Symposium of the Collaborative Research Center 940

Volition and Cognitive Control: From Executive Functions to Meta-Control

11th to 14th July 2022

Bilderberg Bellevue Grand Hotel, Dresden, Germany

Volition and Cognitive Control:
From Executive Functions to Meta-Control

It is a pleasure to welcome you to the 2022 Symposium of the Collaborative Research Center "Volition and Cognitive Control"!

Human goal-directed action rests on a set of remarkable cognitive capacities, including the ability to anticipate future consequences of actions and engage in mental simulations of action plans, to adapt behavioral dispositions flexibly to changing contexts, and to override temporary temptations in favor of long-term goals. The evolution of cognitive control mechanisms underlying these capacities decoupled human action from the immediate stimulus situation and current need state. However, the resulting flexibility and future-directedness of human action also gave rise to novel types of conflicts and "control dilemmas". These control dilemmas reflect the fact that goal-directed agents in constantly changing and uncertain environments face antagonistic adaptive challenges (e.g., to maintain and shield goals from competing response tendencies versus to flexibly switch between goals in response to unexpected changes; to focus attention on relevant information versus to monitor the environment for potentially relevant stimuli; to exploit learnt reward contingencies versus to explore novel and potentially better options). Adaptive action control thus constitutes an optimization problem that confronts agents with the meta-control problem how to adapt control modes and parameters to changing contexts and task-demands and how to achieve an optimal balance between antagonistic adaptive constraints in light of complementary costs and benefits of different control modes and policies.

Despite impressive progress that has been made in uncovering the computational mechanisms and neural systems underlying volitional action and cognitive control, the meta-control processes that mediate the adaptive regulation of cognitive control modes and parameters remain poorly understood. To develop mechanistic models of meta-control constitutes a major challenge for the next wave of cognitive control research and is a precondition for completing the task that has been set four decades ago by Alan Newell: to banish the homunculus from theories of cognitive control.

The aim of the 2022 Symposium is to bring together leading experts working in the field of cognitive control, volition, and executive functions at psychological, computational, and neural levels of analysis, who are invited to present empirical findings, theoretical perspectives and computational modeling work related to the emerging field of meta-control. Core themes of the symposium include:

Beyond executive functions: Cognitive and neural mechanisms underlying meta-control and the adaptive regulation of cognitive control. How can one explain in mechanistic terms how control processes are themselves "controlled", i.e., how cognitive control is dynamically regulated and adapted to changing contexts and task demands? How do agents select among different control strategies and policies in light of the complementary costs and benefits? Which brain networks are

involved in meta-control processes and how do control modes relate to configurations and dynamic interactions of underlying brain networks?

Beyond laboratory tasks: Neurocomputational mechanisms of learning, prediction, and flexible goal-directed action in dynamic and uncertain contexts. How do goal-directed agents learn to adapt control parameters and policies to changing contexts and contingencies in changing and uncertain environments? How are optimal settings of control parameters learnt?

Beyond limited resources: Motivational determinants, costs, and expected value of cognitive control modes. How are cognitive control processes modulated by motivation and reward? How is the balance between complementary control modes optimized based on their estimated costs and benefits? How do agents compute and predict the requirement and expected value of control and adjust control modes to optimize task performance and goal attainment?

By addressing these questions at different levels of analyses, we hope to foster cross-fertilization between psychological, computational, and cognitive neuroscience perspective on meta-control.

We wish you a stimulating meeting and an inspiring and pleasant time!

Thomas Goschke
Spokesperson of the CRC 940

Solveig Otto
CRC Administrative Office

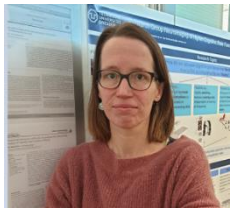
On behalf of the Managing Committee of the CRC 940

Tanja Endrass

Shu-Chen Li

Michael Smolka

Alexander Strobel



Uta Wolfensteller

Anne Gärtner
(Representative of the CRC Research Training Group)

Program and Time Table

MONDAY, 11 JULY 2022

18:00	Welcome Apéro

TUESDAY, 12 JULY 2022

09:00	Registration
09:30	**Thomas Goschke:** Welcome & introductory presentation: From executive functions to meta-control
10:00	**Ruth Krebs:** Anything you can do, you can do better – (A)typical effects of motivational signals on cognitive control
10:50	Coffee break
11:10	**Ross Otto:** Cognitive Effort and decision-making: Integrating computational, behavioral, and physiological approaches
12:00	**Eliana Vassena**: Motivated control as a meta-learning problem: computational, neural and behavioral mechanisms
12:50	Lunch
14:00	**Alexander Soutschek:** Metacognition in value-based choice
14:50	**Sam Parsons**: Finding opportunities in (un)reliability: Tools and strategies for opening this Pandora's box
15:40	Coffee break
16:00	**Poster Session**: Projects of the Collaborative Research Center 940
19:00	Dinner

WEDNESDAY, 13 JULY 2022

10:00	**Senne Braem:** Learning to be in control
10:50	**Nils Kolling:** On the neural substrates of planning, changing motivation and sequential goal pursuit
11:40	Coffee break
12:00	**Joshua Brown:** Computational and neural mechanisms of goal-directed control
12:50	Lunch
14:00	**Wouter Kool:** Cost-benefit tradeoffs in metacontrol
14:50	**Nicolas Schuck:** Representation and value learning in the human brain
15.40	Coffee break
16.00	**Panel Discussion: From executive functions to meta-control**
17.00	**Meet the experts: PhD students and speakers**
18.00	Barbecue

THURSDAY, 14 JULY 2022

09:30	**Matthew Nassar:** Dynamic representations for behavioral flexibility
10:20	**Gesine Dreisbach:** Reasons to switch: How reward, context and ability modulate cognitive flexibility
11:10	Coffee break
11:30	**Matthew Rushworth:** Brain circuits for deciding when it is worth acting
12.20	**Sebastian Musslick:** On the rational bounds of cognitive control
13:10	Closing remarks
13:15	Lunch
14:00	Optional city walk

Learning to be in control

Senne Braem

Department of Experimental Psychology, Ghent University, Belgium

Much of human behavior is characterized by the extraordinary ability to quickly reconfigure our mind, inhibit prepotent responses, and switch between different tasks, often referred to as cognitive control (or executive functions). When defining cognitive control, it is often contrasted with arguably more low-level forms of learning, such as stimulus-response learning. However, this traditional definition on cognitive control might have put us on the wrong path when trying to understand the training of, development of, and impairments in these control processes. In contrast, this talk will start from the idea that control processes can be grounded in the same learning network as stimulus-response representations are. Specifically, I will present a set of studies suggesting that control processes can be selectively reinforced by reward and controlled by the context. Together, these results argue for a more integrative learning perspective on cognitive control.

Computational and neural mechanisms of goal-directed control

Joshua W. Brown

Department of Psychological and Brain Sciences
Indiana University, Bloomington, USA

Despite great strides in both machine learning and neuroscience, we do not know how the human brain solves problems in the general sense. We approach this question by drawing on the framework of control theory from engineering. We demonstrate a computational neural model with only localist learning laws that is able to find solutions to achieve arbitrary and time-varying goals. Computationally, this approach resolves control dilemmas by finding an optimal cost-adjusted sequence of states to achieve a specified goal. Using a combination of computational neural modeling, human fMRI, and representational similarity analysis, we show here that the roles of a number of brain regions can be reinterpreted as interacting mechanisms of a control theoretic system. The results suggest a new set of functional perspectives on the orbitofrontal cortex, hippocampus, basal ganglia, anterior temporal lobe, lateral prefrontal cortex, and visual cortex, as well as a new path toward artificial general intelligence.

Reasons to switch: How reward, context and ability modulate cognitive flexibility

Gesine Dreisbach

Institute for Psychology, University Regensburg, Germany

Goal-directed behavior in a constantly changing environment requires a dynamic balance between two antagonistic modes of control: On the one hand, goals need to be maintained and shielded from distraction (stability), and on the other hand, goals need to be relaxed and flexibly updated whenever significant changes occur (flexibility). I will present studies from our lab, showing how reward and the task context modulates this stability-flexibility-balance during (voluntary) task-switching. The results support our assumption that increased cognitive flexibility can result from (at least) two distinct underlying cognitive mechanisms: lowering the updating threshold in working memory or keeping multiple tasks active in working memory. In the second part of my talk, I will then present ongoing research addressing the role of individual ability and subjective effort costs during voluntary task switching. Results so far suggest that mainly objective performance costs determine the switch rate whereas subjective effort costs and introspective awareness of switch costs, even though present, barely inform the decision to switch.

On the neural substrates of planning, changing motivation and sequential goal pursuit

Nils Kolling

Université Lyon 1, France, Inserm, Stem Cell and Brain Research Institute
Honorary Research Fellow, University of Oxford, UK

Deciding between apples and oranges has been an age-old question not just for hungry shoppers but within the field of decision-making research. However, very rarely have researchers considered the possibility to reject either and move on to the next shelf. I have previously argued that such a sequential decision making framework is not just essential for understanding foraging animals, but also ecological, real life, behaviour in humans[1,2]. While it is intuitive that real life decision strategies require temporally extended coherent behaviours[2] and rely on prospection, maintained motivation and sequential adaptation, those cognitive and neural processes remain poorly understand. In the first part of my talk I will present our recent cognitive model for sequential search decisions and its underlying neural dynamics[3]. In the second part I will further expand into another important element of sustained and sequential behaviours, i.e. intrinsic motivation. In particular, I will focus on the circuits fluctuating with motivation to continue pursuing the current task instead of disengaging, showing task general as well as causal evidence. Lastly, I will talk about ongoing work on sequential incremental goal pursuit and how the nature of decision-making changes with goal progress neurally and behaviourally as participants assess whether to give into temptation or frustration.

1. Kolling N, Akam T. (Reinforcement?) Learning to forage optimally. Curr Opin Neurobiol. 2017;46:162-169. doi:10.1016/j.conb.2017.08.008

2. Kolling N, O'Reilly JX. State-change decisions and dorsomedial prefrontal cortex: the importance of time. Curr Opin Behav Sci. 2018;22:152-160. doi:10.1016/j.cobeha.2018.06.017

3. Kolling N, Scholl J, Chekroud A, Trier HA, Rushworth MFS. Prospection, Perseverance, and Insight in Sequential Behavior. Neuron. 2018;99(5):1069-1082.e7. doi:10.1016/j.neuron.2018.08.018

Cost-benefit tradeoffs in metacontrol

Wouter Kool

Department of Psychological & Brain Sciences, Washington University, St. Louis, USA

We are constantly faced with the issue of metacontrol: how do we decide, from moment-to-moment, which information-processing strategy to engage. I will describe behavioral, computational, and neuroimaging work that suggests that this process is best understood as a cost-benefit analysis. Then, I will highlight some recent efforts of the lab to understand how metacontrol draws on cheap heuristics to implement metacontrol *efficiently*, i.e., without having to rely on higher-order arbitration decisions. Together, our work suggests that the brain flexibly and adaptively integrates the costs and benefits of different decision-making strategies in order to guide arbitration between them.

“Anything you can do, you can do better” – (A)typical effects of motivational signals on cognitive functioning

Ruth Krebs

Department of Experimental Psychology, Ghent University, Belgium

A large body of research highlights how motivational signals (mostly monetary incentives) can promote performance in a variety of cognitive tasks. These benefits are thought to arise through goal-directed attentional control mechanisms. More recently the view that rewards are inevitably beneficial for cognitive functioning has been challenged. In my talk I will highlight different examples of how motivational signals can impair goal-directed behavior, and how these impairments come about. While the effects of motivational signals seem to originate from the same basic principle, i.e., (acquired) value-based saliency, they can benefit or impair performance depending on the nature of the task at hand. Task features that are relevant with respect to these differential effects include cuing and cue-target intervals, overlap of reward and target features, reward-response mappings, and response modes. Investigating this flip side of motivational signals on cognitive functioning also advances our understanding of the commonly observed benefits. I would argue that some of the beneficial effects that have been attributed to voluntary, goal-directed processes might partially rely on attentional and response capture based on low-level saliency.

On the Rational Bounds of Cognitive Control

Sebastian Musslick

Department of Cognitive, Linguistic, and Psychological Sciences
Brown University, Providence, USA

One of the most remarkable features of cognitive control is our inability to exercise it: Humans often fail to perform more than one control-demanding task at the same time or even focus on a single task in the face of distraction. These limitations are universal assumptions of most theories of cognition. Yet, a rationale for why the human brain is subject to these constraints remains elusive. This talk draws on recent insights from neuroscience, psychology, physics, and machine learning, to provide a unified account of constraints on the capacity for cognitive control based on fundamental computational dilemmas in neural architectures. In the first part of this talk, I will discuss computational and behavioral evidence suggesting that limitations in the capability to multitask can be attributed to representation sharing between tasks. Computational modeling suggests that neural systems trade the benefits of shared representation for rapid learning and generalization—a mechanism increasingly exploited in machine learning—against constraints on multitasking performance. This forces neural systems to flexibly switch between tasks to achieve more than one. The flexible switching between tasks, however, gives rise to a tradeoff between cognitive stability and cognitive flexibility. In the second part of this talk, I will review behavioral and computational evidence suggesting that limitations in the intensity of commitment to a single task may reflect a bias toward cognitive flexibility at the expense of cognitive stability. I will conclude by outlining how the consideration of such tradeoffs as fundamental principles of computation may ultimately help us understand constraints in artificial agents that borrow increasingly from computational principles found in the human brain.

Dynamic representations for behavioral flexibility

Matthew Nassar

Department of Neuroscience & Robert J. & Nancy D. Carney Institute for Brain Science, Brown University, Providence, USA

People flexibly adjust their use of information according to context. The same piece of information, for example the unexpected outcome of an action, might be highly influential on future behavior in one situation -- but utterly ignored in another one. Bayesian models have provided insight into why people display this sort of behavior, and even identified potential neural mechanisms that link to behavior in specific tasks and environments, but to date have fallen short of providing broader mechanistic insights that generalize across tasks or statistical environments. Here I'll examine the possibility that such broader insights might be gained through careful consideration of task structure. I'll show that we can think about a large number of sequential tasks as requiring the same inference problem -- that is to infer the latent states of the world and the parameters of those latent states -- with the primary distinctions within the class defined by transition structure. Then I'll talk about how a neural network that updates latent states according to a known transition structure and learns "parameters" of the world for each latent state can explain adaptive learning behavior across environments and provide the first insights into neural correlates of adaptive learning across environments. This model generates internal signals that identify the need for latent state updating, which maps onto previous observations made in pupil dilations and P300 responses across different task environments. I will also discuss an experiment that we are currently setting up to test the idea that these signals might reflect a latent state update signal, with a focus on relationships to learning and perception. Finally, I discuss how deviations from normative structure learning might give rise to aberrant belief updating in mental illness.

Cognitive Effort and decision-making: Integrating computational, behavioral, and physiological approaches

Ross Otto

Department of Psychology, McGill University, Montreal, Quebec, Canada

Our ability to perform tasks is constrained by our limited mental resources, which mandates that people should minimize use of cognitively "effortful" processing when possible. Recent theories posit that decisions to expend effort are governed by a cost-benefit tradeoff, whereby the potential benefits of effort can offset its perceived costs. I will present a series of recent, computationally-informed experiments that yield important insights into understanding when and why we allocate--or withhold--cognitive effort, both from an individual differences perspective, and at the level of the task by examining the effect of changes in costs and benefits. We find that individual differences in cognitive capacity--and relatedly, intrinsic motivation--govern trial-to-trial adjustments to cognitive effort expenditure in accordance with shifts in (subjective or objective) costs and benefits (i.e., reward incentives). Further, we find that 1) task-evoked pupillary responses and 2) indices of reward-related neural processing (measured by EEG) can elucidate internal computations of these effort allocation decisions. Finally, I will present new experimental data illustrating how reward-guided effort allocation also depends on the marginal utility of increasing effort in a particular context---that is, the additional task performance benefits gained from increasing effort allocation. Taken together, these lines of work illustrate how our decisions to deploy effortful cognitive processing can be understood in a decision-theoretic framework.

Finding opportunities in (un)reliability: Tools and strategies for opening this Pandora's box

Sam Parsons

Donders Institute for Brain, Cognition and Behaviour, Radboud University, Nijmegen, NL

Ensuring our measures have adequate psychometric properties for our intended analyses can feel like opening a Pandora’s box. We may worry that uncovering low reliability can jeopardize our results, or that common reliability metrics cannot be applied to our complex behavioural tasks. In this presentation, I aim to persuade all that that avoiding reliability is not the answer. Not because we must uncover the skeletons in our data’s closet. But, because exploring sources of (un)reliability allows us to examine our theories and our models. Further, with easy to use tools and powerful psychometric models, we open the door to new exciting substantive research questions.

Distributed neural networks for initiating voluntary action

Matthew Rushworth

Department of Experimental Psychology & Wellcome Trust Centre for Integrative Neuroimaging (WIN), University of Oxford, UK

Voluntary actions are ones that appear to be initiated by people and other animals in the absence of any external instruction or cue. However, the likelihood that voluntary actions are initiated depends on identifiable features of both the current and the recent environment, recent behaviour, and the consequences that will ensure if the action is made (for example, will it lead to reward or not). These factors mediate their influence on the initiation of voluntary action via a distributed neural circuit spanning cortical regions such as the anterior cingulate cortex and many subcortical nuclei including midbrain areas such as the substantia nigra, habenula, basal forebrain, and raphe nucleus. I review a series of recent studies conducted in non-human and human primates using a combination of neuroimaging, temporary inactivation via ultrasound stimulation, and pharmacological manipulation that begin to dissect these different influences on voluntary behaviour and to trace the anatomical pathways through which each operates on voluntary behaviour. The timing of action initiation depends both on reward expectations and on recent behaviour and these influences are governed by changes in activity in the basal forebrain and anterior cingulate cortex, altered by disruption of activity in either or these areas, or by cholinergic manipulations. However, whether or not an action is initiated also depends on the richness/sparseness of opportunities in the environment in general and this is tracked by activity in the raphe nucleus and altered by serotonergic manipulation. Rethinking why people and animals do, or do not, initiate an action provides new insights into the nature of voluntary behaviour. In turn this provides us with an opportunity to think about how neural process distributed across networks spanning both cortical and subcortical areas allow us to make voluntary choices.

Title: Representation and value learning in the human brain

Nicolas Schuck

Max Planck Institute for Human Development, Berlin, Germany

When learning to make choices, we need to simultaneously learn how to represent our environment and how valuable a particular state of the environment is. In other words, we need to know which features of our environment are relevant for our choices in general, but also which outcomes in particular are associated with each relevant feature. Some previous work has shown that the medial orbitofrontal prefrontal cortex represents relevant states of the environment, while other work has emphasized the role of the same or adjacent ventromedial brain areas in learning values. I will present novel work that speaks to the interaction of value and state information in human behavior, the brain, and neural network models trained with reinforcement learning algorithms. Empirical results indicate that (a) representations of values and states can both be found in ventromedial PFC, (b) the strength of the state representation relates to the strength of the associated value representation and (c) this interaction modulates behavioral conflict between competing value associations.

Metacognition in value-based choice

Alexander Soutschek

Department Psychology, Ludwig-Maximilians-Universität München, Germany

While most research on value-based decision making focusses on how economic preferences determine behavior, also metacognitive beliefs about one's preferences influence choices. For example, decisions about whether to engage in effortful control processes for a goal depend not only on the objective control capacities but also on the subjective confidence in these capacities. So far, however, little is known about how precisely metacognition shapes human choice behavior in healthy and clinical populations as well how metacognition is implemented in the brain. In a series of experiments, we showed that metacognitive insight into economic preferences promotes prospective choices in both individual and social contexts. As neural substrate of metacognition, we identified the frontopolar cortex which causally implements metacognitive processes via functional coupling with brain regions encoding task-relevant information. Lastly, we show that nicotine addiction, besides the well-documented deficits in self-control, is characterized also by reduced metacognitive insight into these self-control processes, which further hampers the capacity to pursue long-term goals in nicotine addiction.

Motivated control as a meta-learning problem: computational, neural and behavioural mechanisms

Eliana Vassena

Donders Institute for Brain Cognition and Behaviour & Behavioral Science Institute, Radboud University Nijmegen, The Netherlands

Adaptive allocation of control is a crucial and widely studied psychological process. To date, one of the most debated question is "*who controls the controller?*". In other words, how does the system adapt to ever-changing environmental and individual needs? How do we choose to put effort in what we do, and deal with variable and unexpected outcomes? We proposed *meta-learning* as the key underlying mechanism: the ability of an agent to interact with the environment, but also to regulate itself. We implemented this theory in a neurocomputational model that combines the ability to select the best actions (through cost-benefit trade-offs), and the ability to boost internal processes required for achieving desired goals. The meta-learning dynamics emerges from recursive loops between medial prefrontal cortex (MPFC) and catecholaminergic nuclei (ventral tegmental area, VTA, and locus coeruleus, LC). This account bridges evidence from psychological theories of motivation with neuroscience of decision-making and control allocation under a single (and neurobiologically plausible) explanatory framework. I will present behavioral, neural and physiological evidence of MPFC and catecholaminergic contribution to adaptive control, with a focus on decision and performance of mentally effortful behavior. Furthermore, I will show how catecholaminergic alterations induced by stress in healthy individuals are linked to changes in this circuit, and discuss simulations showing how impairments in these dynamics may be quantified and used for phenotyping of stress-related disorders.

Silvestrini, Musslick, Berry & Vassena (in press). An integrative effort: Bridging motivational intensity theory and recent neurocomputational and neuronal models of effort and control allocation. *Psychological Review.* doi.org/10.1037/rev0000372

Silvetti, Vassena, Abrahamse & Verguts (2018). Dorsal anterior cingulate-brainstem ensemble as a reinforcement meta-learner. *Plos Computational Biology.* doi.org/10.1371/journal.pcbi.1006370

Vassena, Deraeve. & Alexander (2020). Surprise, value and control in anterior cingulate cortex during speeded decision-making. *Nature Human Behaviour.* doi.org/10.1038/s41562-019-0801-5

Posters (sorted by CRC 940 projects)

A01 **Modulation of the Shielding-Shifting Balance by Instruction and Reward**
Marie Therese Bartossek, Marcus Möschl, Thomas Goschke

A02 **Initial learning of S-R links: Instruction vs. Experience**
Sofia Fregni, Uta Wolfensteller, Hannes Ruge

A06 **Resisting temptation or enduring aversion: two sides of the same coin? – Common and distinct mechanisms of self-control**
Eva Sinning, Thomas Goschke, Franziska M. Korb

A06 **Anticipated emotions in self-control: linking self-control to the ability to engage emotions associated with upcoming events**
Johann D. Kruschwitz*, Thomas Goschke*, Franziska M. Korb, Henrik Walter (*equal contribution)

A08 **Self-structured behavior in an applied cognitive control paradigm**
Peggy Wehner, Judith Herbers, Sebastian Pannasch, Stefan Scherbaum, Caroline Surrey

A08 **Mind and motion: How motoric perturbations affect the processing dynamics in task switching**
Judith Herbers, Caroline Surrey, Stefan Scherbaum

A10 **Rewarding cognitive effort increases the intrinsic value of mental labor**
Christopher Mlynski, Georgia Clay, Franziska M. Korb, Thomas Goschke, Veronika Job

A10 **Honesty is the best policy – but is it intrinsically rewarding?**
Isabelle Caruso, Georgia Clay, Thomas Goschke, Veronika Job, Franziska M. Korb

A11 **Does the thalamus play a role in human goal-directed behavior?**
Chelsea Jarrett, Katharina von Kriegstein, Hannes Ruge, Katharina Zwosta, Uta Wolfensteller

A11 **The Role of the Thalamus in Cognitive Control: an ALE Meta-Analysis**
Midory Higa Diez, Hannes Ruge, Katharina von Kriegstein

B03 Effects of age on forward planning under state transition uncertainty: A reinforcement learning model approach
Sophia-Helen Sass, Lorenz Gönner, Sascha Frölich, Sarah Schwöbel, Johannes Steffen, Dimitrije Markovic, Stefan Kiebel, Franka Glöckner, Shu-Chen Li, Michael N. Smolka

B03 Dopamine differentially modulates spatial learning and memory in young and older adults
Christian Bäuchl, Franka Glöckner, Christoph Koch, Johannes Petzold, Nicolas W. Schuck, Michael N. Smolka, Shu-Chen Li

B05 Modulation of self-control by acute and chronic stress
Jasmin Stein, Franziska Korb, Eva Sinning, Clemens Kirschbaum, Thomas Goschke, Katharina Zwosta

B06 Cognitive effort investment under varying demand and payoff: Results from electroencephalogram and pupil dilation
Corinna Kührt, Sven Graupner, Philipp Paulus[1], Alexander Strobel
[1] Department of Psychology, University of Freiburg, Freiburg

B07 Examining the influence of reward and efficacy in development of the expected value of control
Theresa H. McKim, Romy Frömer[1], Mahalia Prater Fahey[1], Amitai Shenhav[1], Benjamin Eppinger, and Andrea Reiter[2]
[1] Brown University; [2] University Hospital Würzburg

B08 En route of unveiling the neural factors that modulate the interaction of controlled and automatic processes
Anna Helin Koyun, Ann-Kathrin Stock, Christian Beste, Veit Rößner

C01 Beyond dual systems: Neural activity in monitoring, cognitive control, and valuation networks predicts real-life self-control failures
Thomas Goschke, Max Wolff, Holger Mohr, Anja Kräplin, Juliane Fröhner, Michael Smolka, Gerhard Bühringer, Martin Krönke

C03 Altered Midbrain Coding for the Subjecitve Value of Cognitive Effort in Acute Anorexia Nervosa
Joseph A. King, Fabio Bernardoni, Andrew Westbrook, Daniel Geisler, Sophie Pauligk, Franziska M. Korb, Corinna Kührt, Alexander Stroebel, Stefan Ehrlich

C03 Behavioral and pupillometric investigations of the intrinsic value of cognitive effort in anorexia nervosa patients and healthy controls
Joseph A. King, Isabelle Caruso, Franziska Gronow, Luisa Boldt, Franziska M. Korb, Ilka Böhm, Sebastian Pannasch, Inger Hellerhoff, Frances Lemme, Maria Seidel, Stefan Ehrlich

C05 **The cost of fear: Impairments of decision making in specific phobia**
Esther Seidl[1,2], Ulrike Senftleben[1], Lieselotte Leonhardt[1], Kevin Hilbert[1,3], Stefan Scherbaum[1], Markus Mühlhan[4], Katja Beesdo-Baum[1], Judith Schäfer[1]
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C06 **The effects of gain and loss avoidance context on feedback processing in a flanker task**
Rebecca Overmeyer, Raoul Dieterich & Tanja Endrass

C07 **Developing a measure of social self-control and examining its relationship with theory of mind and empathy**
Alexander Giesche, Philipp Kanske

Z02 **Model Comparison identifies dorsal Anterior Insula as a Core Salience Attribution Region**
Michael Marxen, Johanna E. Graff, Philipp Riedel, and Michael N. Smolka

Z02 **Reliability of Dynamic Resting State fMRI Parameters based on Two Brain States**
Xiaojing Fang, Marco Bottino, and Michael Marxen

Z02 **Dynamic transition from integrated to segregated brain states during habit formation**
Xiaoyu Wang, Katharina Zwosta, Uta Wolfensteller & Hannes Ruge

NIC **Societal addictions: An outlook on transdisciplinary concepts for the 21st century**
Charlotte M. Grosskopf

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