Social Agency and Temporal Binding in Mental Disorder

Inaugural Dissertation

zur

Erlangung des Doktorgrades
medicinae doctor/philosophiae doctor (MD/PhD) in Health Sciences
der Medizinischen Fakultät
der Universität zu Köln

vorgelegt von
Dr. med. David Heinz Victor Vogel
aus Koblenz

Köln

2024

Betreuer:	Prof. Dr. Dr. Kai Vogeley
Gutachter*in:	Prof. Dr. Martin Hellmich
	Prof. Dr. Elke Kalbe
Datum der Mündlichen Prüfung:	19.02.2024

Table of contents

1. **Introduction**

1.1 Sense of Agency

Whenever we perform an act – whenever we do something – we experience a degree of intention, control, and responsibility. Imagine a person throwing a stone through a window. If we were the to ask the stone thrower: “What broke the window?”, the correct answer might be: “A stone broke the window”. However, any honest stone thrower would surely respond: “I broke the window with a stone”. Although the person did not immediately break the window, but used a stone, the responsibility undoubtedly lies with them. This assumption of responsibility stems from our inherent sense of being in control over our own bodily actions and the experience of being able to cause change in our surroundings through these actions.

This sense of intending and performing actions as well as causing their outcomes is referred to as the Sense of Agency (SoA) (Gallagher, 2012; Haggard, 2017). With it we influence and shape our environment through our actions and our behavior (Gallagher, 2012). It is as a SoA that we experience ourselves in control and as living our own lives. Without SoA we would be unable to appreciate ourselves as self-motivated, striving, and progressing individuals (Gallagher, 2007; Haggard, 2017).

1.2 Social Sense of Agency

SoA informs us about our status as individual, responsible subjects and helps us discriminate ourselves from other agentic subjects (“persons”) and non-agentic objects (“things”) (David et al., 2008a). With our example: When someone breaks a window with a stone, any onlooker watching the scene would have to agree that it had been the stone thrower who was responsible for breaking the window – not the stone. Hence, agency is not exclusively ascribed to me, but automatically and immediately also to other persons.

Furthermore, the observers of the stone throw are aware that it was not them who threw the stone and broke the window. They know, they were not the agent responsible for breaking the window. This SoA-mediated capacity for self-other-discrimination is an essential prerequisite for the coordination and cooperation between two persons (David et al., 2008a; van der Wel, 2012; Pfeiffer et al., 2012, 2013; Recht & Grynszpan, 2019). If two persons wanted to carry a large rock, too heavy for one of them to carry alone, each person would have to rely on the agency

of the other to successfully move the rock. To properly coordinate the act, both agents must consider the independency of the other to reach the common goal. Both persons are not isolated agents carrying a rock but are participating in a behavior requiring cooperation and a “sense of joint agency”, or “We-agency” (Dewey et al., 2014; van der Wel, 2015; Bolt et al., 2016; Loehr, 2018).

For such interactions to be recognized as successful, it is vital that both agents judge their communicative and cooperative behavior as successful and adjust their strategy accordingly. As the preparation, implementation, and execution of such strategies depend directly on the (inter-)acting agents’ knowledge about their own capabilities and responsibilities within the cooperative effort, it is obvious that their SoA provides indispensable information. With cooperation as a driving factor of joint agency, the spatio-temporal predictability of joint actions and their outcome has repeatedly been implicated as crucial for its emergence (Sato, 2009; Vesper et al., 2011, Pfeiffer et al., 2012; Bolt & Loehr, 2017; Glover & Dixon, 2017; Sahaï et al., 2017; Brandi et al., 2019).

1.3 Temporal Binding

SoA is mostly assessed *explicitly* – experimentally through trial-by-trial questions (e.g., Sato & Yasuda, 2005; Ebert & Wegner, 2010) and more broadly through questionnaires (e.g., Polito et al., 2013; Tapal et al., 2017). A measurable *implicit* correlate to agency has been identified in the temporal binding (TB) between voluntary actions and their consequences (Haggard et al., 2002; Engbert et al., 2007; Moore & Obhi, 2012). In the experimental setting, when participants are asked to judge the duration of time intervals between an agentic, self-performed action (e.g., a key press) and its consequence (e.g. a tone), as compared to judging the duration between two arbitrary events (e.g., two tones) not involving a self-performed action, across trials and across the experimental group, the interval involving self-performed action will be estimated as having been shorter than the one not involving voluntary action (Engbert et al., 2007; for review see Moore & Obhi, 2012). Hence, when I perform an action, the time until its outcome will appear to me as shorter than other durations of the same length.

Although the size of the effect is weakened in correlation to the belief in and the presence of intention (Moore & Obhi, 2012), TB may occur in contexts not involving action-event succession. Recent findings demonstrate that TB corresponds to causation, predictability, and the underlying involvement of neural multisensory

processes (e.g., Buehner, 2012; Kirsch et al., 2019; Suzuki et al., 2019; Hoerl et al. 2020; Weller et al., 2020). In summary, TB occurs whenever the succession of two events is causally relatable. Under the assumption that the second event is likely to happen, causally related events separated by a short time window – the so-called temporal binding window – are processed simultaneously, although the second event has not occurred yet (Jagini, 2012). The more predictable the event sequence is, the larger the measurable TB will be (Cravo et al., 2011; Ruess et al., 2011).

Predictability is enhanced by the amount of information available about the two events (Teufel & Fletcher, 2020). Action-event sequences – agentic sequences – pose a special subset of such causality sequences. Their distinctive feature being that (intentional) action involves a maximum of information, such as prior top-down information e.g., planning of the action and its outcome, as well as bottom-up perceptual information e.g., proprioception, visual information, haptic information, etc. In other words, due to the larger amount of knowledge involved in self-performed action, their expected outcomes are more predictable (Buehner, 2012; Hoerl et al. 2020). The increased predictability in turn causes a larger TB.

Corresponding to SoA, actions-event structures involving social behavior influence TB. The effect is stronger when performing actions in cooperation with others (Obhi & Hall, 2011a; Grynszpan et al., 2019; Sahaï et al., 2019), when leading others as compared to following orders (Pfister et al., 2014), during eye contact, and when manipulating eye movements (Stephenson et al., 2018; Ulloa et al., 2019). Just as with TB outside of social situations, the stable occurrence of the effect during social interaction corresponds to two factors. One, it is primarily measurable during interactions involving a stable SoA. Second, it demonstrates the influence of social information and social stimuli on action-effect-processing.

Concerning social information during the processing of action-event sequences, the current literature has failed to investigate whether there exists a difference between the influence of top-down social knowledge and bottom-up social stimulation for the emergence of TB. Some studies investigated the influence of knowingly performing an action with someone else (Obhi & Hall, 2011a; Pfister et al., 2014; Grynszpan et al., 2019; Sahaï et al., 2019), while other studies investigated the effect of manipulating social pictures (Stephenson et al., 2018; Ulloa et al., 2019), e.g., faces. In conclusion, TB occurs both when performing actions with another human, as well as when performing an action alone with something that has human

appearance. Yet, concerning the emergence of TB, the relationship between the two factors – being human versus appearing human – has not been directly investigated.

1.4 Sense of Agency and Mental Health

As it is a basic constituent of human experience and behavior, we are usually not aware of our agency and do not experience SoA constantly. It is part of our natural self-evidence (Blankenburg, 1971) and hence, is implicit to our self-experience. While SoA may be different during varying situations, such as e.g., under pressure or under coercion (Caspar et al., 2016; Liu et al., 2023), its natural self-evidence as being an author of actions and outcomes is always implicitly present. During phases of mental disorder however, the natural self-evidence of experience may weaken (Blankenburg, 1971).

Hence, it comes as no surprise that disturbances in SoA have consistently been observed in different mental disorders (Fuchs, 2010; Friston, 2012; Haggard, 2017). Various psychopathological phenomena can be reconstructed as involving SoA disturbances. For example, delusions or phenomena related to ego-psychopathology observable during schizophrenia can be understood as a loss of SoA (Gallagher 2015). The lack of self-efficacy in Major Depressive Disorder (MDD) has also been labeled or described as a loss of agency (Bandura & Locke, 2003; Slaby et al., 2013). The clinical definitions of obsessions and compulsions in Obsessive-Compulsive Disorder (OCD) and of tics in Tourette's Syndrome (TS) as ego-dystonic (e.g., Cummings & Frankel, 1985; Rasmussen & Eisen, 1992) can also be understood as symptoms resulting from a loss of SoA.

All these exemplary alterations in SoA include a component of intersubjectivity. In schizophrenia, the delusional patient loses their SoA with respect to another person or personified entity (Scharfetter, 1981; Frith, 2005). Loss and acquisition of self-efficacy in depression are hypothesized to develop based on the comparison with others (Alloy et al., 1987; Ahrens et al., 1988; Maddux & Meier, 1995). Tic symptoms often aggravate while being observed (Staley et al., 1997).

Relative to SoA, TB has not been systematically studied in mental disorders. Research has been limited mostly to schizophrenia (for a recent review see Moccia et al., 2023), where the data suggests a more pronounced TB. Albeit the lack of patient data, TB tasks pose a major advantage for mental health research.

As TB is an *implicit* correlate of SoA, participants do not need to be made aware of their SoA to answer explicit questions about it. As Agency and its alteration occur self-evidently and implicitly, TB allows for a potentially less confounded approach to SoA in mental disorder. It further provides information about the predictive processing of action-event sequences. Both SoA as well as predictive processing have repeatedly been implicated as decisive targets for better understanding, diagnosing, and treating mental disorder (De Vignemont & Fourneret, 2004; Moore & Fletcher, 2012; Moore, 2016; Haggard, 2017).

Studies addressing the social dimension of SoA as measurable by TB and its interconnection with mental disorders are lacking entirely. Disorders of social cognition, such as ASD, offer unique additional insight into SoA and social behavior, as the current literature find no disturbance of SoA in ASD (David et al., 2008b), but altered TB as compared to individuals without ASD (Sperduti et al., 2014).

Herein, I present an experimental research paradigm performed in two studies consisting of four experiments. The first study performed with healthy, typically developed participants answers the question about the relationship between top-down social belief and bottom-up social perceptual input. As a showcase this knowledge is applied to participants with and without ASD in the second study to investigate the implicit differences in social SoA and TB between the two groups. I will discuss the results and the paradigm in terms of their applicability to other mental disorders.

2. Original Publications

This cumulative thesis includes the following publications:

1. **Vogel, D.H.V.**, Jording, M., Esser, C., Weiss, P.H., & Vogeley, K. (2021). Temporal binding is enhanced in social contexts. *Psychonomic bulletin & review*, 28(5), 1545-1555.

2. **Vogel, D.H.V.**, Jording, M., Esser, C., Conrad, A., Weiss, P.H., & Vogeley, K. (2022). Temporal binding of social events less pronounced in individuals with Autism Spectrum Disorder. *Scientific Reports*, 12(1), 14853.

The contributions of all authors to the individual publications are detailed in appendix section 7.1.

2.1 Temporal binding is enhanced in social contexts

Vogel, D.H.V., Jording, M., Esser, C., Weiss, P.H., & Vogeley, K

Published in Psychonomic bulletin & review, Volume 28(5), pp. 1545-1555.

2.2 Temporal binding of social events less pronounced in individuals with Autism Spectrum Disorder

Vogel, D.H.V., Jording, M., Esser, C., Conrad, A., Weiss, P.H., & Vogeley, K

Published in Scientific Reports, Volume 12(1), p. 14853.

3. **Discussion**

3.1 General Discussion

The two studies presented herein consist of three experiments. The first experiment is identical in the two studies and serves as a baseline investigation into the behavior of TB during social interaction. In natural, ecological, and non-virtual situations, social interaction is performed with other persons appearing to us as persons. Accordingly, the experiment presented a face stimulus (appearance) and made use of a cover story (person), meaning that participants were made to believe to be interacting with another person during the experiment while seeing a face (see Vogel et al., 2021, p.1547-8; and Vogel et al., 2022, p.3-4). Interactions with this belief-saturated face stimulus were compared to non-social interactions with a scrambled face (i.e., a field of geometric structures without resemblance of a face).

In both studies, the respective first experiment shows what I have termed *social hyperbinding*. Duration judgements for action-event latencies were relatively smaller for social events, as compared to non-social events (see Vogel et al., 2021, p.1549, Figure 3; and Vogel et al., 2022, p.6, Figure 3) in the sense of larger TB for social situations. Social hyperbinding synthesizes the earlier results on TB for interactions actions with another person (Obhi & Hall, 2011b; Pfister et al., 2014; Grynszpan et al., 2019) and interactions with things of face-like appearance (Stephenson et al., 2018; Ulloa et al., 2019).

The first experiment establishes social hyperbinding for actions involving a combination of top-down social belief and bottom-up social perceptual input. To uncover the relationship between these two influences we performed a second experiment with typically developed, healthy participants in Vogel et al., 2021. This experiment compared interactions with a non-face stimulus (non-social baseline) with interactions with a non-face stimulus enriched with a cover story (top-down social belief), with interactions involving a face stimulus (bottom-up social stimulus), and with interactions with a combination of the two (bottom-up and top-down) (see Vogel et al., 2021, p.1547, Figure 1b).

The results confirm social hyperbinding for all social interactions as compared to the baseline condition (see Vogel et al., 2021, p.1551, Figure 4). Interestingly, there was no detectable difference between the three social conditions (top-down social belief, bottom-up social stimulus, bottom-up and top-down). This suggests that

any form of social information leads to social hyperbinding with no difference between nor additive effect with top-down and bottom-up information.

Taken together, I interpret these results from Vogel et al. (2021) and their partial replication in the first experiment in Vogel et al. (2022) as reflecting an increase in predictive action-effect monitoring brought on by additional social information. In line with the introductory statements on the connection between TB and SoA, this means that the resulting improved prediction stands in connection with an increased implicit SoA. This in turn may constitute an underlying component of an experience of joint agency.

In other words, during cooperative interactions we are better at predicting our interactants behavior, as compared to predicting physical, non-personal events. This betterment in prediction is both brought on by appearing human as well as by being human, as we have more specific assumptions and make more specific predictions when directing our behavior at a face or at another person. In Vogel et al. (2021) I support the theory that the increase in predictability brought on by additional social information relates to research arguing that such processes underlie successful cooperation (Sato, 2009; Vesper et al., 2011, Pfeiffer et al., 2012; Bolt & Loehr, 2017; Glover & Dixon, 2017; Sahaï et al., 2017; Brandi et al., 2019) and reduce the unpredictability of human behavior (Pfister et al., 2020).

The second study, Vogel et al. (2022), performs the baseline experiment presenting a face stimulus (appearance) and simultaneously using a cover story (person) not only with typically developed individuals but also with participants with ASD. The results indicate social hyperbinding for the group with ASD (see Vogel et al., 2022, p.6, Figure 3). Yet, hyperbinding turns out smaller when compared to the group without ASD.

A following second experiment in Vogel et al. (2022) examines the influence of top-down information – belief in the presence of another person – on social hyperbinding in ASD. First, the experiment's results reproduce parts of Vogel et al. (2021), confirming that social hyperbinding occurs with the introduction of belief in the presence of another person (see Vogel et al., 2022, p.9, Figure 4). Second, they again show a reduced TB for individuals with ASD.

Overall, I interpret these results as indicating a reduced influence of social information on action-event binding in ASD. Interestingly, participants with ASD

showed detectable TB for social action-event sequences. This denotes an existing influence of social processing on the effect's emergence. Yet, individuals with ASD seem to integrate and process to a lesser degree the available information.

To explain the emergence of hyperbinding in either group, both studies (Vogel et al., 2021, 2022) conclude that social top-down information equates to an activation of mentalizing processes (Vogeley 2017). The inception of the presence of an interaction partner (cover story conditions) causes the assumption of acting in cooperation with another agentic human being with their own motivations. This assuming another person with their own mental state – mentalizing – constitutes the additional information improving action-event processing and hence increasing TB to social hyperbinding and arguably engendering a sense of joint agency.

This interpretation is in line with a mentalizing deficit in ASD (Chung et al., 2014; Fishman et al., 2014; Vogeley, 2017). However, the studies presented herein did not take measurements of mentalizing abilities. If future investigations discover mentalizing and its deficit as a correlate to social hyperbinding and its relative decrease, the paradigm designed for these studies may serve as a tool for the measurement of mentalizing deficits. Additionally, future experiments might include mentalization training to investigate a direct effect of improving mentalizing on increasing social hyperbinding.

Two studies on ASD and TB did not find a consistent reduction of the effect (Sperduti et a., 2014; Finnemann et al., 2021). The results from Vogel et al. (2022) therefore suggest that the processes underlying TB are not overall impaired but specific to certain contexts, e.g., social interactions. An open question in the case of ASD remains whether this impairment concerns primarily the influence of top-down belief or may also be caused by bottom-up social stimuli alone. Furthermore, some have claimed that information processing is not primarily different in individuals with ASD, even when it concerns social information. The claim states that social information is simply composed of highly complex information and that individuals with ASD process complexity differently from those without ASD (Gepner & Féron, 2009; Hohwy et al., 2016; Vogel et al., 2019). Future investigation including TB paradigms could hence be directed at including various types of top-down and bottom-up information with differing complexity and comparing them to effects of social information.

In conclusion, Vogel et al. (2021) establish a paradigm for the systematic investigation of TB as a correlate to implicit agency and multisensory action-effect processing during social interactions. Vogel et al. (2022) establish its applicability and usefulness to mental health research. In the following we will extend on its implications and make suggestions for its implementation.

3.3 Limitations

The results from the paradigm introduced in Vogel et al. (2021, 2022) and their interpretation are limited by methodological constraints needing to be addressed. Predictive neural processes pose the assumed underlying mechanism of TB (Buehner, 2012; Kirsch et al., 2019; Suzuki et al., 2019; Hoerl et al., 2020; Weller et al., 2020). This is in contrast to earlier theory proposing TB to be a specific correlate to SoA (for review see Moore & Obhi, 2012). Where the former proposes that an increase in predictive action-effect monitoring increases TB, the latter assumes that "more" SoA strengthens TB.

As stated in the introduction, TB is present whenever agentic actions are performed (Moore & Obhi, 2012). Although this makes TB ideal to quantify SoA implicitly, the paradigm presented herein cannot fully discern whether its results in the two study are primarily due to difference in social SoA or whether its results are solely explained by processing differences brought about by enhanced prediction (Buehner, 2012). This limitation needs to be addressed in future studies through agency manipulation, e.g., with forced answers (Sato & Yasuda, 2005; Ebert & Wegner, 2010) or by using transcranial magnetic stimulation (Haggard et al., 2002).

The independent variable evaluated in both studies stems from time judgements on a visual analogue scale. As stated in the studies' respective limitations sections, both visual analogue scales as well as time judgement tasks are prone to bias (see Vogel et al. 2022, p.11). This should be addressed by varying the method of data collection (for review see Moore & Obhi, 2012), e.g., by using verbal time estimates (e.g., Engbert et al., 2007; Caspar et al., 2015; Imaizumi & Tanno, 2019), duration reproduction tasks (e.g., see Imaizumi et al., 2019), or a Libet-Clock design (Libet et al., 1993; for application see e.g., Haggard et al., 2002; Ivanof et al., 2022). Furthermore, the influence of attentional resources on time estimates should be assessed by manipulating the complexity of the task.

3.3 Implications

As implied in the General Discussion, the studies Vogel et al. (2021, 2022) create a variety of opportunities for further scientific investigation. Concerning a general population, I suggested mentalizing processes as the likely source of social hyperbinding. Further investigation might therefore attempt at uncovering such a connection between mentalizing processes and TB in social interaction. For instance, questionnaires such as the Empathy Quotient (Baron-Cohen et al., 2004; Lawrence et al., 2004) or Theory of Mind Tests such as the “Reading the Mind in the Eyes Test” (Baron-Cohen et al., 2001) might correlate with social hyperbinding. A different approach would be manipulating the amount of information provided in a cover story when introducing a confederate. Vogel et al. (2021, 2022) both made use of a confederate design providing identical information about the confederate. By manipulating the amount and quality of the provided information (e.g., by making a person appear unappealing/unfriendly, etc.) social hyperbinding might be affected. From the findings presented herein I would assume that TB should increase irrespective of what quality of information is provided, yet, might increase with the amount of background information.

In all experiments in both studies the action-event sequences were designed to be highly predictable to assure the emergence of a TB effect. This means that the confederate in the experiments was made to behave reliably and predictably. Translated to the social domain, the results from confederate trials imply that social hyperbinding emerges when interaction partners cooperate. The assumption arises whether a misbehaving interactant might reduce TB and level social hyperbinding. Confederates with higher failure rates for movements, or cover stories implying uncooperativity could be introduced into the paradigm to address this.

The question of the influence of cooperation would also concern mental health conditions, such as personality disorders and psychopathy. In a broader sense (un-)cooperation effects might be used to measure cooperation during treatment phases and reflect the outcome of psychotherapeutic interventions.

Concerning other implications for mental health research, the paradigms from Vogel et al. (2021, 2022) could be adjusted to investigate the relationship between complexity and social information in ASD. For example, different visual stimuli of varying complexity and involving both social and non-social pictures could be used to asses whether social hyperbinding and its reduction in ASD are due to a difference in

overall complexity or whether the effect is truly of a purely social nature. This approach would also answer the question raised above on the influence of perceptual bottom-up information on TB in ASD.

Similarly confederates could be introduced with a variation of background information, hence altering the complexity of the provided top-down information. Under the assumptions of Vogel et al. (2021) social hyperbinding should show a general increase corresponding to increasing information with a larger increase for social information. Conceivably however, there might be a tipping point at which information complexity is too large to be adequately processed and TB no longer increases or even decreases.

Implications for clinical research lie in the potential targets listed in the introduction, such as Schizophrenia and Major Depressive Disorder. In the case of schizophrenia the paradigm may be adapted to investigate the influence of delusions as primarily disordered belief or as resulting secondarily from disordered perception (Fletcher & Frith, 2009; Friston, 2010; Vogel et al., 2019; Vogel, 2022). A potential experimental design could compare a purely stimulus based task using a face stimulus to a purely belief based task using a cover story. Differences in hyperbinding between participants with schizophrenia and participants without a diagnosis might reflect distinct influences of top-down or bottom-up processes on the emergence of delusional belief. Concerning MDD, similar experimental procedures can be used to investigate the differential influence of social encounters versus actions performed alone on self-efficacy expectations and their social dependance (Bandura, 1982; Milanovic et al., 2018).

Vogel et al. (2021, 2022) introduce a functional and adaptable research paradigm for mental health research. It has repeatedly garnered results from persons without clinical mental health conditions and has been successfully applied to groups of individuals with ASD. We propose its application to other mental health conditions with disordered social functioning or processing. As stated above, the paradigm presented herein can be adapted and amended to answer questions relating to SoA, TB, and multisensory processing and prediction in these selected conditions.

4. References

Ahrens, A. H., Zeiss, A. M., & Kanfer, R. (1988). Dysphoric deficits in interpersonal standards, self-efficacy, and social comparison. *Cognitive Therapy and Research*, 12(1), 53-67.

Alloy, L. B., Albright, J. S., & Clements, C. M. (1987). Depression, nondepression, and social comparison biases. In *Social processes in clinical and counseling psychology* (pp. 94-112). Springer, New York, NY.

Bandura, A. (1982). Self-efficacy mechanism in human agency. *American psychologist*, 37(2), 122.

Bandura, A., & Locke, E. A. (2003). Negative self-efficacy and goal effects revisited. *Journal of applied psychology*, 88(1), 87.

Baron-Cohen, S., & Wheelwright, S. (2004). The empathy quotient: an investigation of adults with Asperger syndrome or high functioning autism, and normal sex differences. *Journal of autism and developmental disorders*, *34*, 163-175.

Baron-Cohen, S., Wheelwright, S., Hill, J., Raste, Y., & Plumb, I. (2001). The "Reading the Mind in the Eyes" Test revised version: a study with normal adults, and adults with Asperger syndrome or high-functioning autism. *The Journal of Child Psychology and Psychiatry and Allied Disciplines*, *42*(2), 241-251.

Blankenburg, W. (1971). *Der Verlust der natürlichen Selbstverständlichkeit: ein Beitrag zur Psychopathologie symptomarmer Schizophrenien*. Stuttgart: Enke.

Bolt, N. K., & Loehr, J. D. (2017). The predictability of a partner's actions modulates the sense of joint agency. *Cognition*, 161, 60-65.

Bolt, N. K., Poncelet, E. M., Schultz, B. G., & Loehr, J. D. (2016). Mutual coordination strengthens the sense of joint agency in cooperative joint action. *Consciousness and cognition*, 46, 173-187.

Brandi, M. L., Kaifel, D., Bolis, D., & Schilbach, L. (2019). The Interactive Self–A Review on Simulating Social Interactions to Understand the Mechanisms of Social Agency. *i-com*, 18(1), 17-31.

Buehner, M. J. (2012). Understanding the past, predicting the future: causation, not intentional action, is the root of temporal binding. *Psychological science*, 23(12), 1490-1497.

Caspar, E. A., Christensen, J. F., Cleeremans, A., & Haggard, P. (2016). Coercion changes the sense of agency in the human brain. *Current biology*, *26*(5), 585-592.

Caspar, E. A., Cleeremans, A., & Haggard, P. (2015). The relationship between human agency and embodiment. *Consciousness and cognition*, *33*, 226-236.

Chung, Y. S., Barch, D., & Strube, M. (2014). A meta-analysis of mentalizing impairments in adults with schizophrenia and autism spectrum disorder. *Schizophrenia bulletin*, 40(3), 602-616.

Cravo, A. M., Claessens, P. M., & Baldo, M. V. (2011). The relation between action, predictability and temporal contiguity in temporal binding. *Acta Psychologica*, 136(1), 157-166.

Cummings, J. L., & Frankel, M. (1985). Gilles de la Tourette syndrome and the neurological basis of obsessions and compulsions. *Biological psychiatry*, 20(10), 1117-1126.

David, N., Gawronski, A., Santos, N. S., Huff, W., Lehnhardt, F. G., Newen, A., & Vogeley, K. (2008b). Dissociation between key processes of social cognition in autism: Impaired mentalizing but intact sense of agency. *Journal of Autism and Developmental Disorders*, 38(4), 593-605.

David, N., Newen, A., & Vogeley, K. (2008a). The "sense of agency" and its underlying cognitive and neural mechanisms. *Consciousness and cognition*, 17(2), 523-534.

De Vignemont, F., & Fourneret, P. (2004). The sense of agency: A philosophical and empirical review of the "Who" system. *Consciousness and Cognition*, 13(1), 1-19.

Dewey, J. A., Pacherie, E., & Knoblich, G. (2014). The phenomenology of controlling a moving object with another person. *Cognition*, 132(3), 383-397.

Ebert, J. P., & Wegner, D. M. (2010). Time warp: Authorship shapes the perceived timing of actions and events. *Consciousness and cognition*, *19*(1), 481-489.

Engbert, K., Wohlschläger, A., Thomas, R., & Haggard, P. (2007). Agency, subjective time, and other minds. *Journal of Experimental Psychology: Human Perception and Performance*, 33(6), 1261.

Finnemann, J. J., Plaisted-Grant, K., Moore, J., Teufel, C., & Fletcher, P. C. (2021). Low-level, prediction-based sensory and motor processes are unimpaired in Autism. *Neuropsychologia*, 156, 107835.

Fishman, I., Keown, C. L., Lincoln, A. J., Pineda, J. A., & Müller, R. A. (2014). Atypical cross talk between mentalizing and mirror neuron networks in autism spectrum disorder. *JAMA psychiatry*, 71(7), 751-760.

Fletcher, P. C., & Frith, C. D. (2009). Perceiving is believing: a Bayesian approach to explaining the positive symptoms of schizophrenia. *Nature Reviews Neuroscience*, *10*(1), 48-58.

Friston, K. (2010). The free-energy principle: a unified brain theory?. *Nature reviews neuroscience*, *11*(2), 127-138.

Friston, K. (2012). Prediction, perception and agency. *International Journal of Psychophysiology*, 83(2), 248-252.

Frith, C. (2005). The self in action: lessons from delusions of control. *Consciousness and cognition*, 14(4), 752-770.

Fuchs, T. (2010). Phenomenology and psychopathology. In *Handbook of phenomenology and cognitive science* (pp. 546-573). Springer, Dordrecht.

Gallagher, S. (2007). The natural philosophy of agency. *Philosophy Compass*, 2(2), 347-357.

Gallagher, S. (2012). Multiple aspects in the sense of agency. *New ideas in psychology*, 30(1), 15-31.

Gallagher, S. (2015). Relations between agency and ownership in the case of schizophrenic thought insertion and delusions of control. *Review of Philosophy and Psychology*, 6(4), 865-879.

Gepner, B., & Féron, F. (2009). Autism: a world changing too fast for a mis-wired brain?. *Neuroscience & Biobehavioral Reviews*, 33(8), 1227-1242.

Glover, S., & Dixon, P. (2017). The role of predictability in cooperative and competitive joint action. *Journal of Experimental Psychology: Human Perception and Performance*, 43(4), 644.

Gotts, S. J., Simmons, W. K., Milbury, L. A., Wallace, G. L., Cox, R. W., & Martin, A. (2012). Fractionation of social brain circuits in autism spectrum disorders. *Brain*, 135(9), 2711-2725.

Grynszpan, O., Sahaï, A., Hamidi, N., Pacherie, E., Berberian, B., Roche, L., & Saint-Bauzel, L. (2019). The sense of agency in human-human vs human-robot joint action. *Consciousness and Cognition*, 75, 102820.

Haggard, P. (2017). Sense of agency in the human brain. *Nature Reviews Neuroscience*, 18(4), 196.

Haggard, P., Clark, S., & Kalogeras, J. (2002). Voluntary action and conscious awareness. *Nature neuroscience*, 5(4), 382.

Hoerl, C., Lorimer, S., McCormack, T., Lagnado, D. A., Blakey, E., Tecwyn, E. C., & Buehner, M. J. (2020). Temporal binding, causation, and agency: Developing a new theoretical framework. *Cognitive Science*, 44(5), e12843.

Hohwy, J., Paton, B., & Palmer, C. (2016). Distrusting the present. *Phenomenology and the Cognitive Sciences*, 15(3), 315–335.

Imaizumi, S., & Tanno, Y. (2019). Intentional binding coincides with explicit sense of agency. *Consciousness and Cognition*, *67*, 1-15.

Imaizumi, S., Tanno, Y., & Imamizu, H. (2019). Compress global, dilate local: Intentional binding in action–outcome alternations. *Consciousness and Cognition*, *73*, 102768.

Ivanof, B. E., Terhune, D. B., Coyle, D., Gottero, M., & Moore, J. W. (2022). Examining the effect of Libet clock stimulus parameters on temporal binding. *Psychological Research*, *86*(3), 937-951.

Jagini, K. K. (2021). Temporal Binding in Multisensory and Motor-sensory Contexts: Towards a Unified Model. *Frontiers in Human Neuroscience*, 15, 115.

Kirsch, W., Kunde, W., & Herbort, O. (2019). Intentional binding is unrelated to action intention. *Journal of Experimental Psychology: Human Perception and Performance*, 45(3), 378.

Lawrence, E. J., Shaw, P., Baker, D., Baron-Cohen, S., & David, A. S. (2004). Measuring empathy: reliability and validity of the Empathy Quotient. *Psychological medicine*, *34*(5), 911-920.

Libet, B., Libet, B., Gleason, C. A., Wright, E. W., & Pearl, D. K. (1993). Time of conscious intention to act in relation to onset of cerebral activity (readiness-potential) the unconscious initiation of a freely voluntary act. *Neurophysiology of consciousness*, 249-268.

Loehr, J. D. (2018). Shared credit for shared success: Successful joint performance strengthens the sense of joint agency. *Consciousness and cognition*, 66, 79-90.

Maddux, J. E., & Meier, L. J. (1995). Self-efficacy and depression. In *Self-Efficacy, adaptation, and adjustment* (pp. 143-169). Springer, Boston, MA.

Milanovic, M., Ayukawa, E., Usyatynsky, A., Holshausen, K., & Bowie, C. R. (2018). Self Efficacy in depression: bridging the gap between competence and real world functioning. *The Journal of nervous and mental disease*, 206(5), 350-355.

Moccia, L., di Luzio, M., Conte, E., Modica, M., Ambrosecchia, M., Ardizzi, M., Lanzotti, P., Kotzalidis, G.D., Janiri, D., Di Nicola, M., Janiri, L., Gallese, V., & Sani, G. (2023). Sense of Agency and Its Disturbances: a Systematic Review Targeting the Intentional Binding Effect in Neuropsychiatric Disorders. *Psychiatry and Clinical Neurosciences*.

Moore, J. W. (2016). What is the sense of agency and why does it matter?. *Frontiers in psychology*, 7, 1272.

Moore, J. W., & Fletcher, P. C. (2012). Sense of agency in health and disease: a review of cue integration approaches. *Consciousness and cognition*, 21(1), 59-68.

Moore, J. W., & Obhi, S. S. (2012). Intentional binding and the sense of agency: a review. *Consciousness and cognition*, 21(1), 546-561.

Niu, N., Wu, Y., Li, M., Yang, D., Fan, W., & Zhong, Y. (2023). Influence of voluntary action and outcome valence on the sense of agency. *Frontiers in Human Neuroscience*, *17*.

Obhi, S. S., & Hall, P. (2011a). Sense of agency in joint action: Influence of human and computer co-actors. *Experimental brain research*, 211(3-4), 663-670.

Obhi, S. S., & Hall, P. (2011b). Sense of agency and intentional binding in joint action. *Experimental brain research*, 211(3-4), 655.

Pfeiffer, U. J., Vogeley, K., & Schilbach, L. (2013). From gaze cueing to dual eye-tracking: novel approaches to investigate the neural correlates of gaze in social interaction. *Neuroscience & Biobehavioral Reviews*, 37(10), 2516-2528.

Pfeiffer, U., Schilbach, L., Timmermans, B., Jording, M., Bente, G., & Vogeley, K. (2012). Eyes on the mind: investigating the influence of gaze dynamics on the perception of others in real-time social interaction. *Frontiers in psychology*, 3, 537.

Pfister, R., Obhi, S. S., Rieger, M., & Wenke, D. (2014). Action and perception in social contexts: intentional binding for social action effects. *Frontiers in human neuroscience*, 8, 667.

Pfister, R., Weller, L., & Kunde, W. (2020). When actions go awry: Monitoring partner errors and machine malfunctions. *Journal of Experimental Psychology: General,* 149(9), 1778–1787.

Polito, V., Barnier, A. J., & Woody, E. Z. (2013). Developing the Sense of Agency Rating Scale (SOARS): An empirical measure of agency disruption in hypnosis. *Consciousness and cognition*, *22*(3), 684-696.

Rasmussen, S. A., & Eisen, J. L. (1992). The epidemiology and clinical features of obsessive compulsive disorder. *Psychiatric Clinics*, 15(4), 743-758.

Recht, S., & Grynszpan, O. (2019). The sense of social agency in gaze leading. *Journal on Multimodal User Interfaces*, 1-12.

Ruess, M., Thomaschke, R., & Kiesel, A. (2017). The time course of intentional binding. *Attention, Perception, & Psychophysics*, 79(4), 1123-1131.

Sahaï, A., Desantis, A., Grynszpan, O., Pacherie, E., & Berberian, B. (2019). Action co-representation and the sense of agency during a joint Simon task: Comparing human and machine co-agents. *Consciousness and cognition*, 67, 44-55.

Sahaï, A., Pacherie, E., Grynszpan, O., & Berberian, B. (2017). Predictive mechanisms are not involved the same way during human-human vs. Human-machine interactions: a review. *Frontiers in neurorobotics*, 11, 52.

Sato, A. (2009). Both motor prediction and conceptual congruency between preview and action-effect contribute to explicit judgment of agency. *Cognition*, 110(1), 74-83.

Sato, A., & Yasuda, A. (2005). Illusion of sense of self-agency: discrepancy between the predicted and actual sensory consequences of actions modulates the sense of self-agency, but not the sense of self-ownership. *Cognition*, *94*(3), 241-255.

Scharfetter, C. (1981). Ego-psychopathology: the concept and its empirical evaluation. *Psychological Medicine*, 11(2), 273-280.

Slaby, J., Paskaleva, A., & Stephan, A. (2013). Enactive emotion and impaired agency in depression. *Journal of Consciousness Studies*, 20(7-8), 33-55.

Sperduti, M., Pieron, M., Leboyer, M., & Zalla, T. (2014). Altered pre-reflective sense of agency in autism spectrum disorders as revealed by reduced intentional binding. *Journal of autism and developmental disorders*, 44(2), 343-352.

Staley, D., Wand, R., & Shady, G. (1997). Tourette disorder: a cross-cultural review. *Comprehensive psychiatry*, 38(1), 6-16.

Stephenson, L. J., Edwards, S. G., Howard, E. E., & Bayliss, A. P. (2018). Eyes that bind us: Gaze leading induces an implicit sense of agency. *Cognition*, 172, 124-133.

Suzuki, K., Lush, P., Seth, A. K., & Roseboom, W. (2019). Intentional binding without intentional action. *Psychological Science*, 30(6), 842-853.

Tapal, A., Oren, E., Dar, R., & Eitam, B. (2017). The sense of agency scale: A measure of consciously perceived control over one's mind, body, and the immediate environment. *Frontiers in psychology*, 8, 1552.

Teufel, C., & Fletcher, P. C. (2020). Forms of prediction in the nervous system. *Nature Reviews Neuroscience*, *21*(4), 231-242.

Ulloa, J. L., Vastano, R., George, N., & Brass, M. (2019). The impact of eye contact on the sense of agency. *Consciousness and cognition*, 74, 102794.

van der Wel, R. P. (2015). Me and we: Metacognition and performance evaluation of joint actions. *Cognition*, 140, 49-59.

van der Wel, R. P., Sebanz, N., & Knoblich, G. (2012). The sense of agency during skill learning in individuals and dyads. *Consciousness and cognition*, 21(3), 1267-1279.

Vesper, C., Van Der Wel, R. P., Knoblich, G., & Sebanz, N. (2011). Making oneself predictable: Reduced temporal variability facilitates joint action coordination. *Experimental brain research*, 211(3-4), 517-530.

Vogel, D. H. V., Beeker, T., Haidl, T., Kupke, C., Heinze, M., & Vogeley, K. (2019). Disturbed time experience during and after psychosis. *Schizophrenia research: cognition*, *17*, 100136.

Vogel, D., Falter-Wagner, C. M., Schoofs, T., Krämer, K., Kupke, C., & Vogeley, K. (2019). Interrupted time experience in autism spectrum disorder: empirical evidence from content analysis. *Journal of autism and developmental disorders*, 49(1), 22-33.

Vogel, D.H.V. (2022). The Temporality of Aberrant Salience and Schizophrenia. *Frontiers in Integrative Neuroscience*, *16*, 925716.

Vogel, D.H.V., Jording, M., Esser, C., Conrad, A., Weiss, P.H., & Vogeley, K. (2022). Temporal binding of social events less pronounced in individuals with Autism Spectrum Disorder. *Scientific Reports*, *12*(1), 14853.

Vogel, D.H.V., Jording, M., Esser, C., Weiss, P.H., & Vogeley, K. (2021). Temporal binding is enhanced in social contexts. *Psychonomic bulletin & review*, *28*(5), 1545-1555.

Vogeley, K. (2017). Two social brains: neural mechanisms of intersubjectivity. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 372(1727), 20160245.

Weller, L., Schwarz, K. A., Kunde, W., & Pfister, R. (2020). Something from nothing: Agency for deliberate nonactions. *Cognition*, 196, 104136.

Wylie, K. P., Tregellas, J. R., Bear, J. J., & Legget, K. T. (2020). Autism spectrum disorder symptoms are associated with connectivity between large-scale neural networks and brain regions involved in social processing. Jo*urnal of autism and developmental disorders*, 50, 2765-2778.

5. **Summary**

This work consists of two studies performing three different experiments. They make use of the temporal binding effect (TB), the judgment error in a time estimation task when performing voluntary actions. TB manifests as an underestimation of durations between two events and particularly occurs when judging the time between actions and their effects.

As TB reliably occurs during self performed action, it can be used as a measurable correlate to the Sense of Agency (SoA). As SoA is often altered during states of mental disorder, TB tasks pose an implicit way to assess disturbances and alterations in its experience. Additionally, TB relies heavily on predictive processes allowing for deductions about potentially underlying cognitive mechanisms.

The paradigm employed in the two studies merges existing theory on the influence of social cognitive processes on TB and adapts it to investigate their influence on Autism Spectrum Disorder (ASD) as a showcase for further mental health research. The aim of the paradigm was to disentangle the difference between bottom-up perception and top-down belief on TB. It does so by using a face stimulus and a confederate study design.

The results identify a *social hyperbinding*. TB emerges for changes in faces, as well as for interactions with a human partner. The effect is larger when compared to interactions with non-face stimuli and actions performed without a partner. Social hyperbinding appeared whenever social information was present in the action-event sequence, irrespective of perception and belief.

For participants with ASD social hyperbinding was smaller as compared to participants without ASD. These results indicate a differential processing of social information during action-event monitoring and might reflect stronger SoA during social interaction for individuals without ASD.

The paradigm is discussed in terms of its limitations and its amendability to the investigation of other mental disorders, particular to Schizophrenia and Major Depressive Disorder (MDD).

6. Zusammenfassung

Diese Arbeit besteht aus zwei Studien mit drei verschiedenen Experimenten. Sie nutzen den “temporal binding” Effekt (TB) - den Beurteilungsfehler in einer Zeitschätzungsaufgabe bei der Ausführung freiwilliger Handlungen. TB äußert sich in einer Unterschätzung der Dauer zwischen zwei Ereignissen und tritt insbesondere bei der Beurteilung der Zeit zwischen Handlungen und ihren Auswirkungen auf.

Da TB zuverlässig bei selbstständig ausgeführten Handlungen auftritt, kann es als messbares Korrelat zum Urheberschaftsgefühl (“Sense of Agency”, SoA) verwendet werden. Da SoA bei psychischen Störungen häufig verändert ist, stellen TB-Aufgaben eine implizite Möglichkeit dar, Störungen und Veränderungen im Erleben von SoA zu beurteilen. Darüber hinaus stützt sich TB in hohem Maße auf prädiktive Prozesse, was Rückschlüsse auf möglicherweise zugrunde liegende kognitive Mechanismen zulässt.

Das in den beiden Studien verwendete Paradigma vereint bestehende Theorien über den Einfluss sozialer kognitiver Prozesse auf TB und passt sie an, um ihren Einfluss auf Autismus-Spektrum-Störungen (ASD) zu untersuchen, um so ein Schaufenster für die weitere Forschung im Feld der psychischen Gesundheit zu schaffen. Ziel des Paradigmas war es, den unterschiedlichen Einfluss zwischen Wahrnehmungen und Überzeugung bei TB zu entschlüsseln. Zu diesem Zweck wurde ein Gesichtsreiz und ein Partner-Studiendesign verwendet.

Die Ergebnisse zeigen eine soziale Hyperbindung (“social hyperbinding”). TB tritt sowohl bei Veränderungen von Gesichtern als auch bei Interaktionen mit einem menschlichen Partner auf. Der Effekt ist größer im Vergleich zu Interaktionen mit Nicht-Gesichtsreizen und Handlungen, die ohne einen Partner durchgeführt werden. Soziale Hyperbindung trat immer dann auf, wenn soziale Informationen in der Handlungs-Ereignis-Sequenz vorhanden waren - unabhängig von Wahrnehmung und Überzeugung.

Bei Teilnehmern mit ASD war die soziale Hyperbindung geringer als bei Teilnehmern ohne ASD. Diese Ergebnisse deuten auf eine differenzierte Verarbeitung sozialer Informationen während der Überwachung von Handlungsereignissen hin und könnten stärkere SoA während sozialer Interaktionen bei Personen ohne ASD widerspiegeln.

Das Paradigma wird im Hinblick auf seine Grenzen und seine Anwendbarkeit bei der Untersuchung anderer psychischer Störungen, insbesondere bei Schizophrenie und Major Depressive Disorder (MDD), diskutiert.

7. Appendix

7.1 Author contributions

1. **Vogel, D.H.V.**, Jording, M., Esser, C., Weiss, P.H., & Vogeley, K. (2021). Temporal binding is enhanced in social contexts. Psychonomic bulletin & review, 28(5), 1545-1555.

DV contributed to conceptualization, paradigm design, data curation, statistical analysis, and writing—original draft, review, and editing. MJ contributed to paradigm design, statistical analysis, and writing—review and editing. CE contributed to data curation, statistical analysis, and writing—review and editing. PW contributed to conceptualization, paradigm design, and writing—original draft, review and editing. KV contributed to conceptualization, paradigm design, and writing—original draft, review, and editing.

2. **Vogel, D.H.V.**, Jording, M., Esser, C., Conrad, A., Weiss, P.H., & Vogeley, K. (2022). Temporal binding of social events less pronounced in individuals with Autism Spectrum Disorder. Scientific Reports, 12(1), 14853.

DV contributed to conceptualization, paradigm design, data curation, statistical analysis, and writing—original draft, review, and editing. MJ contributed to paradigm design, statistical analysis, and writing—review and editing. CE contributed to data curation, statistical analysis, and writing—review and editing. AC contributed to data curation, statistical analysis, and writing—review and editing. PW contributed to conceptualization, paradigm design, and writing—original draft, review and editing. KV contributed to conceptualization, paradigm design, and writing—original draft, review, and editing.

7.2 Danksagung

Meine tiefe Dankbarkeit gilt meinem Betreuer Prof. Dr. Dr. Kai Vogeley, sowie Prof. Dr. Peter Weiss-Blankenhorn für ihre anhaltende Lehrbereitschaft, konstante Ermutigung und wiederholte Nachsichtigkeit gegenüber meinen Eigenwilligkeiten.

Ich danke allen ehemaligen und gegenwärtigen Mitarbeitern der Arbeitsgruppe Soziale Kognition der Klinik für Psychiatrie und Psychotherapie, allen ehemaligen und gegenwärtigen Mitarbeitern des INM-3 des Forschungszentrums Jülich und ganz besonders Mathis Jording, Shiva Viswanathan, Carolin Esser und Amelie Conrad für ihre tatkräftige Unterstützung.

7.3 Curriculum vitae

DAVID HEINZ VICTOR VOGEL

geboren am 12.01.1990 in Koblenz, Deutschland
E-Mail: david.vogel@uk-koeln.de

BERUFSERFAHRUNG

Klinik und Poliklinik für Psychiatrie und Psychotherapie, Uniklinik Köln, Köln, Deutschland
Assistenzarzt und Wissenschaftlicher Mitarbeiter — **seit 01.12.2023**

Klinik und Poliklinik für Neurologie, Uniklinik Köln, Köln, Deutschland
Assistenzarzt und Wissenschaftlicher Mitarbeiter — **01.12.2022 – 30.11.2023**

Klinik und Poliklinik für Psychiatrie und Psychotherapie, Uniklinik Köln, Köln, Deutschland
Assistenzarzt und Wissenschaftlicher Mitarbeiter — **01.07.2021 – 30.11.2022**

Forschungszentrum Jülich GmbH, Institut für Neurowissenschaften und Medizin, Teilinstitut Kognitive Neurowissenschaften (INM-3)
Wissenschaftlicher Mitarbeiter — **01.02.2019 – 30.06.2021**

Klinik und Poliklinik für Psychiatrie und Psychotherapie, Uniklinik Köln, Köln, Deutschland
Assistenzarzt und Wissenschaftlicher Mitarbeiter — **01.01.2016– 14.01.2019**

BILDUNGSWEG

Promotion doctor medicinae (Dr. med.) — **24.08.2020**
DGPPN Promotions-Preis – Hans-Heimann-Preis 2021

ECFMG Certificate (United States Medical Licensing Examination) — **07.05.2020**

Approbation als Arzt — **08.12.2015**

Medizinische Fakultät, Universität zu Köln, Köln, Deutschland
Studium der Humanmedizin — **2009 – 2015**
Abschluss der Ärztlichen Prüfung

Bellefontaine Highschool, Bellefontaine, Ohio, USA
Auslandsschuljahr USA — **2006 – 2007**

Graf-Zeppelin-Gymnasium, Friedrichshafen, Deutschland — **2003 – 2006, 2007 – 2009**
Allg. Hochschulreife, Abitur
Peoria-Preis für besondere Leistungen im Fach Englisch

VERÖFFENTLICHUNGEN

Vogel, D.H.V., Krämer, K., Schoofs, T., Kupke, C., & Vogeley, K. (2018). Disturbed Experience of Time in Depression—Evidence from Content Analysis. *Frontiers in human neuroscience*, 12, 66. — 2018

Vogel, D., Falter-Wagner, C. M., Schoofs, T., Krämer, K., Kupke, C., & Vogeley, K. (2019). Interrupted time experience in autism spectrum disorder: empirical evidence from content analysis. *Journal of autism and developmental disorders*, 49(1), 22-33. — 2019

Vogel, P., & **Vogel, D.H.V.** (2019). Cognition errors in the treatment course of patients with anastomotic failure after colorectal resection. *Patient safety in surgery*, 13(1), 4. — 2019

Vogel, D.H.V., Beeker, T., Haidl, T., Kupke, C., Heinze, M., and Vogeley, K. (2019). Disturbed time experience during and after psychosis. *Schizophrenia Research: Cognition.* 17:100136 — 2019

Vogel, D.H.V., Falter-Wagner, C. M., Schoofs, T., Krämer, K., Kupke, C., & Vogeley, K. (2020). Flow and structure of time experience–concept, empirical validation and implications for psychopathology. *Phenomenology and the Cognitive Sciences*, 1 9, 235–258. — 2020

Vogel, D.H.V., Vogeley K. (2020) Time Experience in Autism Spectrum Disorder. In: Volkmar F. (eds) *Encyclopedia of Autism Spectrum Disorders*. Springer, New York, NY. — 2020

Vogel, D.H.V. & Vogeley, K. (2020). “Gelebte Zeit“ bei Depression und in Todesnähe. In Ewald, H., Vogeley, K., & Voltz, R (Hrsg.). *Palliativ& Zeiterleben*. Kohlhammer, Stuttgart. 2020

Vogel, D.H.V., Jording M., Kupke C. and Vogeley K. (2020). The Temporality of Situated Cognition. *Frontiers in Psychology,* 11:546212. 2020

Vogel, D.H.V., Jording, M., Esser, C., Weiss, P H., & Vogeley, K. (2021). Temporal binding is enhanced in social contexts. *Psychonomic bulletin & review*, 28(5), 1545-1555. 2021

Jording, M., **Vogel, D.H.V.**, Viswanathan, S., & Vogeley, K. (2022). Dissociating passage and duration of time experiences through the intensity of ongoing visual change. *Scientific reports*, 12(1), 8226. 2022

Meermeier, A., Jording, M., Alayoubi, Y., **Vogel, D.H.V.**, Vogeley, K., & Tepest, R. (2022). Brief Report: Preferred Processing of Social Stimuli in Autism: A Perception Task. *Journal of Autism and Developmental Disorders*, 1-8. 2022

Vogel, D.H.V. (2022). The Temporality of Aberrant Salience and Schizophrenia. *Frontiers in Integrative Neuroscience*, 16, 925716. 2022

Vogel, D.H.V., Jording, M., Esser, C., Conrad, A., Weiss, P. H., & Vogeley, K. (2022). Temporal binding of social events less pronounced in individuals with Autism Spectrum Disorder. *Scientific Reports*, 12(1), 14853. 2022

Unruh, F., **Vogel, D.**, Landeck, M., Lugrin, J. L., & Latoschik, M. E. (2023). Body and Time: Virtual Embodiment and its Effect on Time Perception. *IEEE Transactions on Visualization and Computer Graphics*, 29(5), 2626-2636. 2023

SPRACHEN

Deutsch – Muttersprache
Englisch – verhandlungssicher; TOEFL-Score: 116/120 (Mai 2009)
Französisch, Spanisch, Italienisch – Grundkenntnisse

9.4 Erklärung

Hiermit versichere ich an Eides statt, dass ich die vorliegende Dissertationsschrift selbstständig und ohne die Benutzung anderer als der angegebenen Hilfsmittel angefertigt habe. Alle Stellen - einschließlich Tabellen, Karten und Abbildungen -, die wörtlich oder sinngemäß aus veröffentlichten und nicht veröffentlichten anderen Werken im Wortlaut oder dem Sinn nach entnommen sind, sind in jedem Einzelfall als Entlehnung kenntlich gemacht. Ich versichere an Eides statt, dass diese Dissertationsschrift noch keiner anderen Fakultät oder Universität zur Prüfung vorgelegen hat; dass sie - abgesehen von unten angegebenen Teilpublikationen - noch nicht veröffentlicht worden ist sowie, dass ich eine solche Veröffentlichung vor Abschluss der Promotion nicht ohne Genehmigung der / des Vorsitzenden des IPHS-Promotionsausschusses vornehmen werde. Die Bestimmungen dieser Ordnung sind mir bekannt. Die von mir vorgelegte Dissertation ist von Prof. Dr. Dr. Kai Vogeley betreut worden. Darüber hinaus erkläre ich hiermit, dass ich die Ordnung zur Sicherung guter wissenschaftlicher Praxis und zum Umgang mit wissenschaftlichem Fehlverhalten der Universität zu Köln gelesen und sie bei der Durchführung der Dissertation beachtet habe und verpflichte mich hiermit, die dort genannten Vorgaben bei allen wissenschaftlichen Tätigkeiten zu beachten und umzusetzen.

Übersicht der Publikationen:

1. Vogel, D.H.V., Jording, M., Esser, C., Weiss, P.H., & Vogeley, K. (2021). Temporal binding is enhanced in social contexts. Psychonomic bulletin & review, 28(5), 1545-1555.

2. Vogel, D.H.V., Jording, M., Esser, C., Conrad, A., Weiss, P.H., & Vogeley, K. (2022). Temporal binding of social events less pronounced in individuals with Autism Spectrum Disorder. Scientific Reports, 12(1), 14853.

Ich versichere, dass ich alle Angaben wahrheitsgemäß nach bestem Wissen und Gewissen gemacht habe und verpflichte mich, jedmögliche, die obigen Angaben betreffenden Veränderungen, dem IPHS-Promotionsausschuss unverzüglich mitzuteilen.

19.02.2024 

Datum, Unterschrift