# “The self-tracking paradox: How self-improvement decreases experience of agency”

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## Abstract

At the core of human agency stands reflection about one’s life and the future goals one might pursue. In this agentic act, digital self-tracking apps offer their assistance and entice their users with the prospect of self-improvement. Yet, the technology’s rapid diffusion into consumer markets comes with uncertainties about the app’s effectiveness. While a third of app users abandon their tracking activities shortly after purchase, academic reviews find that a great number of apps even have detrimental effects on the behaviours they strive to improve. This study proposes that the root of these self-tracking illusions lies in the partition between objectively agentic acts and their manifestation as the subjective sense of agency. While users work towards self-improvement, the apps might not support the experience of control. In a one-week experience sampling study with 32 first-time self-trackers, I study the interactions of self-tracking practices, situational influences and the experience of self-agency. Results show that (1) in moments of receiving negative performance-feedback from the app, users experience a brief drop in self-agency. The expected reverse effect for positive feedback does not occur. (2) over the course of the week in which participants increasingly integrated self-tracking in their lives, the Sense of Agency steadily declined. Descriptive results indicate that this decrease might be even stronger in activities that are tracked by the app. From a methodological point of view, this study also further develops an experience sampling approach to measuring self-agency in the field.

*Keywords: Sense of Agency, self-agency, quantified self, personal informatics, self-tracking, experience sampling method, goals*

# Content

# 1. Introduction

In his philosophy of action, Bratman (2000) identifies the triad of reflection, conscious planning, and actions persisting over time as the cornerstones of human agency. However, putting one's consciously reflected plans into action not only requires navigating external obstacles, but persuading the self into compliance. Given the fundamental role of automated processes in daily behaviour (Bargh & Ferguson, 2000; Chen & Bargh, 1997) our consciously deliberated goals might collide with our unconscious self. A notion of an autonomous will which carves out a plan and must dialogically relate to both cognition and emotion mirrors classic theories about a tripartite of the mind (James, Burkhardt, Bowers, & Skrupskelis, 1890). More recently and under the impression of dual-processing accounts for cognition and decision making (Evans, 2008) digital self-tracking apps promise to assist their users in moulding everyday behaviour according to conscious intention. Accordingly, the majority of contemporary self-trackers regard their apps as tools for self-improvement (Kersten-van Dijk, Westerink, Beute, & IJsselsteijn, 2017). The apps are thus used to foster self-knowledge and support self-control.

However, the growth of the commercial self-tracking market coincides with an increasing scepticism about the technology's efficacy. The newly emerged academic field of personal informatics

professionalises the research on self-tracking. Here, Rapp and Cena (2016) find that new users experience the technologies as cumbersome and superficial while not receiving any valuable reward. In addition, there is a lack of suggestions about what to do with the data (Hunter, 2017), often insufficient support for key determinant of behavioural, such as self-efficacy (Kersten-van Dijk et al., 2017) and behavioural contingencies or contextual factors that inevitably affect how one is feeling are not captured (Choe et al., 2014). This leads to the overall impression that the "effects of self-tracking intervention are not sufficiently clear" (Hermsen, Moons, Kerkhof, Wiekens, & De Groot, 2017). Furthermore, this academic scepticism is reinforced by reports that even the more costly tracking-tools are often soon abandoned by consumers, and after purchase their usage significantly declines (Lupton & Deborah, 2014). These effects occur even with the most established apps (Rapp et al., 2018). In sum, while users initially welcome the apps as agency supporting tools, using them frequently seems to end in disappointment.

This gives rise to the question: how exactly does self-tracking influence the daily experience of agency? Interestingly, this question has not yet been addressed by the literature. Further motivation for developing this question comes from the possible disassociations of objectively agentic actions and how they are subjectively experienced (Wegner, 2005). In light of current research on the Sense of Agency (SoA), it seems possible that a user does in fact change her behaviour with assistance of an app, yet, this change fails to manifest as a conscious experience of agency.

This paper has two foci, the first on methodology, and the second on self-tracking. After reviewing the literature on the Sense of Agency, self-tracking and their potential interplay, the methodology section entails a secondary-data analysis of data from two previous dissertations. In building upon this previous research, I refined the pre-study and re-designed an experience-sampling method to measure self-agency in the field. The second focus, on self-tracking, presents my own experience-sampling study with 32 self-tracking novices. The interplay of self-tracking and the experience of agency was explored via multilevel modelling.

# 2 Literature review

## 2.1 The Sense of Agency

Agency has been described as the metacognitive capacity to reflect on oneself (Bandura, 2006) and live a self-determined life (Deci & Ryan, 2000). Within tradition of Cognitive Psychology, human agency can be understood broadly as the ability to perform an action (Chambon, Sidarus, & Haggard, 2014). Taking this ability to a *subjective* level, agency appears in one's mind as the realisation that *one initiates and controls one's actions* (Synofzik, Vosgerau, & Voss, 2013). This experience or judgement of self-causation is called the *Sense of Agency*. It captures the universal human feeling that we are "in the driving seat" (Moore, 2016) of our actions – rather than our lives just happening. In other words, the feeling that through voluntary acts we shape our environment in a goal-directed

manner. The Sense of Agency (SoA) particularly refers to actions that an agent initiated, consciously intended and that are line with her goals (Haggard & Eitam, 2015). It involves a person recognising herself as the author and in charge of her actions.

This highlights the important distinction between the subjective *sense* and the objective *facts* of agency. The notion of *objective* agency can be found within many social institutions. For example, criminal responsibility is attributed based on external judgements of who has initiated and controlled an action. The components of "intention" and "initiation" play a central role in many legal systems, where a pre-planned murder is treated differently from involuntary manslaughter. This distinction between objective and subjective agency parallels Wegner's (2005) juxtaposition of the empirical and the phenomenal will: While the *empirical* will is the covariation of a person's intention and behaviour, the *phenomenal* will results from the ongoing self-assessment of what role our mind plays in our actions.

### 2.1.1 How does the Sense of Agency come about?

#### Part A "Modalities of agency"

The two most prominent models on the Sense of Agency emphasise two different modalities. The Comparator Model (C. Frith, 2005; C. D. Frith, Blakemore, & Wolpert, 2000) starts with efferent feedback from the sensorimotor system. Based on our intention, the motor system predicts the state we desire. Based on perceptual information, it compares the desired state to the observed outcome. A match between the two produces a sense of agency. The model's clarity is due to its emergence from the "mid-twentieth century rapprochement between system engineering and biological cybernetics" (Sperry 1950 in Haggard&Eitam 2015). However, it reaches its limit when trying to explain the role of consciously held agency-beliefs as top-down influences: A significant amount of empirical evidence shows that manipulating high-level information about causal-relations alters the perception of sensorimotor agency (Desantis, Roussel, & Waszak, 2011; Haering & Kiesel, 2012).

The second model is the "theory of apparent mental causation" (Wegner & Wheatley, 1999). This model infers the SoA from top-down processes in which the mind interprets itself. According to Wegner (2005), when interpreting actions and their causes, people apply a priori theories to account for the relationships between their own thoughts and the actions in their environment. Taking a deterministic stance, Wegner claims that intentions are mere previews of what the unconsciousness is about to conduct. Only our intention and the action itself appear in consciousness. The relation between the action tokens that reach consciousness – the intention and the action itself - determine the SoA.

While the two theories appear as competing accounts, both in fact feature a comparison between anticipated and actual action outcomes. Frith and colleagues (2000) claim this comparison is based on pre-existing intention, yet Wegner (2005) argues that people can retrospectively make themselves

believe they did have a prior intention. As mentioned before, the models also differ in their modality. One draws on sensorimotor processes and the other on environmental and social cues. As these modalities are not mutually exclusive, theoretical advancements propose that the SoA emerges from an integration of both (Synofzik et al., 2013), in their approach to combine the two accounts, see SoA based on two complementary components. First, the feeling of agency (FOA) and second, the judgement of agency (JOA). Judgements (JOA) stem from one's agency related cognitions. This higher order process involves explicit attributions of agency based on beliefs and knowledge about the context of the action. In a similar interpretation, Franks and Voyer (2014) describe this branch as "explicit self-agency" and suggest that such higher-level knowledge might involve long term intentions, the concept of self or cultural beliefs. On the other hand, a *feeling* of agency (FOA) is a lower-level non-conceptual feeling. Voyer and Franks (2014) name these pre-reflective processes "implicit self-agency". While this dichotomy between explicit and implicit modalities in some way seems to mirror dual-processing accounts for cognition and decision making (Evans, 2008; Evans & Stanovich, 2013). Franks and Voyer (2014) propose a third, intermediate level of self-agency (Northoff, Qin, & Feinberg, 2011; see also: Pacherie, 2008). This is a neither fully implicit nor explicit agency-perception. This intermediate level can be composed of complex plans of action (e.g. locking a bike) without "requiring conscious awareness of that agency" (Franks & Voyer, 2018). The intermediate level is also the docking-point for affordances.

## Part B "Agency situated through affordances"

The ability to perform an action emerges from a dialogue between subject and the environment. Gibson (XXX), in his ecological approach to psychology, conceptualises agency as situated and based on *affordances*: Action possibilities that arise from the interplay of agent and environment. Agents manoeuvre a world of action opportunities: Door knobs to press, light switches to flick, music to dance to, or an idle football to kick. Affordances are detected, used and modulated depending on the perceptual, social and cultural characteristics of the agent. While an object can be designed to suggest a certain action (like a bench inviting to take a seat) it can provoke different behaviour, depending on the actor and her choices (Withagen, De Poel, Araújo, & Pepping, 2012) – a bench to skateboard on. Affordances link mind and situation.

Affordances do not require conscious thought. Instead, responses to an environment can be automatic and enacted without much thinking. The environment can motivate action "without conscious mental representation" (Gray, Bargh, & Morsella, 2013). Accordingly, Franks and Voyer (2014) locate affordances at the intermediate level of representation (Franks, 2011), where complex plans of action are produced automatically, but can also enter consciousness.

### Part C "Joint action"

Affordances point to the inherently social nature of human agency. One's potential for action arises from other people - who are either directly present, or in the cultural artefacts that surround us. Teaming up with others creates a "plural subject" (Gilbert, 1997) and an emerging feeling that "we" are the agent (Franks, 2018). A collaborative action in the strong sense – meaning when a group of people coordinate their intentions - can be said to constitute a *joint action* (Pacherie, 2008).

While there are competing accounts for what makes an action as *joint*, philosophers of action agree that jointness involves shared intentions (Pacherie, 2008). The ability to have shared intentions has been proposed as the main characteristic that differentiates humans from other species, and as the fundamental cognitive process underpinning cultural transmission and human evolution (Tomasello, 1995; Tomasello & Carpenter, 2007).

At the centre of the debate around joint-agency is how individual intentions mesh together. Gilbert (1990) regards joint action as coordinated individual action. Tuomela (2006) proposes the notion of a "We-mode" where individuals come together in a "meeting of minds" (Gallotti & Frith, 2013) intend as a group. Despite the dispute, the two accounts might actually produce qualitatively different experiences of agency (Franks, 2018), where one involves a "blurring" of self and other while the other involves separated individuals.

## 2.1.2 "Agency: Juxtaposing facts and feeling"

Considering the complexity of its emergence, it is not surprising that the Sense of Agency not uncommonly misleads us about our role in causing the events around us. According to Wegner (2004), the *feeling* of agency can map rather weakly onto the actual *causal relationship* between a person's previous thoughts and the action that follows. We adorn ourselves with confabulated causal power, or do not consciously notice our own automated actions.

### Automatisms: Sense of Agency and consciousness

Most of our everyday behaviour is directed by automatic processes (Chen & Bargh, 1997). As mentioned above, agency is based on affordances. Affordances inhibit the level between explicit and implicit cognition. They can invite the composition of complex action plans - without conscious involvement. The automatisms in human behaviour give central importance to the distinction between 'empirical facts of agency' and the 'phenomenology of experiencing agency'. If once cycles home while thinking about a problem, the action of cycling might empirically be agentic as it fulfils the intention to get home. Yet, as consciousness is occupied with internal thoughts, the action of cycling fails to manifest itself as an agentive experience.

Social psychological theories have traditionally regarded the congruence of *conscious* previous intention and action outcome as centre piece of the human agency experience (Ajzen, 1991; Bandura, 2001). Yet more recent research in cognitive psychology highlights the emergence of a Sense of

Agency even from *unconscious* intentions (Haggard, 2005). In laboratory experiments, these intentions are also susceptible to primes, creating a feeling of agency in the absence of self-causation. In conjunction with the three-tier structure of agency sources presented above (explicit, intermediate, implicit) (Franks & Voyer, 2018; Pacherie, 2013) this gives rise to the notion that our actions might constantly produce a sense of agency. Yet, this Sense of Agency does not necessarily reach consciousness. Consequentially, Haggard and Eitam (2015) call the everyday experience of agency a "phenomenally thin" backdrop to our daily life. Most often, it is not a clear and distinct perceptual experience. Preparing a cup of tea does not produce a strong experience of intentionally controlling each discrete action. To the contrary, it is rather the *absence* of the SoA that appears as a prominent perceptual event. This is also reflected in the Comparator Model which only produces a net-signal if prediction and outcome are mismatched. It is central for the experience of agency what brings an action to consciousness.

One pillar of action awareness might be conflicting intentions. Bargh & Morsella (2008) claim action can remain unconscious if it does not involve action-selection conflicts. While most plans of actions are activated and selected unconsciously, the arising of alternative and incompatible courses of action lead to competing intentions. This conflict, they claim, brings the matter to consciousness, and provokes the person to make a choice. Gray and colleagues (2013) claim that the action-representation often enter the mind involuntarily, as urges. Urges are reflex like reaction that appear automatically, such as when "presented with an orthographic stimulus, one cannot help but read the word subvocally" (Helmholtz, 1856 in Krisst, Montemayor, & Morsella, 2015). In this account of competing action intentions, a Sense of Agency also arises from supressing the urge to breath when being under water.

### 2.1.3 Agency and Self-Knowledge: Know thyself

The experience of agency might be influenced by our attention to unconsciousness. This follows the dual-process concept of mind, that holds that much of our actions happen habitually or automatically (System 1) without the slower consciousness (System 2) attending to them. It involves the idea of a divide between our conscious knowledge and objective reality, which has a long tradition in self-knowledge research and more recently fuels the "self-tracking craze" (Lupton & Deborah, 2014). The absence of a conscious intention can for instance lead to misattributed self-causation, resulting in confabulated self-knowledge (Bar-Anan, Wilson, & Hassin, 2010). One finding from self-knowledge research central to self-tracking is that people make flawed predictions of future behaviour. Dunning, Heath, and Suls (2004) argue this is for two reasons. Firstly, this is because, on the one hand, they fail to anticipate situational details and on the other hand, they have an imperfect understanding of their "emotions and visceral drivers" (Wilson & Dunn, 2004). A plan to only eat salad from now on does not anticipate the bodily state in the moment of food-choice. Secondly, people take an "inside-view", running through the behavioural sequence in their minds. Wilson (2004) characterises introspections

like these as merely “inferring what our emotional states might be”. He invokes that, while according to Self-Perception-Theory Bem (1972) people deduce their internal states by observing themselves, it remains unclear whether these introspective inferences are self-revelation (I eat ice-cream, so I must like it) or self-fabrication (my friend ate an ice-cream, so I did, so I must like ice-cream). The introspective (inward looking) path to self-knowledge has accordingly been contrasted with feedback from external sources (Bollich, Johannet, & Vazire, 2011). While direct feedback from intimate others might be the most insightful source of information (Vazire, 2010), other studies show that improved self-awareness develops from confronting people with video-recording of themselves (Albright & Malloy, 1999). By representing the self in numeric recordings, popularly known as the Quantified Self-Movement (QS), strives to circumvent the alleged flaws of introspection and get an objective glimpse at the unconscious self.

### 2.1.4 Agency and Self-Tracking: Change thyself

Both recording of the self and the pursuit of objective feedback have a long history. Pencil traces of height on walls mark the growth of children and diaries record thoughts. The modalities for recording have evolved with technology towards an increasing quantification and objectification of the self. From the early adoption of the weight scale for domestic, bodily, use to the introduction of pedometers in leisure sports (Laurson, Welk, & Eisenmann, 2015), this recording of the self has culminated in contemporary digital self-tracking.

Here, the ubiquity of affordable sensors has fuelled the integration of biometric measurements, once reserved for pilots and astronauts, into every smartphone. Since the Quantified Self-Movement (QS) first propagated “self-knowledge through numbers” (Wolf & Kelly, 2009), practices of digitally recording one’s life have diffused into consumer markets and manifested in the research field of personal informatics (PI). Their first models define self-tracking as following the purpose of “self-reflection and gaining self-knowledge” (Li, Dey, & Forlizzi, 2010), yet despite the diverse motivations and practices of QS-enthusiasts (Rooksby et al., 2014) the widest spread applications are now imbued with “commercial and managerial value” and vested with the public interest in the propagation of self-care for health (Neff, G., & Nafus, 2016). (Lupton & Deborah, 2014)Accordingly, in a meta-study of the self-tracking literature Dijk and colleagues (2017) summarised the primary motivation for users today is *self-improvement*.

Two of the main mechanisms underpinning people’s motivation for self-improvement will be discussed here: Self-insight and self-monitoring. The notion of changing for the better through more profound self-knowledge is intuitive, yet the quality and originality of the knowledge derived apps remains debatable. In their Dijks and colleagues (2017) highlight that only a few apps support the desire for self-discovery, while the majority focus on the implementation of previously existing goals. In the studies they reviewed, many people reported learning about themselves, yet their insights were often trivial or surface-level. Also, few apps supported capturing behavioural contingencies (social

company, location) which in light of social and situational affordance underpinning agency seems incomplete. In sum, while the often science-related and highly engaged extreme-trackers of the QS-movement advocate their self-discoveries online and in conferences, average users might not always use the available technology in a way that means they are able to make new discoveries.

Arguably the best developed feature of the most used apps is self-monitoring. Monitoring techniques are an established part of psychotherapy (Elliot & Harackiewicz, 1996), as well as cognitive and behavioural psychology (Fawcett & Provost, 1999). While monitoring also has a documentation function, a primary reason for its reputation as a standalone intervention technique are its reactive effects. Reactivity describes a behaviour changing solely because it is recorded (Nelson, Boykin, & Hayes, 1982) – most often into the desired direction and towards personally accepted social norms. Its effects as a behavioural intervention are well documented, for instance in the domain of weight loss (Burke, Wang, & Sevick, 2011) or energy usage (Buchanan 2013).

### Shift of attention

Moments of using an app to monitor one's behaviour inherently involves a shift of attention. While most of our daily activities are guided by automatism, self-tracking can re-focuses attention onto habitual activities. From a *dual-system* perspective, this re-ignites conscious action-selection in the domain of automated processes. Within this line of thinking, an attentional focus is central for the experience of agency. It brings peoples' intention for their everyday activities back to consciousness and might develop them sources of agency-experiences. More generally, monitoring might also increase self-awareness, a process shown to increase the Sense of Agency. In sum, this leads to the hypothesis that "Using a self-tracking app refocuses attention on actions that are mastered well, thus raise one's Sense-of-Agency".

### Goal-pursuit

Distal goals might also influence the Sense of Agency through a "goal-directed state of mind" (Van Der Weiden, Ruys, & Aarts, 2013). Attending to goals activate specific processes that facilitate their achievement. This mindset is hypothesised to direct attention and behaviour towards goal-achievement (Carver & Scheier, 2004). Goals are supported by focussing attention on the intended outcome and shielding it from potential disturbances. A Sense of Agency is derived not only from achieving the goal, but also through monitoring the progress towards it. Weiden and colleagues (2013 claim that while a match between goal and action increases self-agency, a mismatch allows the agent to actively navigate the attribution of agency: The causal ambiguity associated with a mismatch allows a person to ascribe authorship to external factors such as e.g. other people or circumstances. This reflects a dependence of the SoA on the outcome, where people accept authorship according to the desirability of the outcome (Morevedge, 2009; Bednark, 2014; Christensen, 2016); . In sum, opening the self-tracking app might ignite the goal-directed state of mind, which limits the awareness of other actions. This give rise to the hypothesis: "After the event of using the self-tracking app, temporally closely

following actions should align in their Sense of Agency to the user's performance in regard to the distal-goal."

### 2.1.5 Self-efficacy

Finally, both the contemplation about goals and aspiration, as well as the capacity to put the resulting intentions into practice is strongly influences by self-efficacy beliefs. These are conscious expectations about the ability to perform a specific action (Bandura, 2001; Chambon et al., 2014). The central role of perceived self-efficacy for successful behaviour change is an established research finding. Mastering an activity and *beliefs* about mastering the activity in the future have an obvious circular connection: Memories of successfully performing an activity in the past are the primary determinant of self-efficacy beliefs. In light of this feedback loop, the Sense of Agency – subjectivity experiencing agency over a specific action – might be a central influence on self-efficacy. The idea that explicit experiences of self-agency feed into self-efficacy beliefs can be derived from the theory (Bandura, 2001, 2006). However, the connection between the often implicitly present SoA and self-efficacy remains yet to be explored (Haggard, 2005).

A formal outline of the sub-questions and hypothesis that arose from the literature can be found as the first page of the appendix.

# 3. Methodology and research design

The most appropriate framework for a field-study of self-tracking and the Sense of Agency - an action related immediate experience or judgement - is the Experience Sampling Method (ESM). Being fleeting, "phenomenologically thin" and thus often not even consciously noticed, one's SoA is especially prone to recall biases and the confabulations that impede retrospective reports (Fisher&To, 2012) The Experience Sampling Method (ESM) limits these distortions by recording he Sense of Agency (SoA) immediately, as a situation it occurs. It does not tap into one's *memory* , but instead, the *experiencing self* (Kahnemann&Rijs, 2005). While more comprehensive one-off questionnaires or qualitative interviews could have allowed for richer descriptions of how people interpret their agency when using self-tracking apps, the results from these methods risk being skewed by recall biases. These methods would have also captured self-narratives and general beliefs [Gloabal SoA, Efficacy] instead of the situated states. Instead, the ESM enables me to capture the someone's immediate feeling of agency as they complete an action.

## 3. 1 Experience Sampling Method

The Experience Sampling Method (ESM) captures in-situ how people think, feel, and behave. By briefly asking a few questions several times a day, it samples phenomena in their real-word setting, immediately as they occur. This creates a longitudinal sequence of situated snapshots, which contain both the variable of interest and information about the environment (Lawton, Conner, & McEachan, 2009). Pioneered by Csikszentmihalyi (1977) the method is valued for its ecological validity. By contextualising measurements within the environmental contingencies of peoples' daily lives, ESM

data allows the researcher to later analyse cause and effect relations between a situation and the phenomena of interest. Consequentially, it is a popular method for studying situation dependent, state-like phenomena and has been called the "gold standard" for capturing within-person fluctuations (Fisher & To, 2012). The repeated nature of ESM observations, spanning days and sometimes weeks, allows the researcher to differentiate *within-person fluctuations* from *between-person differences*. This permits the researcher to discern individual reactions from generalisable psychological causalities (Bolger & Laurenceau, 2013).

### 3. 1.1 An ecological method for the Sense of Agency

As mentioned in the literature-review, the Sense of Agency (SoA) is typically studied in either implicit or explicit experimental paradigms. Both types take place in highly controlled laboratory environments, often in front of a digital device. The SoA arises from a multitude of factors. For instance, it is situated through affordances, derived from cues, dependent on the social environment and influenced by physiological states. When SoA experiments are conducted in sterile laboratory environments, this normally stabilises this plethora of potentially confounding factors and can isolate a comparable state.

Carrying an SoA measurement into the field thus faces two main challenges. First, it is difficult to condense the complex concept of agency into the small number of items that can be answered several times a day. Second, it is difficult to specify a set of questions which can quickly capture the most relevant ecological influences of the situation.

### 3.1.2 Agency Scale

Until today there have been no published studies measuring the Sense of Agency in an ecological setting. However, Franks and Bauer have developed an "Agency Scale" to measure agency in the field. This self-report measure contains scale 1 (S1) with 7 questions for explicit self-agency, scale 2 (S2) with 16 measures for joint agency (Voyer&Franks, 2014), measures for the self-other overlap (Myers & Hodges, 2012) and several variables on characteristics of the situation (Location, Action, Sociality, Emotion). Following Tuomela (2006) in this philosophy of action, the scale was designed especially to discern the "I"-mode of self-agency from the "We"-mode of joint action. For ESM purposes, this scale had previously been used in conjunction with a combination of a custom made signalling-service and online-questionnaires, called the "Agency App". Due to technical reasons this app was no longer available. Therefore, assembling an ESM tool myself entailed the possibility to first, adapt the tool to the specific needs of my research project and second, learn from the experiences and data of two previous dissertations that had used the "Agency App".

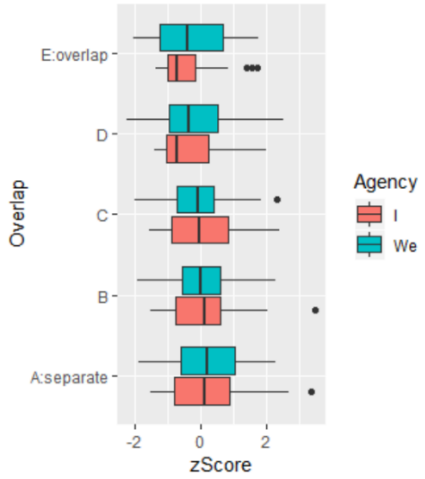
## 3. 2 Secondary data analysis

The “Agency App” was implemented in a random within-segment signalling schedule, alerting participants three times a day. At random times in the morning, afternoon and evening it presented a brief smartphone questionnaire. One of the app’s unique features was that for every session, it would randomly draw 2 of the 7 items from S1 (“I”) and three of the 16 items from S2 (“We”). So, unlike traditional ESM-measures which typically reduce the scale of the dependent concept to a few items that are repeatedly asked (Hektner, Schmidt, & Csikszentmihalyi, 2007) the app changed the questionnaire with every session, sequentially covering the whole scale.

### 3.2.1 The sample and data preparation

The two previous dissertations had used identical versions of the “Agency App” as described above. Dataset A was comprised of 9 participants with 15 observations, and a study duration of five days. Dataset B sampled 32 participants, 21 of which had responded to at least 5 sessions, which lasted 7 days. The two datasets came in relatively different formats and had to be comprehensively cleaned, homogenised and scored to finally extract the S1 and S2 scales [Details in Appendix.M1]

Finally, I could merge the data and received data for 30 participants in total. Both “I” and “We” agency vividly fluctuate over the course of the studies, which supports the “state” conception of agency. However, searching for relation between these fluctuation and ecological measures remained somewhat inconclusive. For instance, while the “We” agency scale is theoretically based in Tuomela (2000) who sees the merging of individuals into “intending as a group” as necessary condition for the emergence of “We”-agency, the S2 score did not significantly change with increasing self-other overlap (plot below).



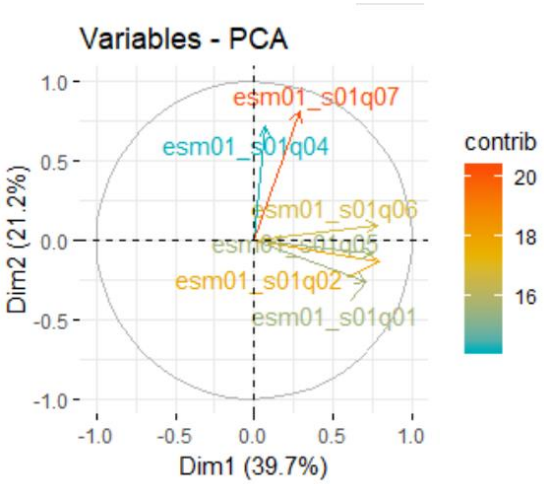

### 3.2.2 Scale reliability

Due to the random selection of the items, it was not possible to calculate traditional ESM reliability statistics. For each person, I thus took the means of all the times a person had answered an item. This meant losing all within-person fluctuations for the items but permitted me to approximate traditional

reliability statistics. The Cronbach's alpha for S1 ("I"-agency) was 0.64; and 0.33 for the S2 "We"-mode scale. The S2 scale had multiple illogical item-correlations (for instance conceptually similar items being reversely correlated). Automatically flipping these items increased the alpha to 0.58 yet turned them against the meaning of the scale. These values were in range with what the two previous dissertations had reported [S1 (0.69 and 0.54), S2 (0.46 and 0.73)]. However, their reliability statistics were based on one-off questionnaires separate to and outside of the actual ESM studies and thus can only serve as an indication. Equally, my analysis had to rest on mean values and not the actual ESM values, disregarding within-person fluctuation.

### 3.2.3 Component analysis

The Cronbach's alpha values called for a decomposition of the data. A principal component analysis enabled me to first carve out the main factors of each scale and then identify the central items for these factors. For the 7 items of the "I"-agency scale, the PA revealed one main component covering 39,7% of the variance and two side components (Dim2: 21%; Dim3: 16%). The strongest items of the main component in descending order where 2,6,5,1; of the first side component items 7 and 4 (see plot below).




The 16 items of the "We"-scale on the other side did not reveal one main component. Instead, the variance was spread out over four relatively even dimensions: Dim1: 23%, Dim2: 17%, Dim3: 15%, Dim4: 13%. This might partially explain the low Cronbach's alpha for S2.

## 3.3 Learnings from Secondary Analysis

### 3.3.1 Reduce "We-mode" scale

The ongoing debate about the typology of the agency experience further complicates determining their magnitude. While both individual and social actions include a comparison of prediction and outcome, the Sense of Agency from joint action is also influenced by a person's position in a group, the control

she can exert, egalitarian or hierarchical group structures, the biased dynamics of social attribution (self-serving bias) or the valence of the action outcome, to name only a few (Pacherie, 2008). It might thus be more feasible to capture thy type of the action than its magnitude.. As the "We-mode" scale S2 covers a four-component construct I did not consider it feasible to cover it with a loo one-digit number of ESM items.  Instead, in regard to my research question, include a "joint-intention" indicator item.

The ecological (situational) measures of the "Agency App" were asked in closed ended format [Appendix.M2]

### 3.3.3 Use small number of fixed items

Having found multiple orthogonal components within the S1 an S2 scale, not fixing items but randomly selecting them might skew the measurement. If – like in the case of "We-mode" agency – a 16 item scale comprises four principal components, the method of randomly drawing three items per session might in one session over-represent a certain component and under-represent it in the next. This would introduce a session-to-session fluctuation.

### 3.3.4 Variance and accessibility

Only questions that indeed vary throughout the day can represent fluctuations of a construct. Consequentially, items where ranked by their variance [Appendix.M3]. Furthermore, the previous dissertation surfaced participants partially not understanding the meaning of some items, both in S1 and S2. These reports were empirically supported by negative correlations between substantially similar items.

## 3.4 Research design

### 3.4.1 Item selection

Concentrating the questionnaire on "I"-mode self-agency, the item selection ran through three stages. First, it took inspiration from a 2017 publication on a global SoA scale (Tapal, Oren, Dar, & Eitam, 2017). The group had developed a closely related scale for a context-independent *global* Sense of Agency and tested it on 644 participants. A transparently presented factor-analysis which had decomposed their observations into a positive and a negative Sense of Agency included reports for the most predictive items. These had interesting parallels with the "Agency Scale" (Bauer & Franks). Second, I created a shortlist of six items which were separately discussed with English native speakers. This shortlist also contained two candidates from  that were substantially like Agency Scale items but differently worded. Third, bringing all strands together, the objective was to find intuitively understandable items, maintain the concept validity and ensure some variance. The six item shortlist, including a discussion of each item, as well as the final four items can be found in the appendix.

### 3.4.2 Procedure

To sample how self-tracking apps influence their users' Sense of Agency I conducted a six day experience sampling study, also designed as a within-subject experiment. For the first two days participants were sampled without any app. Then, from the third day of the study onwards, subjects started tracking an aspect of their lives. First sampling a no-self-tracking baseline permitted me to compare the cross-situational ("global") SoA between the two conditions. Participants were signalled via text-message (SMS) by SurveySignal (Hofmann & Patel, 2015). The signalling schedule, descriptions of linking the different software can be found in Appendix.M4.

### 3.4.3 Recruitment

The repeated and relatively obtrusive measurements in ESM studies are a burden for participants (Hektner et al., 2007). On the other hand, valid statistical tests allow only for a fraction of missed responses. In addition, participants had to start self-tracking an aspect of their lives. This made selecting and motivating participants key for the quality of my study. Candidates were found through convenience and approached in personal conversations, to create a feeling of involvement in the research project.

### 3.4.4 Choice of self-tracking apps

To most closely resemble a realistic situation in which a person voluntarily picks-up an app to self-track an aspect of her life, it was crucial that participants had a genuine and inherent interest in the app they would use. A high engagement was therefore prioritised over prescribing an app. Instead, I compiled a "menu" of the most widely used self-tracking apps, coming from health, nutrition, sports, finances and work (appendix) and participants chose an app from this list.

### 3.4.5 Sample and Language-Versions

The final sample comprised of 32 people (19 female, 13 male). 75% were between 22 and 27 years old and 90% had at least one university degree. For 56% of the sample English was their primary or secondary language (either native-speakers or English education system). Of these, the main nationalities were 26% UK, and 11% Italy. The remaining 44% were German. Thus, I supplied the study alternatively in English and German, to control for ambiguities in the understanding of items. The questions were several times translated and back-translated by separate bilingual people.

### 3.4.6 Measures

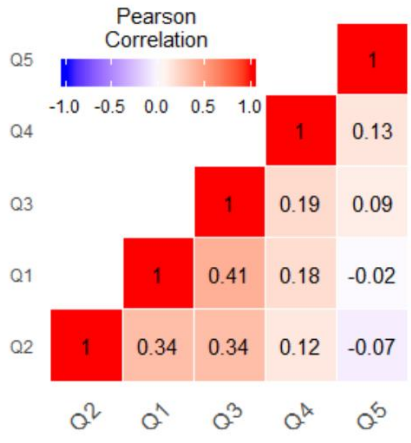
After signing up and consenting to the study (Appendix) participants were directed to an income-questionnaire, assessing their familiarity with self-tracking, measuring the cross-context global Sense of Agency (Tapal et al., 2017) and collecting demographic information. An overview all measures and their timing can be found in Appendix.M5.

# 4. Results

## 4. 1 Sample statistics and descriptive analysis

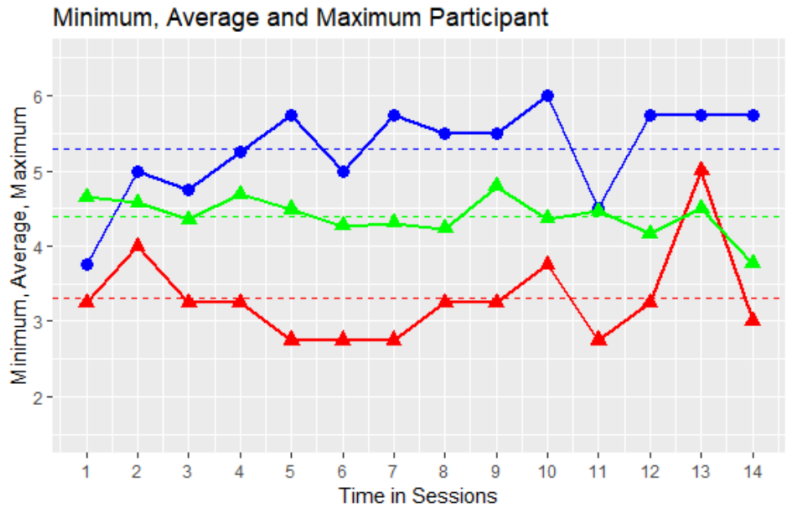
### Completion rates and sample

From the 32 participants, 27 fulfilled the inclusion criterion of a minimum 30% completion rate. The mean response rate of 74% for the remaining 27 participants was comparably high (Csikszentmihalyi et al., 1977). The data set contained 403 observations. After removing rows with missing answers for SoA, 384 sessions remained. The English and German language versions of the questionnaire had no significant between-group differences for either of the five SoA-variables. The p-values of the five separate two-Sided Kolmogorov Smirnov test were in the range of [0.27-1]. This is strong support for the validity of the item translation [Appendix.D1]. After reversing the two negatively formulated questions, all SoA items (Q1-Q4) substantially had meaningful positive correlation (plot on the left). The agency score was calculated as the mean of these four fixed items. The Cronbach's alpha for the four items was 0.59. This moderate value reflects the different sub-concepts integrated in the item which supports validity and reflects the inherent trade-off between validity and reliability in ESM studies.




## 4. 2 Inferential analysis

An analysis of ESM data fundamentally rests on the distinction between within-subject [Level 1] and between-subject [Level 2] variations. While a particular subject might feel more agentic e.g. on Thursday morning rather than Friday afternoon, there are also more general person-to-person differences in how agentic someone feels *on average*. This is illustrated in its extreme by the graph below. It plots the person with the highest (blue) and the lowest (red) mean SoA from the sample, over time.



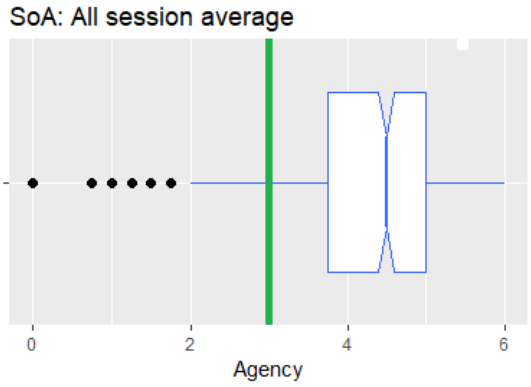
### Statistical methodology: OLS Linear Regression versus Multilevel Modelling

Common ordinary-lease-square (OLS) based linear regression models assume the independence of the underlying observations. Regarding all 384 sessions in this study as independent clearly neglects the fact that they gravitate around the 27 participants which produced them. Also, the higher number of observations in analysis of the session-level data would underestimate the p-values. Multilevel models (MLM) take the nested nature of the data into account and distinguish Level 2 from Level 1 variation, which can be quantified in the interclass correlation (ICC). It states how much of the total variation in the dataset is accounted for by between-person differences and how much by within-person fluctuations. If ICC equals 1, all variance is due to the between-person differences. If ICC is 0, all subjects have the same mean, the variance is due to within-person fluctuation and the MLM equals a linear model (Bolger & Laurenceau, 2013). Typical ICC values for ESM data lie in the range of 0.2 to 0.4. Running a multilevel model without predictors yields the ICC for this sample, which is 14.29%. On the flipside, 85.71% of the variance is explained by within-person fluctuation. In sum, the between-person differences in the SoA exist, yet they are less pronounced than in other measures typically analysed by MLM. This provides some justification for the exploratory use of linear models. Furthermore, a full MLM not only discerns Level 1 from Level 2 variations in the depended variable, but Bolger and Laurenceau (2013) argue that the explanatory variables must be divided into a mean and a situation component. Simultaneously allowing for effects to differ between people (random effects) and controlling for confounding variables makes these models computationally intensive and complex to interpret. My inferential analysis will thus proceed by exploring the data with linear models and validate findings through multilinear modelling. To account for different scale-usage and potential mean-differences in the SoA between people, all linear models were run on means-corrected data. Therefore, the deviation of each person-mean from the global sample-mean is added to every session, so that all participants have the same mean value.

## Agency in an experience-sampling setting

The first part of the statistical analysis examines the general manifestation of the Sense of Agency in everyday life. This particularly concerns how the concept's components - Default-agency, Joint-action, and sensorimotor-influences – can be outlined from the collected data.

## Agency by default




The median level of experienced agency in the sample was 4.5 (mean 4.375) on a scale reaching from 0 to 6. A value of 3 (green vertical line) was the centre statement of the scale: "Neither agree nor disagree". As also apparent from the adjacent plot, an experience of control seemed to be the default for the great majority of all actions. As actions in the sample comprised both conscious (System2) and automatic (System) behaviour, this highlights the inherent reactivity involved when measuring the Sense of Agency with explicit methods. While automatic action based on nonconscious intentions does produce a Sense of Agency (XXX, XXX), this sense is normally a "phenomenally thin" backdrop to our action and is not consciously attended to. While, in general a construct is never asked for directly by through latent variable (Cronbach & Meehl, 1955), the act of asking for related elements might have lifted the otherwise unnoticed SoA into consciousness. However, the plot also highlights that participants experienced rare but distinct moments of unusually low agency.

## Collaborative action with joint-intention

In 36% of all sessions participants stated someone else was involved their action. In these cases, being with others and sharing an intention about "where this action should go" was associated with an average decrease in the Sense of Agency of -0,25 units (p-value 0,017, significant on alpha 5% level), keeping time, arousal, mood valence and mind valence constant. Acting with others without a shared intention did not decrease the sense of agency (p-value 0,94). In light of the ongoing debate around the qualitative differences between joint-actions it appears that collaborative agency in the weak-sense (Pacherie, 2008) does not decrease the individual sense of agency. Collaboration in the stronger sense – the sense of joint action – does however decrease self-agency. The joint-intention item indicating joint-action was designed as a common denominator between "we-mode" joint action Tuomela (2006) and Gilbert's (2009)account of simultaneous individual action. While it is theoretically possible that participants generally felt less agentic in moments of joint-intention, yet it seems more likely that these moments gave rise to a qualitatively different kind of agency, namely agency from joint-action. In sum, in moments of joint-action with joint-intention, participants might not have felt less agentic per-se (as indicated by these results at the first glance) but entered a different type of agentive experience. Even without specifying the joint-action type or its magnitude, this result shows the importance of incorporating joint-action as a confounding factor when measuring individual self-agency.

## Arousal – Sensorimotor influences

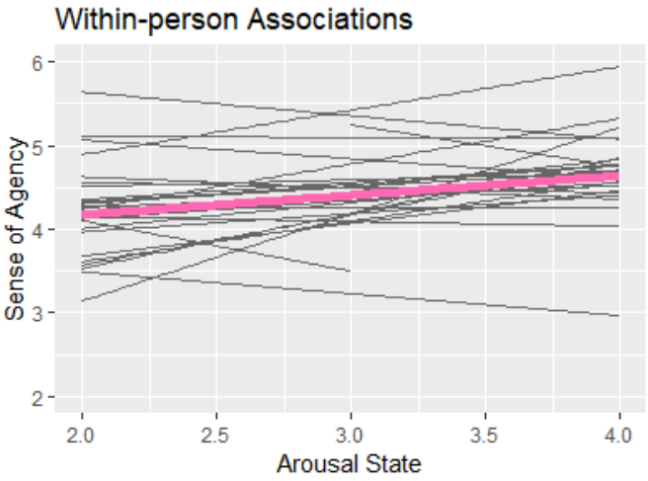
The SoA is theorised to arise both from sensorimotor and cognitive sources. Due to its close link to bodily states, the experience of agency is influenced e.g. by physical effort or recreational-drugs

(Demanet, Muhle-Karbe, Lynn, Blotenberg, & Brass, 2013), or more generally the level of arousal. In conjunction with emotional valence, arousal is a basic dimensions of human affective experience (Kuppens XX) and in laboratory studies, higher levels of arousal have been found to increase the SoA (Wen Wen 2015). My analysis replicated these findings for explicit SoA within an ecological setting. A multilevel model with random effects and controlling for time, found both the state and the trait component of arousal to have a significant influence on the Sense of Agency. State and trait component were derived by splitting the arousal variable into the per-person mean levels and the within-person fluctuations (Bolger & Laurenceau, 2013). Splitting the explanatory variable isolates the between-person differences (higher average arousal) from the within-person differences (one person's arousal in different situations).

```
Fixed effects: SoA ~ 1 + TIME + state_arousal + trait_arousal
                  Value  Std.Error  DF  t-value p-value
(Intercept)    4.615188 0.11231044 355 41.09313  0.0000
TIME          -0.027342 0.01006782 355 -2.71577  0.0069
state_arousal  0.219876 0.06454496 355  3.40655  0.0007
trait_arousal  0.483461 0.17308384  25  2.79322  0.0099
```

Interpreting the output above (from the lme-function in R), a person with average arousal in an average aroused state has a Sense of Agency of 4.615 on a 0-6-point scale. Each extra unit mean-arousal (a person's average arousal) adds on an average of 0.483 units of SoA, when controlling for time. On the other hand, for the average person, being one more unit "aroused" than in an average situation, adds 0.21 points onto the 0-6 points SoA scale. Given that the range of "arousal" is [1-5], the difference between a particular person being at his arousal minimum and his arousal maximus amounts to 5x0,21= 1,05 units of SoA. Bearing in mind that more than half of all observations had SoA levels in the narrow range between 3.5-5 (displayed in the plot above), both the between person and the between situation differences in arousal have a strong impact on the Sense of Agency.

Plotting the model's random effects (the individual relation of arousal and SoA for each person) reveals some individual differences in the SoA-arousal relation yet a similarly positive tendency for most participants. This is supported by the variance of the arousal-coefficient, which is 0.04 compared to the variance of the intercept, revealing only a small between-person variation in the effect of arousal on the SoA [Appendix.D2]. In sum, independent of person and situation, arousal had a strong general effect on the Sense of Agency.




## Effects of self-tracking on the Sense of Agency

### The global Sense of Agency over time

This study's most general question is whether introducing self-tracking to one's life raises their SoA. To strengthen this test's empirical basis, the first two days were sampled as a baseline without self-tracking and participants started tracking from day three onwards. The TIME variable signified timepoint over the entire study, where Time 1-6 is the first two baseline-days, and Time>7 includes self-tracking [Time: Appendix.D4].

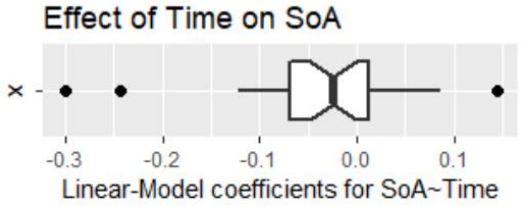
Contrary to the intuition of self-tracking apps as an agency-supporting tool, the course of time had a relevant and significant *negative* impact on the Sense of Agency. A multilevel model showed a coefficient for the "TIME" variable of -0,025 (p-value=0,0069; controlling for "Shared Intention", and the fixed and random effects of "Arousal"). Considering the "TIME" variable's ranges from session 1-to-21, this means a person loses on average 0,525 units of agency over the course of the study (21*-0,025= -0,525**)**. Again, bearing in mind that in more than 50% of all case the SoA was in the range between 3.5 and 5, this 0.525 point decrease is a strong impact. Testing whether this time-trend could be due to weekly cycles (Sanders, 2016), a linear-model found no evidence for weekdays influencing the day of agency [Appendix.D5]. Two other time-models tested within-day cycles and also found no significant effect [Test, Illustration and Description: Appendix.D3].

### SoA for actions of the tracked domain

To further examine whether this decline in SoA over time could indeed be a treatment effect from using the self-tracking app, I examined whether the time-trend depends on how frequently a person lives up to her tracked-goal. Participants had self-reported their goal-performance from day three onwards. This followed the idea that an analysis should allow for the possibility that receiving positive feedback ("you are such a fast runner") influences the SoA differently from negative feedback ("You have again eaten too much").

For each person, I thus examined how goal-performance related to the individual time-trend, asking: Does the frequency of an incongruence between one's behaviour and distal goal-intention influence the development of the SoA over time?

Therefore, for every person, I first calculated the percentage of session in which a participant felt she was "behind" on her goal; and second, I fitted individuals linear-regressions relating SoA and TIME and extracted the slopes. The calculated percentage was then set in relation to the slopes of the SoA-Time effect.



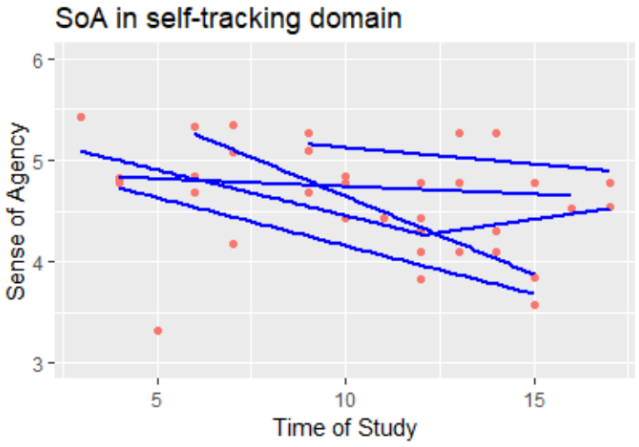

As displayed in the plot above, while the individual time-trend confirmed the multilinear model in that they were predominantly negative, a linear model between the goal-performance percentages and the slops did not find a significant relation (p=0,847). This means that the decrease in the global SoA – which comprises of a variety of everyday activities – cannot simply be attributed to positive or negative feedback from the self-tracking app. In sum, the global Sense of Agency – for all action – steadily decreased over the time of the study. Also, over the time of the study participants start and establish the use of self-tracking apps. This could suggest a connection between self-tracking and a decreasing SoA. However, it did not matter for the trend of the global SoA whether the feedback participants received from their app was positive or negative. In my opinion, it seems unlikely that the mere presence of a self-tracking app in a fraction of the daily actions decreases the global Sense of Agency for all actions, partially because the SoA is a highly action-specific feeling (Moor XX). The analysis has to further disentangle the types of actions.

As quoted in the methodology section, Tapal et al. (2017) had forwarded the idea of a context-independent Sense of Agency. This assumes that the magnitude of self-agency a person receives from their actions is partially a personal disposition. To test his idea, the global SoA scale was included in the intake-questionnaire of the experiment. However, while the multilevel models do indicate between-person differences in the average-experience of SoA, these person-level mean-values (mean of all session for a person) had no significant relation with the one-off values derived from "Sense of Agency Scale". In sum, as the SoA is a fundamentally action-specific feeling, it seems hard to capture this in general one-off questionnaires. For this study, these findings support an approach that differentiates between action types.

The previous analysis looked at the SoA in a global way, melding together scores from actions that are as different as stirring a pan of pasta-sauce to solving a mathematical problem. To carve out whether self-tracking influences the SoA of specific actions, I focused the analysis on the types of actions that are also captured by the self-tracking app.

## Domain related agency

To test whether the course of ones Sense of Agency in the self-tracked domain diverges from the global SoA, I zoomed in onto those actions that where closely related to one's self-tracked domain either in thought or action. From day three onwards participants had self-reported the closeness of action and thought to the self-tracked domain [see Appendix.D6 for details]. This narrow criterion left only 72 of the 384 observations. As a sensible linear regression requires a minimum of five observations (Bolger & Laurenceau, 2013), I further excluded participants with less than five observations, reducing the data to only 6 participants and 39 sessions. The development of these participant's Sense of Agency in their self-tracked domain is plotted below.




Except for the one person who was an increase in the SoA, the slope coefficients are between -0,032 and -0,139, thus more negative than the general time trend in the study (-0,02). This refined view at the time trend suggests a negative impact of self-tracking on actions related to the tracked domain. Unfortunately, the confined scope of data neither allow a multilevel modelling, and the nested nature of the data does not allow for a meaningful linear model. While from a descriptive point of view, for five out of the six participants the SoA seems to have decreased stronger over time in their self-tracked domain than their overall SoA, this impression could also be by chance. However, interpreting the impression indicated by the plot above, the average time-course of the SoA in the tracked domain is in complete opposition to the idea that self-tracking might shift conscious attention to actions that are normally unconscious and mastered well, thus re-discovering them as a source of agentic experiences. One possible explanation for the non-existence of the hypothesised effect could be the personal relevance of an action as established by Aarts, Custers and Marien (2009). Accordingly, the explicit SoA derived from an action is mediated by its how strongly it links to central motivations of the person (see also: Van Der Weiden et al., 2013)). Simply put, while one might generally succeed in tying one's shoe-laces, its irrelevancy from a motivational point-of-view might first, make it an unlikely candidate for tracking, second, minimise its impact on the explicit SoA.

## Being “on-track” versus being “behind”

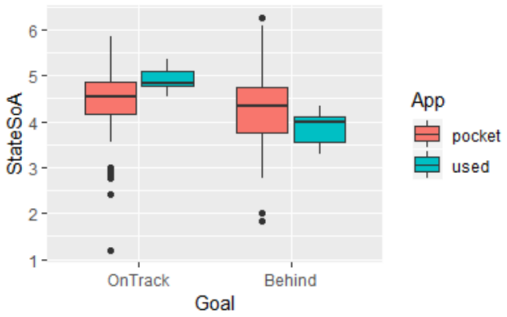
From the third day of the study onwards participants self-reported how their behaviour in the self-tracked domain aligned with their distal goal. Leaving out cases with missing answer and those where participants felt “indifferent” about the goal reduced the dataset to 166 observations [Appendix.D7], yet for every session included the binary information whether the person felt “on-track” versus “behind”.

## Goal, Usage and Time-effect

Concentrating the goal-performance into a dichotomous variable was combined with zooming in onto the moment of using the self-tracking app. Building on the notion of a conflict-mindset (Kleinmann&Hassin 2013), I hypothesised that, if there was a change in the SoA due to self-tracking, there should be a temporally defined connection between using a self-tracking app and a change in the SoA. According to Weiden and colleagues (2013), the SoA should increase after a positive feedback from the app and decrease after a negative one. From day three of the study onwards, participants were asked whether, since the last questionnaire, they had used their self-tracking app. If affirmed, they were asked to self-report the time since that event on a slider, captured in the variable “TimeLag”. If there indeed was a temporally limited “spike” or “low” in the sense of agency after using the app, the functional forms of standard regression model could struggle to align themselves to the data. Accordingly, a test for linear and quadratic effects showed no significant relation of TimeLag and SoA.

For analysis, the numerical time-lag was accordingly turned into a dichotomous variable: Where someone either “used” or left it in her pocket, including how long ago the participants had last used their self-tracking app. The dichotomous transformation rests on defining a temporal cut-off point: Can I speak of “usage” if the app was last opened three hours ago, or rather half an hour? Altering this temporal cut-off point allowed me to examine whether a potential effect of using the app and realising one is “on-track” with achieving their goal *fades out* over time.

Controlling for “Arousal” and “Time”, the analysis identified a crucial cut-off point of 15 minutes. Statistically widening the definition of which sessions count as “having just used the app” meant increasing the chance for significant results, only due to increasing the number of observations (Sullivan 2012). Nonetheless, the significant change in SoA was only found up until 15 minutes after actual usage, not thereafter. The temporally limited effect of using the self-tracking app is illustrated and described below:




A linear model confirmed the impression given from the grouped boxplot above. For the SoA, it did not make a difference whether one was generally on-track towards one's goal or not (p=0,72) but when the app was used during the 15 minutes before the measurement, being "on-track" meant a rise in the SoA of 0.5 units, whereas being "behind" decreased the SoA by an average of 0.37 units, compared to not having used the phone during the last 15 minutes before the measurement (having left it in the pocket). The effect of a diminished SoA when being "behind" and using one's phone is even stronger in the more conservative multilevel modelling approach. Here, a person who is "behind" on her goal and used her self-tracking app in the last 15 minutes lost an average of 1.03 units in the SoA. However, the positive impact for SoA of being "on-track" was not confirmed by the MML. The table below shows predicted SoA, calculated based on the significant (alpha 5%) coefficients of a) the linear model and b) the multilevel modelling approach. Both models controlled for TIME, Arousal and Intention [Appendix.Models].

| Predicted values by<br>a) linear-model on means-corrected SoA data, compared to<br>b) multilevel-modelling prediction based on SoA data | | **"Goal"** | |
|---|---|---|---|
| | | 0: "On-Track" | 1: "Behind" |
| **"App"** | 0: "Pocket" | LM: 3.80<br>*MLM: 4.06* | LM: 3.80<br>*MLM: 4.06* |
| | 1: "Used | LM: 4.30<br>*MLM: 4.06* | LM: 3.43<br>*MLM: 3.03* |

In sum, it seems that using the app amplified the SoA for a limited amount of time. There is strong evidence for a diminished SoA from not being "on-track" regarding what a person is tracking, and having been confronted with that feedback during the last 15 minutes in one's self-tracking app. The positive effect for being "on-track" has to be analysed with some caution – stemming from the linear model this framework does not correct for the dependence of the observations.

One attempt to interpret the dampened SoA in the case of being "behind" is the "goal-directed state of mind" (called here: goal-attention) proposed by (Weiden, Aarts, Ruys XX). In using the self-tracking

app, a user's attention is directed to the distal goal, thus limiting awareness for actions after the event, causing a lower SoA. As in the example above: Riding home on a bike without consciously attending to it, the direction of consciousness and attention takes centre stage in explicitly perceiving the Sense of Agency. However, my results show an alignment of SoA and performance on the distal goal only for the negative case (being behind). On grounds of the more reliable multilevel model, there is no significant effect for the positive case, while in a 'goal-attention' account, there should be a positive effect of being "on-track". Consequentially, the hypothesis of a "goal-directed state of mind" could not be confirmed. The absence of a positive amplification of SoA in the case of positive performance feedback is also surmising because being confronted with oneself through the app should increase self-awareness, which has a positive influence on the SoA (XXX).

An alternative account for the moments of low agency comes from research on the attribution of negative outcomes. According to Morevedge (2009), the valence of an outcome can influence how much agency a person attributes to herself. In a self-serving manner, people accept less agency for negative outcomes, and if possible, deflect the outcomes on external factors or other people (Bednark, 2014; Christensen, 2016). For instance, being confronted with a lack of physical activity by the app, a participant might have deflected agency for the situation. This account is in line with Weiden and Ruys (2012), where in case of a mismatch between intended and observed outcome, people actively navigate and deflect the attribution of agency.

# Conclusion

The aim of this study was to research the daily experience of self-agency when using a self-tracking app. I first re-designed an Experience Sampling Method (ESM) tool, and second, recorded the self-agency experience of 32 participants over the course of a week.

Concerning the further development of the ESM tool, I exposed the conceptual difficulties in sampling the multi-component "We-mode" concept of joint-agency with a small number of items. To reliably detect the *existence* of a "We-mode" join-action in an ecological setting, in my opinion it is necessary to reduce the S2-componen of the existing "Agency Scale" (Bauer&Franks). A reiteration seems most promising from a conceptual, rather than a psychometric angle. Subsequentially, I designed a single-item indicator for joint intention. Also, integrating qualitative elements in the study provided rich and insightful context-data.

After this first methodological step, I recorded the self-agency experience of self-trackers. The data-analysis first confirms three characteristics of the Sense of Agency, which gives validity to the ESM tool. First, the study confirmed that the presence of a Sense of Agency is the default backdrop of participant's daily actions. Herein, the SoA fluctuates from situation to situation, supporting its

conception as situationally dependent. Second, the very stable relation of arousal-level to SoA reflects the strong influence of sensorimotor cues as sources of SoA. Accordingly, recording physiological parameters could be a valuable addition to ESM studies in social-psychology. Third, moments of joint-intention were associated with a significant drop in the level of self-agency. This supports the notion of a qualitative shift from self-agency to agency in a "plural subject" mode.

While participants were increasingly adopting self-tracking practices in their lives, the Sense of Agency continuously decreased over the course of the study. Zooming in onto those actions which were captured by the self-tracking app revealed an even stronger decrease. However, this latter finding is only a descriptive impression. Further, in moments of not attaining the self-tracked goal, participants experienced a drop in experienced self-agency. This effect was limited to the 15 minutes after using the app. Interpreting these results highlighted two possible explanations: On the one hand, users could have rejected agency when their self-tracking app confronted them with their failure to life up to their tracked goal. On the other hand, drawing on the logic of self-efficacy influences, repeated experience of low agency could lead to decreasing Sense of Agency in regard to a specific action. This would also explain the decrease in SoA over time.

One central question and possible limitation of the study is the steadily decreasing self-agency over time. The ESM tool represented the Sense of Agency, an action specific feeling of control. Consequentially, it is unlikely that the SoA would decrease for all action simultaneously. The time-trend could be due to measurement reactivity or internal consistency. However, all other findings adjusted for this possibly confounding factor. Also, the finding that the SoA for action which are capture by the self-tracking app had to remain descriptive. Ideally, future studies should attempt to more often ask question right after using the self-tracking app. For example, this could be achieved by coupling the ESM software and the self-tracking app, to enable event-contingent sampling.

This study supports the growing academic scepticism about the efficacy of self-tracking interventions. If users experience a loss of agency from negative performance, yet positive performance remains without any productive effects, this could lead to a growing aversion against an app. In this case, the prospect of agentive empowerment through self-tracking would instead lead to a loss of subjective agency. However, people tend to deflect agency for actions with negative outcome. Over time, this means they could reject self-tracking all-together.

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# Appendix

## Formalised research question

**This study asks: "How do self-tracking practices impact it's users Sense of Agency?"**

The two first hypothesis examined will test the validity of the ESM methodology developed below. While they will be explained in the methodology section, they are included in this overview for reasons of completeness:

Due to the strong sensorimotor components of the Sense of Agency, the general "arousal" level should influence the experience of self-agency.

H1: Arousal has a significant influence on the Sense of Agency

As explained below, the ESM included one general indicator item for joint-action:

H2: Self-agency in moments of joint-action is different from moments of individual intention

Gathering the sub-questions and hypothesis developed above, this can be specified as:

<u>At the most general level:</u>

- Q3 Over time, does self-tracking influence the global, action-independent Sense of Agency?

This question does not explicitly arise from the literature because the Sense of Agency is theorised as an *action-specific* experience or judgement. However, in light of more *global* (context-independent) conceptions of self-agency (Agency-Scale Eitam XX; Self-efficacy Bandura XX), it is necessary to test for a "treatment-effect" of introducing self-tracking to the participants life.

H3: The global SoA in the first two days without the app should be different from the global Sense of Agency in remaining days.

Testing for the effect of positive versus negative feedback from the App:

H4: The global development of the SoA over time depends on performance on the self-tracked goal.

For actions that are captured by the self-tracking app:

- Q4 Over time, does self-tracking influence the Sense of Agency of actions that are tracked by the app?

As self-tracking might shift conscious attention to actions that are normally unconscious and mastered well, thus deriving a Sense of Agency from them:

H5: "The sense of agency in the actions tracked by the app should increase over the course of the study."

Self-tracking and performance in relation to the distal-goal

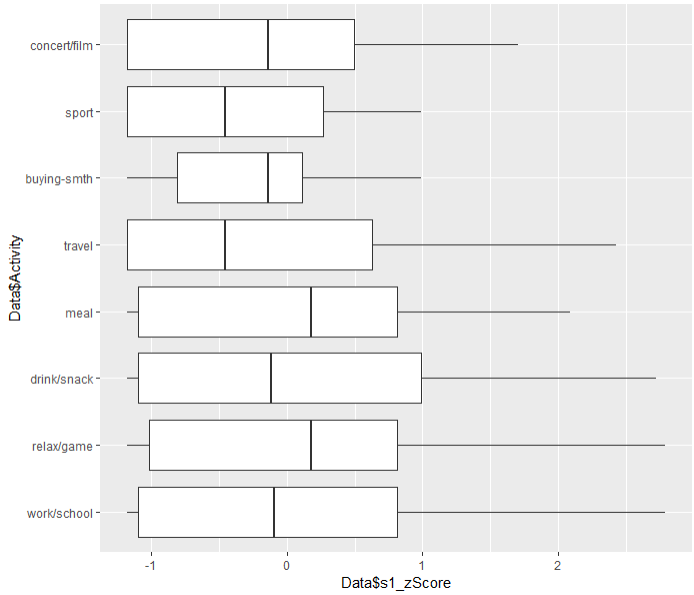
- Q5 How do moments of using the app influence the Sense of Agency?

As a goal directed state-of-mind might overshadow temporarily close action:

H6: "Temporally close actions should align in their Sense of Agency to the user's performance in regard to their distal-goal".

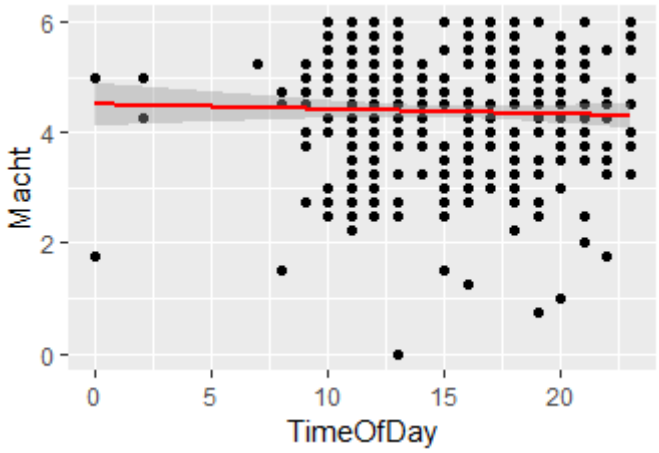
## Annotations

| | |
|---|---|
| M1 | [Appendix: The two datasets came in relatively different formats and for each one I ran thought the sequence of: Making the data compatible with R, switching reverse coded items, z-scoring the items based all observations for that item, taking the mean of the randomly appearing items in each session, z-scoring the means, to eventually receive S1 and S2 scores. This resulted in a the "long" data table format, where every row is a participant's session. For every person and item, I then also calculated the mean and standard-deviation over all the occasions in which the randomiser had prompted a person with an item. |
| M2 | 3.3.2 Include open ended questions<br>The ecological (situational) measures of the "Agency App" were asked in closed ended format. To describe their Location, Action, Sociality and Emotion, participants selected from short lists of pre-defined answers. For instance, the app offered the choice between only eight relatively specific emotions. While this might make participants who do not find their actual emotion on the list tick something random, it is also somewhat opaque during analysis. For instance, while there seem to be differences in "I"-mode agency between activities (plot below), an analysis would require more information on underlying reasons. Following Hektner, Schmidt XXX BUCH I decided to ask these questions in an open ended format via free-text fields, both for the "Activity" and the current "Thought." |

| | |
|---|---|
| |  |
| M3 | Items therefore must have some variance. For each person and item, I calculated the standard-deviation for all the answers to that item. The mean over all participants then expresses the average within-person fluctuation of that item. Ranking the items by their standard deviation enabled me to identify those with the least variance (Appendix). |
| M4 | Participants were signalled per text-message (SMS) three times a day, random within segments: morning [9-13], afternoon [13-17 and evening [17-21]. This spread out the measurements over the day yet avoided sampling the same timepoints of daily routines. Each text-message contained the link to a web-based questionnaire. Participant signup, panel-management and signalling were implemented with the ESM-service "SurveySignal"[ Hoffmann, XXX], (which charged the researcher 10 cents per signal). When clicking on the questionnaire link, in the background each text-message (SMS) transmitted a unique participant ID, signal number and timestamps. The questionnaire tool Qualtrics was configured to receive this background information and store it alongside with every participant response. The advantage of having signals sent via text-message over alternative iPhone/Android-survey apps is that they stand out more from the plethora of other messages smartphones usually display. Due to reasons of feasibility, participants were not all signed up onto the study on the same day, the tandem of SurveySignal and Qualtrics was therefore configured to automatically communicate with participants according to how long they had been on the study. This way the questionnaire could send reminders and adapt to the experimental condition by itself. |
| M5 | During the first two days, each questionnaire first contained measures for mood (Desmet, 2012 XX) and arousal, as well as free-text fields for the open ended questions about the current thought and action. It then presented four SoA items in randomised order, two of which were reversely formulated. This block also asked whether someone else was involved in the action, if affirmed, followed by the joint-intention item. The last questions were closed ended about Location and Sociality.<br>From day three onward, the thought and action questions were supplemented by sliders to self-report the closeness of the action/thought to the self-tracked aspect of one's life (explained further in the results). It also asked, whether the participant had used their self-tracking app since the last session. If affirmed, |

| | |
|---|---|
| | the questionnaire presented a free-text field to report the experience of using the app and a slider to indicate how long ago the app was used. Finally, from day three onwards, all session included a measure of whether and how the notion of performance applied to the self-tracked aspect, tapping into the goal-directedness of agency (explained further in the results). |

Data Analysis Comments

| | |
|---|---|
| D1 | 12 participants used the German, 20 the English version of the questionnaire. I carried out Two-Sided Kolmogorov Smirnov test for each of the five agency items, to make sure they were equally distributed in both the English and the German version of the sample. P-values were all in the range [0,27-1], meaning no significant difference was found on any level in either of the five variables, so there is no rejection towards treating both language versions of the questionnaire as one sample. This is strong support for the validity of the item translation. Side-by-side distributions including the test values can be found in the appendix. |
| D2 | <u>Fixed and random effects of the Arousal-SoA MML, controlling for TIME</u><br>Random effects of the model<br>`PID = pdLogChol(1 + state_arousal)`<br>`Variance StdDev Corr`<br>`(Intercept) 0.11211000 0.3348283 (Intr)`<br>`state_arousal 0.03942268 0.1985515 -0.405`<br>`Residual 0.81707140 0.9039200` |
| D3 | No daily cycles<br>  <br><br>As with (many other__) physiological parameter, it would be possible that the Sense of Agency follows within-day time-patterns. First, I created a "TimeOfDay" variable, lining up all 384 sessions by the full hour (00:00 – 24:00). Due to the "random within intervals" design of the study, the times participants took the questionnaire were relatively evenly spread-out over the day. Visual inspection did not indicate any pattern, as can be seen in the plot above. A linear model showed no significant influence for the time of the day (coefficient -0,01; p-value 0,23; n=384). Second, to allow for non-linear effects I also tested whether the three time-segments "morning", "afternoon" and "evening", compiled as the variable "SIG" had an influence on the SoA. Yet, also these three categories showed no significant influence. They did, however, predict a change in "arousal" over the course of the day. Using the same three categories, arousal during the evening session was on average -0,28 units lower than in the morning (p=0,029, n=384). This confirms the idea of testing over the three |

| | |
|---|---|
| | intervals (… as its intuitive / or: source: proven otherwhere? That arousal decreases over the day (people get tired…) and further supports the finding that there seem to be no daily pattern in the Sense of Agency. |
| D5 | The categorical "Weekday" variable had no significant effect (could have cyclic effects.) |
| D6 | As part of every session, participants in their own words described their current thought and action. Just below these free text fields were sliders, as indicators for how closely the just described thought or action relates to the "self-tracked" aspect of one's life. For instance, if I am eating a chocolate bar and my self-tracking project is to track my calories, my action can be said to fall into the self-tracked domain. This was necessary to test the hypothesis of an *increase* in SoA in the tracked domain. For analysis, the indicator for thought and action were each split into binary categories: 'The thing that is on my mind "is"/"is not" related to what I am tracking' (TRC variable) and 'the action I am doing "is"/"is not" closely related to what I am tracking' (CAT variable). |
| D7 | From the third day of the study onwards participants self-reported the importance of their self-tracked life-aspect and their performance therein by stating whether they felt "indifferent", "on-track", "overperforming" or "behind". Leaving out observations with either missing (n=170) or "indifferent" (n=48) statements and including the "overperforming" cases into the "on-track" category, I reduced the dataset to 166 observations, yet creating a dichotomous variable "on-track" versus "behind. This allows a more nuanced analysis of goal-related self-tracking. |

**Goal** <*categorical*>

| *val* | *frq* | *raw.prc* | *valid.prc* | *cum.prc* |
|---|---|---|---|---|
| Indifferent | 48 | 12.5 | 22.43 | 22.43 |
| Overperform | 8 | 2.08 | 3.74 | 26.17 |
| OnTrack | 75 | 19.53 | 35.05 | 61.21 |
| Behind | 83 | 21.61 | 38.79 | 100 |
| NA | 170 | 44.27 | NA | NA |

*total N=384 · valid N=214 · $\tilde{x}$=2.90 · σ=1.15*

**Goal** <*categorical*>

| *val* | *frq* | *raw.prc* | *valid.prc* | *cum.prc* |
|---|---|---|---|---|
| OnTrack | 83 | 50 | 50 | 50 |
| Behind | 83 | 50 | 50 | 100 |
| NA | 0 | 0 | NA | NA |

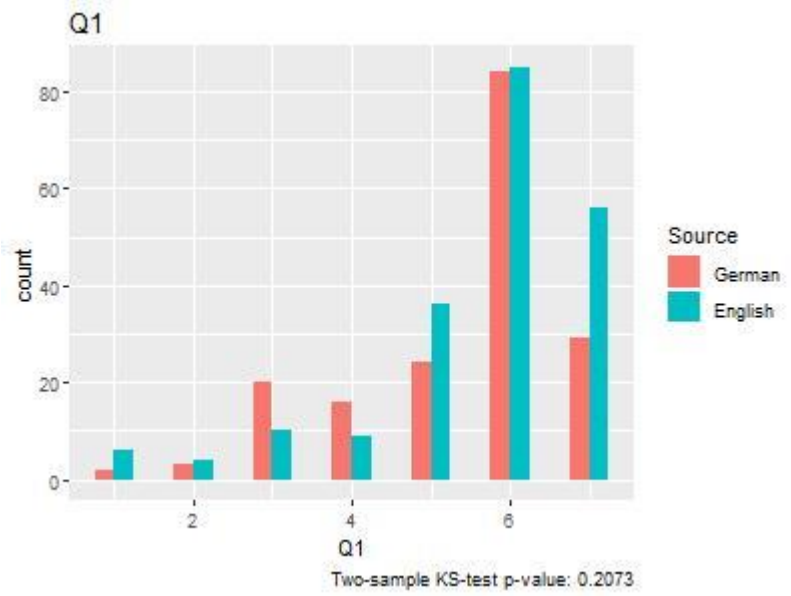
*total N=166 · valid N=166 · $\tilde{x}$=1.50 · σ=0.50*

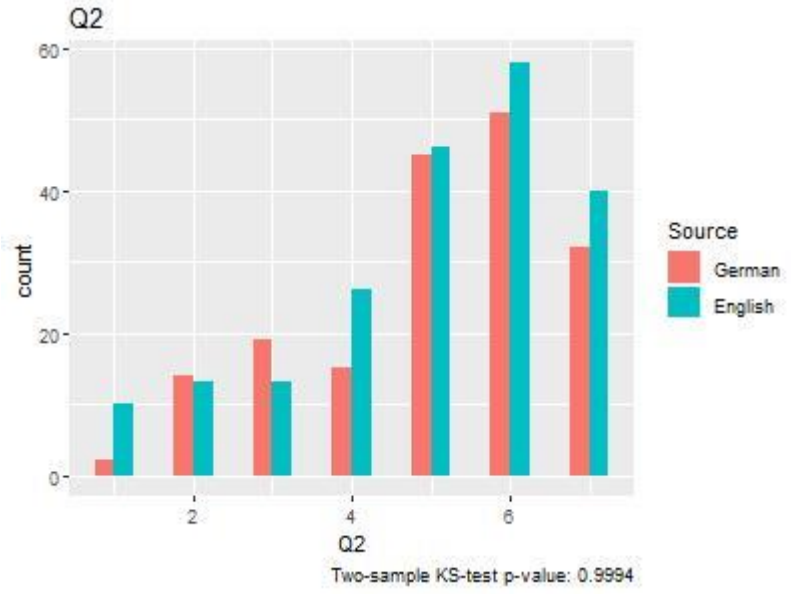
| | |
|---|---|
| D8 | There was no significant *linear* correlation between the SoA and the TimeLag variable. This was in line with a hypothesised "spike" of SoA after a positive app-event. I also tested for a reverse *quadratic* effect, which also was not significant. Thus, the SoA observations were split up in two dichotomous time-containers {"use", non-use: "pocket"} to capture a potential "spike" of non-parametric shape. |

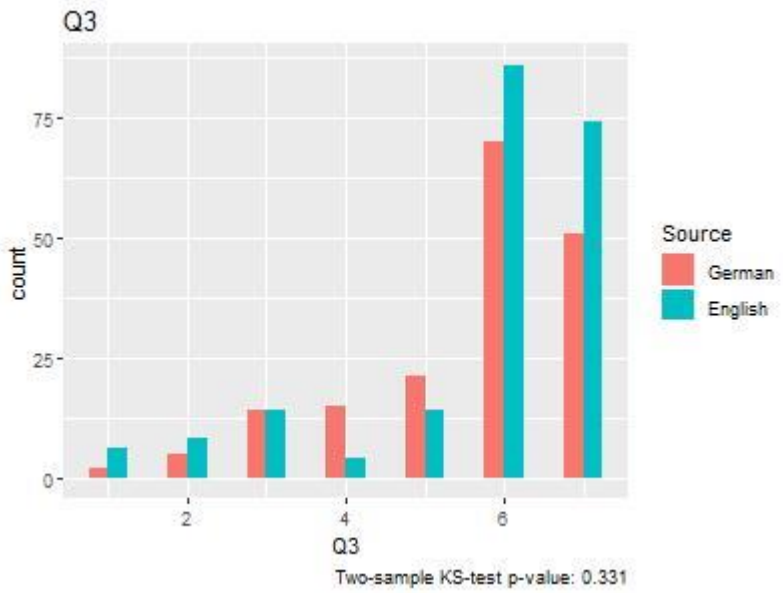
## Data Analysis

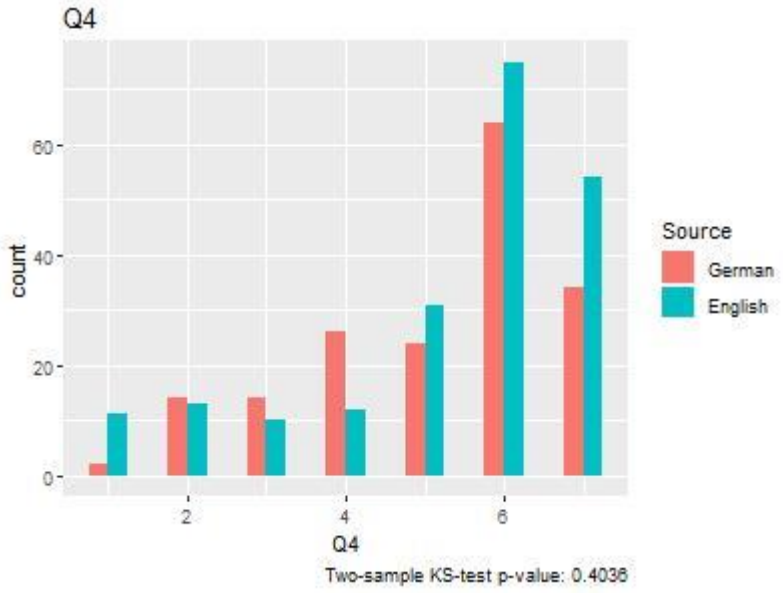
### Distribution of SoA-ESM items including Kolmogorov-Test-Values (p-values)

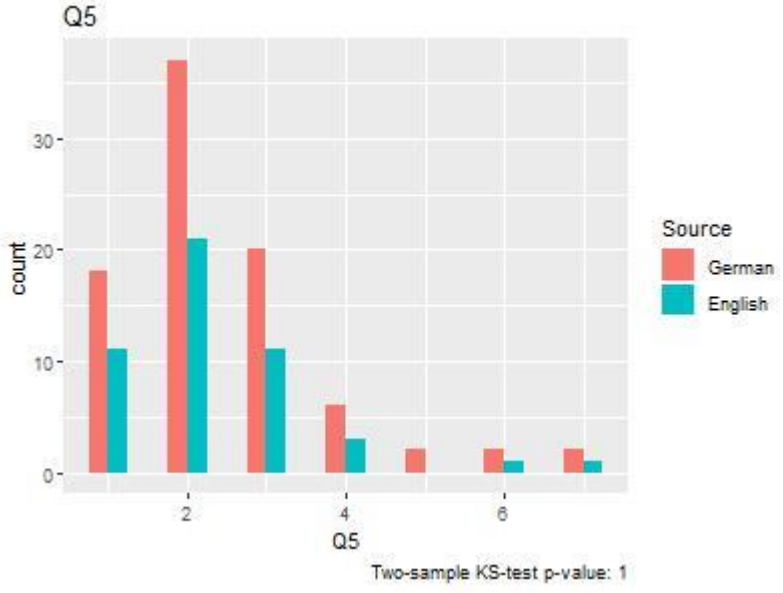
Comparing the English and the German version of the sample.




Q3
count
75
50
25
0
2
4
6
Q3
Source
German
English
Two-sample KS-test p-value: 0.331


Q4
count
60
40
20
0
2
4
6
Q4
Source
German
English
Two-sample KS-test p-value: 0.4036


Q5
count
30
20
10
0
2
4
6
Q5
Source
German
English
Two-sample KS-test p-value: 1

# Variable Book

## Location

---

**Location** <*categorical*>

| *val* | *frq* | *raw.prc* | *valid.prc* | *cum.prc* |
|---|---|---|---|---|
| home | 165 | 42.97 | 48.53 | 48.53 |
| work/school | 82 | 21.35 | 24.12 | 72.65 |
| outdoor-public | 36 | 9.38 | 10.59 | 83.24 |
| indoor-public | 36 | 9.38 | 10.59 | 93.82 |
| public-transport | 20 | 5.21 | 5.88 | 99.71 |
| walking | 1 | 0.26 | 0.29 | 100 |
| NA | 44 | 11.46 | NA | NA |

*total N=384 · valid N=340 · $\bar{x}$=2.02 · $\sigma$=1.26*

## Sociability

---

**Sociability** <*categorical*>

| *val* | *frq* | *raw.prc* | *valid.prc* | *cum.prc* |
|---|---|---|---|---|
| alone | 120 | 31.25 | 32 | 32 |
| not together | 52 | 13.54 | 13.87 | 45.87 |
| stranger | 1 | 0.26 | 0.27 | 46.13 |
| colleague | 10 | 2.6 | 2.67 | 48.8 |
| friend | 62 | 16.15 | 16.53 | 65.33 |
| family member | 35 | 9.11 | 9.33 | 74.67 |
| 2+ strangers | 18 | 4.69 | 4.8 | 79.47 |
| 2+ colleagues | 14 | 3.65 | 3.73 | 83.2 |
| 2+ friends | 42 | 10.94 | 11.2 | 94.4 |
| 2+ family members | 21 | 5.47 | 5.6 | 100 |
| NA | 9 | 2.34 | NA | NA |

*total N=384 · valid N=375 · $\bar{x}$=4.30 · $\sigma$=3.12*

## Intention

The question “Someone else was involved in carrying out the action” and item five (Q5) “The other people involved and myself had a shared intention about where this action should go” were combined into one categorical variable. If someone else’s involvement was mentioned, Intention was set “Shared” when Q5 was answered in the range of [Strongly agree to neither agree nor disagree]. For 17 cases Q5 indicated no shared intention.

**Intention** *<categorical>*

| *val* | *frq* | *raw.prc* | *valid.prc* | *cum.prc* |
|---|---|---|---|---|
| Alone | 249 | 64.84 | 64.84 | 64.84 |
| NoShared | 17 | 4.43 | 4.43 | 69.27 |
| Shared | 118 | 30.73 | 30.73 | 100 |
| NA | 0 | 0 | NA | NA |

*total N=384 · valid N=384 · $\bar{x}$=1.66 · σ=0.92*

## Closeness of Action and Thought to the self-tracked aspect of one's life

As part of every session, participants described first their current thought and then their current or just completed action. Both were answered in their own words. Just below these free text fields were sliders, as indicators for how closely the just described thought or action relates to the "self-tracked" aspect of one's life. For example, if I am eating a chocolate bar, this might to some degree related to my calorie tracking project.

Conceptually, these indicators were introduced to later determine whether a measurement (and its agency score) should be associated to the self-tracked domain of the participant. This was necessary to test the hypothesis of an *increase* in SoA in the tracked domain.

"1" denotes no relation at all, "5" means that the thought/action is exactly what is being tracked.

**ClosenessMindTracking** <*numeric*>

| *val* | *frq* | *raw.prc* | *valid.prc* | *cum.prc* |
|---|---|---|---|---|
| 1 | 45 | 11.72 | 31.69 | 31.69 |
| 2 | 29 | 7.55 | 20.42 | 52.11 |
| 3 | 30 | 7.81 | 21.13 | 73.24 |
| 4 | 21 | 5.47 | 14.79 | 88.03 |
| 5 | 17 | 4.43 | 11.97 | 100 |
| NA | 242 | 63.02 | NA | NA |

*total N=384 · valid N=142 · x̄=2.55 · σ=1.38*

**ClosenessActionTracking** <*numeric*>

| *val* | *frq* | *raw.prc* | *valid.prc* | *cum.prc* |
|---|---|---|---|---|
| 1 | 49 | 12.76 | 33.79 | 33.79 |
| 2 | 25 | 6.51 | 17.24 | 51.03 |
| 3 | 17 | 4.43 | 11.72 | 62.76 |
| 4 | 21 | 5.47 | 14.48 | 77.24 |
| 5 | 33 | 8.59 | 22.76 | 100 |
| NA | 239 | 62.24 | NA | NA |

*total N=384 · valid N=145 · x̄=2.75 · σ=1.59*

For further analysis, these two are split into binary indicators. To the tracking novices, these questions were only displayed from session three onwards. The much greater number of NAs in the tables above is due to a particularity in how Qualtrics displayed this question. Position "1" on the slider indicated the probably most frequent answer that the thought or action was "completely unrelated" to what was being tracked. This answer was ticked by default. It seems that not touching the scale - due to an agreement to the default answer - unfortunately led to the question being counted as "NA" not as "1". Thus, in the dichotomous variable, the NAs were counted as "1". The dividing line for the dichotomous split was 3,9.

Dichotomous "Closeness of Thought and Tracking" (TMD) and "Closeness of Action and Tracking" (CAT)

Domain

**TMD** <*categorical*>

| *val* | *frq* | *raw.prc* | *valid.prc* | *cum.prc* |
|---|---|---|---|---|
| mDistant | 346 | 90.1 | 90.1 | 90.1 |
| mClose | 38 | 9.9 | 9.9 | 100 |
| NA | 0 | 0 | NA | NA |

*total N=384 · valid N=384 · x̄=1.10 · σ=0.30*

**CAT** <*categorical*>

| *val* | *frq* | *raw.prc* | *valid.prc* | *cum.prc* |
|---|---|---|---|---|
| aDistant | 330 | 85.94 | 85.94 | 85.94 |
| aClose | 54 | 14.06 | 14.06 | 100 |
| NA | 0 | 0 | NA | NA |

*total N=384 · valid N=384 · x̄=1.14 · σ=0.35*

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## Tracking Intensity

---

**TrackingIntensity** *<numeric>*

| *val* | *frq* | *raw.prc* | *valid.prc* | *cum.prc* |
|---|---|---|---|---|
| 1 | 5 | 18.52 | 20 | 20 |
| 2 | 9 | 33.33 | 36 | 56 |
| 3 | 6 | 22.22 | 24 | 80 |
| 6 | 2 | 7.41 | 8 | 88 |
| 7 | 3 | 11.11 | 12 | 100 |
| NA | 2 | 7.41 | NA | NA |

*total N=27 · valid N=25 · $\bar{x}$=2.96 · $\sigma$=1.99*

## Goal

---

**Goal** *<categorical>*

| *val* | *frq* | *raw.prc* | *valid.prc* | *cum.prc* |
|---|---|---|---|---|
| Indifferent | 48 | 12.5 | 22.43 | 22.43 |
| Overperform | 8 | 2.08 | 3.74 | 26.17 |
| OnTrack | 75 | 19.53 | 35.05 | 61.21 |
| Behind | 83 | 21.61 | 38.79 | 100 |
| NA | 170 | 44.27 | NA | NA |

*total N=384 · valid N=214 · $\bar{x}$=2.90 · $\sigma$=1.15*

# Regressions

## Time of day

| | State So A | | | | |
|---|---|---|---|---|---|
| *Predictors* | *Estimates* | *std. Error* | *CI* | *Statistic* | *p* |
| (Intercept) | 4.58 | 0.18 | 4.23 – 4.93 | 25.67 | **<0.001** |
| Time Of Day | -0.01 | 0.01 | -0.04 – 0.01 | -1.21 | 0.228 |
| Observations | 384 | | | | |
| $R^2$ / adjusted $R^2$ | 0.004 / 0.001 | | | | |

## SIG

| | State So A | | | | |
|---|---|---|---|---|---|
| *Predictors* | *Estimates* | *std. Error* | *CI* | *Statistic* | *p* |
| (Intercept) | 4.42 | 0.08 | 4.27 – 4.57 | 58.68 | **<0.001** |
| Afternoon | 0.01 | 0.11 | -0.21 – 0.23 | 0.10 | 0.921 |
| Evening | -0.17 | 0.12 | -0.40 – 0.05 | -1.50 | 0.133 |
| Observations | 384 | | | | |
| $R^2$ / adjusted $R^2$ | 0.008 / 0.003 | | | | |

## Arousal predicted by SIG

| | Arousal | | | | |
|---|---|---|---|---|---|
| *Predictors* | *Estimates* | *std. Error* | *CI* | *Statistic* | *p* |
| (Intercept) | 3.28 | 0.08 | 3.11 – 3.44 | 38.70 | **<0.001** |
| Afternoon | -0.02 | 0.13 | -0.26 – 0.23 | -0.15 | 0.878 |
| Evening | -0.28 | 0.13 | -0.54 – -0.03 | -2.19 | **0.029** |
| Observations | 384 | | | | |
| $R^2$ / adjusted $R^2$ | 0.015 / 0.009 | | | | |

## Effect of time in the self-tracked domain (n=39)

| | State So A | | | | |
|---|---|---|---|---|---|
| *Predictors* | *Estimates* | *std. Error* | *CI* | *Statistic* | *p* |
| (Intercept) | 3.87 | 0.37 | 3.15 – 4.59 | 10.54 | **<0.001** |
| TIME | -0.02 | 0.02 | -0.06 – 0.01 | -1.27 | 0.214 |
| Arousal | 0.27 | 0.09 | 0.10 – 0.44 | 3.09 | **0.004** |
| Observations | 39 | | | | |
| $R^2$ / adjusted $R^2$ | 0.267 / 0.226 | | | | |

## Multiple Linear Regression on normed SoA Data

| | State So A | | | | |
|---|---|---|---|---|---|
| *Predictors* | *Estimates* | *std. Error* | *CI* | *Statistic* | *p* |
| (Intercept) | 3.98 | 0.25 | 3.48 – 4.47 | 15.71 | **<0.001** |
| TIME | -0.01 | 0.01 | -0.03 – 0.01 | -1.41 | 0.158 |
| Arousal | 0.16 | 0.05 | 0.07 – 0.26 | 3.29 | **0.001** |
| Mood Valence | 0.01 | 0.04 | -0.07 – 0.09 | 0.24 | 0.808 |
| Mind Valence | 0.20 | 0.10 | -0.00 – 0.41 | 1.96 | 0.051 |
| No Shared | -0.02 | 0.23 | -0.46 – 0.43 | -0.08 | 0.939 |
| Shared | -0.25 | 0.11 | -0.46 – -0.05 | -2.40 | **0.017** |
| Congruence | 0.04 | 0.10 | -0.16 – 0.24 | 0.38 | 0.704 |
| Observations | 362 | | | | |
| $R^2$ / adjusted $R^2$ | 0.079 / 0.061 | | | | |

Linear regression for “Location”, on normed SoA data

| | State So A | | | | |
|---|---|---|---|---|---|
| *Predictors* | *Estimates* | *std. Error* | *CI* | *Statistic* | *p* |
| (Intercept) | 4.36 | 0.07 | 4.23 – 4.49 | 66.19 | **<0.001** |
| work/school | 0.16 | 0.11 | -0.06 – 0.38 | 1.40 | 0.162 |
| outdoor-public | 0.23 | 0.16 | -0.07 – 0.54 | 1.49 | 0.138 |
| indoor-public | -0.12 | 0.16 | -0.42 – 0.19 | -0.76 | 0.449 |
| public-transport | -0.32 | 0.20 | -0.71 – 0.07 | -1.59 | 0.114 |
| walking | -1.06 | 0.85 | -2.73 – 0.60 | -1.25 | 0.211 |
| Observations | 340 | | | | |
| $R^2$ / adjusted $R^2$ | 0.030 / 0.016 | | | | |

Linear Regression for “Sociality”, on normed SoA data

| | State So A | | | | |
|---|---|---|---|---|---|
| *Predictors* | *Estimates* | *std. Error* | *CI* | *Statistic* | *p* |
| (Intercept) | 4.46 | 0.08 | 4.30 – 4.62 | 54.64 | **<0.001** |
| not together | -0.21 | 0.15 | -0.50 – 0.08 | -1.41 | 0.159 |
| stranger | -4.53 | 0.90 | -6.29 – -2.78 | -5.05 | **<0.001** |
| colleague | 0.06 | 0.29 | -0.52 – 0.64 | 0.21 | 0.835 |
| friend | 0.03 | 0.14 | -0.24 – 0.30 | 0.22 | 0.827 |
| family member | -0.24 | 0.17 | -0.57 – 0.10 | -1.38 | 0.168 |
| 2+strangers | -0.37 | 0.23 | -0.81 – 0.08 | -1.63 | 0.105 |
| 2+colleagues | -0.40 | 0.25 | -0.90 – 0.09 | -1.59 | 0.112 |
| 2+friends | 0.08 | 0.16 | -0.24 – 0.39 | 0.48 | 0.629 |
| 2+family members | -0.14 | 0.21 | -0.55 – 0.27 | -0.66 | 0.510 |
| Observations | 375 | | | | |
| $R^2$ / adjusted $R^2$ | 0.086 / 0.063 | | | | |

(the category stranger contains one observation only and is thus neglected).

Subset mClose OR aClose – The effect of time in the domain that is being self-tracked.

| | State So A | | | | |
|---|---|---|---|---|---|
| *Predictors* | *Estimates* | *std. Error* | *CI* | *Statistic* | *p* |
| (Intercept) | 3.87 | 0.37 | 3.15 – 4.59 | 10.54 | **<0.001** |
| TIME | -0.02 | 0.02 | -0.06 – 0.01 | -1.27 | 0.214 |
| Arousal | 0.27 | 0.09 | 0.10 – 0.44 | 3.09 | **0.004** |
| Observations | 39 | | | | |
| $R^2$ / adjusted $R^2$ | 0.267 / 0.226 | | | | |

Effect of Weekday on normed SoA

| | State So A | | | | |
|---|---|---|---|---|---|
| *Predictors* | *Estimates* | *std. Error* | *CI* | *Statistic* | *p* |
| (Intercept) | 4.25 | 0.31 | 3.65 – 4.86 | 13.81 | **<0.001** |
| Weekday 16 | 0.19 | 0.35 | -0.50 – 0.87 | 0.54 | 0.592 |
| Weekday 17 | 0.27 | 0.33 | -0.38 – 0.91 | 0.81 | 0.417 |
| Weekday 18 | 0.20 | 0.33 | -0.44 – 0.84 | 0.61 | 0.541 |
| Weekday 19 | 0.13 | 0.33 | -0.52 – 0.78 | 0.39 | 0.697 |
| Weekday 20 | 0.01 | 0.33 | -0.65 – 0.66 | 0.02 | 0.982 |
| Weekday 21 | 0.02 | 0.35 | -0.67 – 0.71 | 0.06 | 0.949 |
| Weekday 22 | 0.03 | 0.35 | -0.65 – 0.71 | 0.08 | 0.934 |
| Weekday 23 | -0.06 | 0.35 | -0.75 – 0.63 | -0.17 | 0.864 |
| Observations | 384 | | | | |
| $R^2$ / adjusted $R^2$ | 0.013 / -0.008 | | | | |

Linear model – {Time~SoA+Arousal} ~ PercentBehind

The coefficients of the TIME~SoA function (controlling for "Arousal" predicted by the percentage of times a person felt "behind" on the aspect of her life that she was self-tracking.

| | COEF | | | | |
|---|---|---|---|---|---|
| *Predictors* | *Estimates* | *std. Error* | *CI* | *Statistic* | *p* |
| (Intercept) | -0.03 | 0.03 | -0.08 – 0.03 | -0.91 | 0.371 |
| Percent Behind | -0.01 | 0.05 | -0.11 – 0.09 | -0.20 | 0.847 |
| Observations | 27 | | | | |
| $R^2$ / adjusted $R^2$ | 0.002 / -0.038 | | | | |

## Self-trackers and novices' goal-reactivity compared

| | State So A | | | | |
|---|---|---|---|---|---|
| *Predictors* | *Estimates* | *std. Error* | *CI* | *Statistic* | *p* |
| (Intercept) | 4.49 | 0.11 | 4.26 – 4.72 | 39.07 | **<0.001** |
| Behind | -0.20 | 0.16 | -0.52 – 0.12 | -1.23 | 0.220 |
| High | 0.08 | 0.20 | -0.32 – 0.47 | 0.38 | 0.705 |
| GoalBehind:TrackingIntensityHigh | -0.20 | 0.29 | -0.77 – 0.37 | -0.67 | 0.502 |
| Observations | 152 | | | | |
| $R^2$ / adjusted $R^2$ | 0.027 / 0.008 | | | | |

## Testing for potential quadratic effect of TimeLag on SoA

| | State So A | | | | |
|---|---|---|---|---|---|
| *Predictors* | *Estimates* | *std. Error* | *CI* | *Statistic* | *p* |
| (Intercept) | 4.56 | 0.14 | 4.28 – 4.85 | 31.76 | **<0.001** |
| Time Lag | -0.01 | 0.18 | -0.35 – 0.33 | -0.05 | 0.960 |
| Time Lag 2 | -0.03 | 0.04 | -0.11 – 0.04 | -0.82 | 0.413 |
| Observations | 78 | | | | |
| $R^2$ / adjusted $R^2$ | 0.077 / 0.052 | | | | |

This could have been the case, as after the event of seeing on your phone that you are "on-track" or "behind" the SoA could spike and then fade-off.

## Effect of "on-track" versus "behind" 15 minutes after App usage

| | State So A | | | | |
|---|---|---|---|---|---|
| *Predictors* | *Estimates* | *std. Error* | *CI* | *Statistic* | *p* |
| (Intercept) | 3.85 | 0.32 | 3.23 – 4.47 | 12.22 | **<0.001** |
| Behind | -0.04 | 0.14 | -0.31 – 0.24 | -0.25 | 0.802 |
| used | 0.48 | 0.24 | 0.01 – 0.95 | 2.00 | **0.047** |
| Arousal | 0.21 | 0.07 | 0.08 – 0.34 | 3.11 | **0.002** |
| TIME | -0.01 | 0.02 | -0.04 – 0.02 | -0.54 | 0.593 |
| No Shared | -0.31 | 0.36 | -1.03 – 0.40 | -0.86 | 0.391 |
| Shared | -0.20 | 0.15 | -0.48 – 0.09 | -1.34 | 0.183 |
| GoalBehind:Appused | -0.86 | 0.44 | -1.71 – 0.00 | -1.96 | 0.052 |
| Observations | 152 | | | | |
| $R^2$ / adjusted $R^2$ | 0.148 / 0.106 | | | | |

Without non-significant "Intention" variable:

| | State So A | | | | |
|---|---|---|---|---|---|
| *Predictors* | *Estimates* | *std. Error* | *CI* | *Statistic* | *p* |
| (Intercept) | 3.80 | 0.31 | 3.19 – 4.42 | 12.12 | **<0.001** |
| Behind | -0.05 | 0.14 | -0.32 – 0.22 | -0.36 | 0.720 |
| used | 0.50 | 0.24 | 0.03 – 0.97 | 2.10 | **0.037** |
| Arousal | 0.22 | 0.07 | 0.09 – 0.35 | 3.29 | **0.001** |
| TIME | -0.01 | 0.02 | -0.04 – 0.02 | -0.85 | 0.397 |
| GoalBehind:Appused | -0.87 | 0.44 | -1.72 – -0.01 | -1.99 | **0.049** |
| Observations | 152 | | | | |
| $R^2$ / adjusted $R^2$ | 0.134 / 0.104 | | | | |

Jetzt noch MML?

### Action Close to Self-tracked domain, by Goal-oriented progress

| | State So A | | | | |
|---|---|---|---|---|---|
| *Predictors* | *Estimates* | *std. Error* | *CI* | *Statistic* | *p* |
| (Intercept) | 3.76 | 0.32 | 3.14 – 4.39 | 11.80 | **<0.001** |
| Behind | 0.08 | 0.16 | -0.23 – 0.39 | 0.52 | 0.605 |
| a Close | 0.41 | 0.19 | 0.04 – 0.77 | 2.19 | **0.030** |
| Arousal | 0.22 | 0.07 | 0.09 – 0.36 | 3.28 | **0.001** |
| TIME | -0.01 | 0.02 | -0.04 – 0.02 | -0.64 | 0.526 |
| No Shared | -0.29 | 0.36 | -1.00 – 0.43 | -0.79 | 0.429 |
| Shared | -0.21 | 0.15 | -0.50 – 0.07 | -1.46 | 0.146 |
| GoalBehind:CATaClose | -0.69 | 0.29 | -1.26 – -0.12 | -2.39 | **0.018** |
| Observations | 152 | | | | |
| $R^2$ / adjusted $R^2$ | 0.156 / 0.115 | | | | |

# Method Appendix

## Secondary analysis: Average within-person standard-deviation for each item

Average within person standard deviation by item, S1

| q02 | q06 | q04 | q01 | q03 | q07 | q05 |
|---|---|---|---|---|---|---|
| 1.943 | 1.922 | 1.846 | 1.845 | 1.558 | 1.523 | 1.008 |

Average within person standard deviation by item, S2

| q01 | q11 | q09 | q08 | q05 | q04 |
|---|---|---|---|---|---|
| 2.302 | 2.290 | 2.275 | 2.247 | 2.195 | 2.189 |
| **q16** | **q06** | **q03** | **q10** | **q13** | **q14** |
| 2.086 | 2.084 | 1.991 | 1.861 | 1.813 | 1.781 |
| **q07** | **q02** | **q15** | **q12** | | |
| 1.710 | 1.668 | 1.529 | 1.382 | | |

## Original Scale 1 “I”-Agency items “Agency Scale, Bauer&Franks”

S01Q01 I feel I am drifting
S01Q02 I feel a sense of control over what I am doing
S01Q03 I am confident about accepting whatever follows from the action
S01Q04 I feel no responsibility for whatever follows from the action
S01Q05 If I intend to perform this action, I can do it
S01Q06 My feeling of commitment to this action is at the front of my mind
S01Q07 I feel no commitment towards this action

## Pilot shortlist of items

These items were separately discussed with five English native speakers to ensure they are intuitively understandable.

Annotated with principal component information and source.

**Thinking about the action you the action you are completing or have just completed…**

**(1) I feel a sense of control over what I am doing**

Completely agree…..Neither agree nor disagree…..Completely disagree
1 2 3 4 5 6 7 8 9

(Agency Scale, Bauer&Franks)
Principal Component 1; Highest contribution to component

**(2) My feeling of commitment to this action is at the front of my mind**

Completely agree…..Neither agree nor disagree…..Completely disagree
1 2 3 4 5 6 7 8 9

(Agency Scale, Bauer&Franks)
Principal Component 1; 2nd highest contribution to component

**(3) I feel I am drifting**

Completely agree…..Neither agree nor disagree…..Completely disagree
1 2 3 4 5 6 7 8 9

(Agency Scale, Bauer&Franks)
Reverse Item; Principal Component 1; 4th highest contribution to component

*Judgement: Item was not found intuitive. Especially the word "drifting" was found to be ambiguous.*

**(4) My [action] is planned by me from the very beginning to the very end**

Completely agree…..Neither agree nor disagree…..Completely disagree
1 2 3 4 5 6 7 8 9

(Global Sense of Agency Scale; Tapal, Oren, Dar, Eitam, 2017)
Item No. 12, Positive Agency, Factor loading 0.63

*Judgement: It is not clear what the "end" of the action is. While it is somewhat in-line with the philosophy of action (Bratman, XXXX) that individual agency actions goal directed (Whereas "we-mode"-actions are based on broader aim-intentions); The discussion revealed a hesitation about what the "end" of an action could mean, even in high agency situations.*

**(5) The action just happens, without my intention**

Completely agree…..Neither agree nor disagree…..Completely disagree
1 2 3 4 5 6 7 8 9

(Global Sense of Agency Scale; Tapal, Oren, Dar, Eitam, 2017)
Item No. 12, Negative Agency, Factor loading 0.71

*Judgement: While "intention" was criticised for being somewhat too conceptual, it was also regarded too central to the agency concept to be left out.*

**(6) My movements are automatic, my body simply makes them**

Completely agree…..Neither agree nor disagree…..Completely disagree
1 2 3 4 5 6 7 8 9

(Global Sense of Agency Scale; Tapal, Oren, Dar, Eitam, 2017)
Item No. 12, Negative Agency, Factor loading 0.69

*Shortlisted, later dropped, as "body" was thought to be to specifically direct at sensorimotor agency, leaving out judgements of agency for wide range of more cognitive actions.*

## Footnotes

During Sunday the 21st of July, the text-message server went offline from 3pm onwards. Although the provider quickly resolved the problem, I asked to affected participants whether they would stay on the study for a da

## Code

The data analysis of this M.Sc. dissertation was done in R and comprises around 1700 lines of code. A collection of all code documents can be found on Github at https://github.com/kusterlu/publish/