Currently funded projects

SAVe – Teilprojekt: Gesellschaftliche Aspekte des automatisierten und vernetzten Fahrens /

subproject: Social acceptance of automated and connected driving

Principal Investigators: Prof. Dr. Marco Steinhauser, Prof. Dr. Andreas Riener, Prof. Dr. Jens Hogreve
Duration: 2018 - 2020
funded by: BMVI, Federal Ministry of Transport and Digital Infrastructure
Link to project Homepage

Project description:
Public acceptance of automated driving critically relies on the perceived safety benefits of this technology as well as its potential to allow passengers to engage in non-driving related tasks (NDRTs). It is unclear, however, under which conditions passengers in an automated vehicle can comfortably and efficiently engage in NDRTs. Likewise, there is still a knowledge gap as to which variables might increase trust in an automated vehicle. Our lab will approach these interdisciplinary research questions in cooperation with various partners, including the Technische Hochschule Ingolstadt (Prof. Dr. Andreas Riener), the Ingolstadt School of Management (Prof. Dr. Jens Hogreve), and the AUDI AG (project leader SAVe). For example, using physiological measures (e.g., EEG), we will conduct experiments in a simulated driving environment to establish the role of motion sickness for engaging in NDRTs during automated driving. This and other studies aim to develop novel methods to measure social acceptance of automated driving and to derive implications for the design of automated vehicles.

Causes and Consequences of Errors in Dual-Tasking II.

Principal Investigator: Prof. Dr. Marco Steinhauser
Duration: 2018 - 2021
funded by: DFG, German Research Foundation
Link to DFG project page (German only) - **Link to project Homepage**

Project description:
Efficient task performance requires an error monitoring system that detects errors and initiates control adjustments in order to prevent further errors. These mechanisms are even more important when multiple subtasks are executed simultaneously or in rapid succession as interference between subtasks makes dual-tasking performance particularly error-prone. The present project investigates how reliable error monitoring under dual-tasking is achieved, and how errors can be prevented by adaptive cognitive control processes. The project focusses on four research questions: First, we investigate how errors on the subtask-level and dual-task-level are simultaneously monitored. Second, we ask how the error monitoring system solves the credit assignment problem that emerges when multiple error signals have to be correctly assigned to their corresponding tasks. Third, we address how dynamic changes of visual attention following errors contribute to adaptive control adjustments and error-induced interference. And finally, we examine how successful dual-tasking performance is achieved by advance preparation. Our methodological approach is to analyze behavioral data and event-related potentials in the Psychological Refractory Period paradigm. Our studies aim to improve our basic understanding of the architecture of error monitoring and the operation of cognitive control under dual-tasking.

Adaptive control of working memory.

Principal Investigators: Prof. Dr. Marco Steinhauser, Prof. Dr. Miriam Gade
Duration: 2018 - 2021
funded by: DFG, German Research Foundation
Link to DFG project page (German only)

Project description:
Human working memory (WM) is a highly flexible system optimized for guiding goal-directed (cognitive) actions. However, the flexibility of WM comes at the cost of a strict capacity limitation, requiring that the content of WM is continuously adapted to ongoing retrieval demands. The present project investigates how this is achieved by mechanisms of adaptive cognitive control. We focus on three well-known phenomena from the cognitive control literature: frequency congruency effects, congruency sequence effects, and post-error adjustments. These three effects have previously been used to describe how adaptive cognitive control balances attention to relevant and irrelevant stimuli in the environment. Here, we consider equivalent effects in declarative WM tasks to investigate how WM content is continuously adapted to future retrieval demands. Using behavioral and EEG studies, we seek to examine (1) on which representational levels, declarative WM content is adaptively adjusted during phases of encoding and maintenance, (2) how proactive and retroactive control processes achieve this adaptiveness, and (3) whether the monitoring of errors and conflicts contribute to this ability in the same way as in adaptive control of attention. Finally, the project aims to advance existing computational models of WM by including and validating conflict-based adaptive control mechanisms.

Mensch in Bewegung – Teilvorhaben: Akzeptanz automatisierten Fahrens/Subproject: Acceptance of automated driving.

Principal Investigators: Prof. Dr. Andreas Riener, Prof. Dr. Marco Steinhauser
Duration: 2018 - 2021
funded by: BMBF, Federal Ministry of Education and Research
Link to BMBF project page (German only) - **Link to Project Homepage**

Project description:
Automated driving will play a crucial role in future mobility. Since 2016, Ingolstadt is one of only seven German model regions, where automated driving is tested in daily traffic. In an interdisciplinary transfer project (engineering, psychology), chances and risks of this emerging technology will be explored and critically investigated. Specific project goals are to study conditions for societal acceptance, and to improve acceptance and understanding of this technology via outreach and dialogue activities. To this end, a roadshow will be conducted using a mobile driving simulator, in which citizens will experience automated driving as well as the specific opportunities and limitations of this future technology. This setting will also be used to collect data on individual behavior, desires, user acceptance and system trust. The project results will help to support local companies in advancing automated driving and to strengthen Germany as a lead market for automated and connected driving.

Interplay of cognitive control in behavioral and neurophysiological correlates: Towards an understanding of control in human behavior.

Principal Investigator: Dr. Alodie Rey-Mermet
Duration: 2016 - 2019
funded by: SNF, Swiss National Science Foundation
Link to SNF project page (German only)

Project description:
Our society increasingly requires us to be multitaskers in everyday life, such as answering a phone call while driving or scheduling meetings during cooking. Due to this, we encounter frequent situations in

which we face multiple conflicts at the same time that require rapid decisions regarding how to react according to our current goals. To resolve these concurrent conflicts, we implement cognitive control processes. Cognitive/executive control is among the core cognitive processes because it allows us to adapt to environmental changes in a fast and flexible way. The processes behind such adaptability include focusing attention on the relevant information as well as inhibiting competing alternatives or habitual responses. Investigating the question of how cognitive control processes are implemented and how they interact is, therefore, an important pre-requisite towards understanding human behavior. The purpose of this project is to contribute to this endeavor. In cognitive psychology, control processes are investigated by presenting incongruent stimuli (i.e., stimuli which induce a conflict between response alternatives). For instance, a stimulus is incongruent when the color word “green” is printed in red (Stroop), when the stimulus is associated with a left key-press but is presented on the right side of the screen (Simon), or when the relevant stimulus is flanked by irrelevant characters (Flanker). Responding to incongruent trials requires us to activate goal-relevant features (e.g., the color “red”, the left key-press or the central stimulus, respectively) and inhibit irrelevant ones (i.e., the word meaning “green”, the right side, or the irrelevant characters, respectively). Recent research has highlighted different inhibition processes (Stahl et al., 2014). However, it is unclear how these different inhibition processes interact to allow a rapid and goal-appropriate adjustment of control when multiple conflicts are presented concurrently. So far, only a few studies have addressed this question by combining two conflict tasks. For example, the Stoop task was paired with a Simon task by presenting the color words on either the right or left side (e.g., Hommel, 1997, Kornblum, 1997, Wendt, Kluwe, & Peters, 2006). The results were mixed. Some studies found no interaction between the control processes deployed to solve the two conflicts (e.g., Hommel, 1997; Kornblum, 1994). In contrast, other studies found an interaction such that inhibiting the irrelevant information of one conflict facilitates the processing of the other conflict (Hommel, 1997, Wendt et al., 2006). Critically, when the stimulus set size for each task was large enough to discourage the use of episodic memory processes to perform the task, the results revealed an interaction between the conflicts, irrespective of the conflict combination (i.e., Stroop with Flanker, Stroop with Simon, or Flanker with Simon; see Rey-Mermet & Gade, 2016). The purpose of the present project is to use behavioral measures as well as event-related potentials (ERPs) in order to investigate how responding to multiple conflicts within the same trial results in an interaction of control processes. To this end, the first part of the project is designed to determine to what extent this interaction results from a temporal, verbal or spatial overlap in the processes underlying task performance. In the second part, the aim is to discover the processes responsible for the interplay of cognitive control. Specifically, the focus will be on disentangling the impact of conflict detection and control implementation by means of ERPs, then on the contribution of stimulus/response frequency, and finally on the precise role of inhibitory processes. In sum, the overall goal is to advance our understanding of flexible adjustments of cognitive control processes, especially in situations that require handling of multiple conflicts at the same time.

Completed projects

Causes and Consequences of Errors in Dual-Tasking I.

Principal Investigator: Prof. Dr. Marco Steinhauser
Duration: 2015 - 2018
funded by: DFG, German Research Foundation
Link to DFG project page (German only) - **Link to project Homepage**

Project description:
Efficient task performance requires a performance monitoring system that detects errors and initiates control adjustments in order to prevent further errors. These mechanisms are even more important when multiple subtasks are executed simultaneously or in rapid succession. Under these conditions, interference between subtasks can emerge which makes dual-tasking performance particularly error-

prone. The present project investigates the relationship between errors and cognitive control in dual-tasking by addressing three research questions: First, we ask how errors induce short-term control adjustments that prevent further errors and optimize performance. Second, we ask how performance monitoring and control-adjustments in one subtask interfere with processing in another subtask, thus leading to error propagation. Finally, we ask how failures of preparation cause errors and how preparation is adjusted in response to errors to prevent further errors. To achieve this, we analyze behavioral data and event-related potentials in the Psychological Refractory Period paradigm. Our studies aim to improve our understanding of how errors emerge and how cognitive control operates in dual-tasking. Based on our results, we hope to derive recommendations how learning from errors can be optimized in applied dual-tasking scenarios.

Publications:
Steinhauser, M., Ernst, B., & Ibald, K. W. (2017). Isolating component processes of post-error slowing with the psychological refractory period paradigm. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, 43, 653-659.

The influence of top-down control on feedback processing and reinforcement learning in decision tasks.

Principal Investigator: Prof. Dr. Marco Steinhauser
Duration: 2014- 2016
funded by: DFG, GermanResearch Foundation
Link to DFG project page (German only)

Project description:
Evaluation of external feedback is an important prerequisite for optimal decision-making. Feedback allows for improving future decisions by taking the consequences of past decisions into account. In recent years, learning from feedback has been considered within the theoretical framework of reinforcement learning. That is, feedback has been viewed as a reinforcer that leads to the adjustment of stimulus-response associations involved in a decision. Evidence for this comes from studies that examined feedback using event-related potentials (ERPs). The feedback-related negativity (FRN), a negative deflection elicited by negative feedback, has been shown to reflect a prediction error that is used as a learning signal for the adjustment of behavior. The present project aims to investigate whether and how the FRN - and thus reinforcement learning due to feedback - is influenced by top-down control. In the planned experiments, participants are instructed about the validity of feedback. This creates a situation in which learning from feedback is more or less beneficial, and hence, in which reinforcement learning should be more or less modulated by top-down control. By applying formal models of reinforcement learning to empirical data, we aim to describe the interaction between these top-down effects and reinforcement learning. Further experiments will be conducted to reveal how mechanisms like proactive control or selective attention contribute to top-down control. On the one hand, our studies aim to provide an answer to the classical question whether reinforcement learning can be influenced by cognitive processes. On the other hand, we hope to validate and improve current models of reinforcement learning by taking cognitive processes into account.

Publikations:
Ernst, B. & Steinhauser, M. (2017). Top-down control over feedback processing: The probability of valid feedback affects feedback-related brain activity. *Brain & Cognition*, 115, 33-40.

Evaluation of error source in human performance monitoring: Validating a model using behavioral, electrophysiological and patient studies

Principal Investigator: Dr. Martin Maier
Duration: 2014- 2017
funded by: DFG, GermanResearch Foundation
Link to DFG project page (German only)

Project description:

Recent evidence suggests that the human brain is capable of an extremely rapid but yet highly specialized evaluation of the source of behavioral errors. The output of this process can be used for an efficient optimization of performance. The present project investigates the mechanisms underlying this ability by testing predictions of a novel model of performance monitoring that assumes an early evaluation process based on cognitive and affective heuristics and a late evaluation process based on working memory processing. In several series of experiments, electrophysiological markers (error-related brain potentials like the Ne/ERN) and behavioral markers of error evaluation (post-error adjustments of behavior, error classification responses) are used to validate the model in paradigms in which errors due to different sources can occur. In a collaboration study, patients with focal lesions of the rostral anterior cingulate cortex are examined to reveal the role of affective processes for the evaluation of error source. The results of the project should contribute to our understanding of performance monitoring mechanisms.

Publikations:

Maier, M. E., & Steinhauser, M. (2017). Working memory load impairs the evaluation of behavioral errors in the medial frontal cortex. *Psychophysiology*, 54, 1472-1482.

Di Gregorio, F., Steinhauser, M., & Maier, M.E. (2016). Error-related brain activity and error awareness in an error classification paradigm. *Neuroimage*, 139, 202-210.

INEMAS - Grundlagen interaktions- und emotionssensitiver Assistenzsysteme/Basics of interaction- and emotion-sensitive assistance systems.

Principal Investigators: Prof. Dr. Marco Steinhauser, Prof. Dr. Dr. Björn Niehaves (Siegen); Prof. Dr. Xiaoyi Jiang (Münster); Dr. Martin Wimmer (AUDI AG); Dr. Jörg Monschau (Spiegel Institut Mannheim GmbH & Co. KG);

Duration: 2015- 2018

funded by: BMBF, Federal Ministry of Education and Research

Link to BMBF project page (German only)- **Link to project homepage** (German only)

Project description:

Assistenzsysteme dienen der Unterstützung des Menschen bei der Nutzung von technischen Geräten und Maschinen. Dabei werden zentrale Aspekte der menschlichen Interaktion jedoch oft nicht bedacht. Herkömmliche Assistenzsysteme erlauben kaum nutzerspezifische Anpassungen und lassen emotionale und soziale Informationen des Nutzers unberücksichtigt.

Das Ziel von INEMAS ist die Erforschung sozialer und emotionaler Fahrerzustände und deren nutzbringende Integration in Fahrerassistenzsysteme. Diese sollen durch eine nutzerzentrierte Individualisierung adaptiv auf emotionale, soziale und kognitive Zustände des Fahrers reagieren. In einem interdisziplinären Ansatz wird untersucht, wie unter Berücksichtigung von ethischen Aspekten, Datenschutz und Nutzerakzeptanz Informationen über soziale Interaktionen und Emotionen erfasst und in Assistenzsysteme integriert werden können. Hierzu werden Algorithmen zur Mustererkennung entwickelt und Zusammenhänge von Emotionalen oder sozialer Interaktion mit Kognition und Fahrleistung untersucht. Unter Einbezug der Forschungsergebnisse wird ein adaptives Nutzermodell entwickelt, das auf Basis des emotionalen Zustands des Fahrers und sozialer Interaktionen im Fahrzeug Vorhersagen über kognitive Parameter und damit die Fahrleistung des Fahrers macht. Hierdurch werden Grundlagen für die Integration sozialer und emotionaler Informationen in adaptive und nutzerzentrierte Assistenzsysteme geschaffen.

Verbal and non-verbal control settings in action control: Configuring the cognitive system for present and future task performance.

Principal Investigator: PD Dr. Miriam Gade

Duration: 2016- 2018

funded by: DFG, German Research Foundation; continued at the Medical School Berlin

Link to DFG project page (German only)

Projectdescription:

Cognitive control ensures our successful achievement of goals. Models of action control assume automatic as well as controlled processes to ensure successful completion of goal-directed actions. These two modes of action control differ in the use of language and associative learning. Next to differential involvement of control processes in actual task performance, the two control settings under investigation in this project, namely verbal and non-verbal ones, are assumed to lead to differential learning and expertise. Verbal control settings are control settings relying on language, comprising processes such as self-instruction and rather abstract, symbolic representations. In contrast, non-verbal control settings make use of formerly learnt associations and lead to the formation of episodic memory traces. Cognitive control processes and their flexible adaption to situational constraints have been studied using the task-switching paradigm, for example. In a task-switching situation, people encounter at least two tasks and are asked to alternate between them as indicated by valid task cue next to other tasks, such as the Stroop task. In a first series of experiments, we will investigate how situational characteristics such as task, cues and stimuli lead participants to adopt one or the other control setting in a current situation. Moreover, we are interested in how different control settings lead to differential learning to achieve expertise/skills. We expect that verbal control settings lead to faster learning, but also less flexibility in case of a goal change. Non-verbal control settings, on the other hand will take longer to achieve automatization, yet might lead to larger congruency effects exploiting seemingly irrelevant information. In a second series of experiments, we plan to identify the neural underpinnings of verbal and non-verbal control settings using event-related potentials (ERPs). Furthermore, the impact of semantic relatedness between cues and tasks on task performance will investigated. In series 3, we will investigate how individual differences in intelligence, working memory capacity and self-directed speech affect the choice of verbal and non-verbal control settings. This series will investigate the choice of control settings to solve cognitive tasks (i.e., Stroop or Flanker) as an individual difference next to contextual triggers. In the final series we will investigate the impact of lifelong training by testing bilingual and monolingual participants. We assume that the constant need to manage two languages leads bilinguals to adopt the verbal control mode constantly and therefore one qualifying condition of bilingualism might be a reduced flexibility in the adaption of control settings because of the dominance of verbal control settings. In sum, we suggest four series of experiments to broaden our understanding of the flexibility of cognitive control and its modulating conditions and the achieved skill formation.