deutsche
Forschungsgemeinschaft
German Research Foundation

FOR2974

<https://www.uni-due.de/for2974>