Promoting Flow Experiences:
Adaptive Mechanisms for Everyday Knowledge Work

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Abstract

Flow is defined as the experience of complete absorption and fluency in a challenging task which is associated with individual and organizational benefits such as increased performance or decreased stress. Promoting flow can be complex due to its emergence in everyday life with varying contexts and tasks, which results in strong inter- and intraindividual variability in flow. In order to address these difficulties and to exploit the expected benefits of promoting flow, this dissertation aims to develop an intervention that promotes flow in everyday knowledge work.

To address this objective, a conceptual analysis based on a narrative review of research on the flow sequence and flow-promoting interventions is conducted. The identified modes of action of flow-promoting interventions for the workplace are compiled in a three-dimensional framework. Based on this theoretical foundation, a smartphone-based intervention is developed for application by the targeted individuals themselves. This intervention adaptively prompts the use of mental contrasting, a metacognitive strategy for increasing goal commitment. In order to provide flow support only when needed and to avoid intervention fatigue, the intervention integrates an adaptive mechanism that allows to prompt the use of mental contrasting depending on the individual's flow. For evaluating the effectiveness of this intervention, two experimental field studies were conducted. Both studies used ambulatory assessment over the course of several days to capture momentary experiences concurrently with everyday life of participants who regularly engaged in knowledge work. Study 1 (N = 39 participants) investigates how to generally measure the effect of interventions on flow without negatively impacting compliance and ease of participation or introducing bias into flow reports. Study 2 (N = 59 participants) applies the methodological recommendations derived from the results of Study 1 and specifically examines whether prompting mental contrasting adaptively is helpful for promoting flow.

The studies in this dissertation suggest that flow-promoting interventions can be categorized and evaluated depending on the intervention's goal, target, and executor. They also indicate that the differences in observation approaches used to capture everyday flow do not affect compliance. Instead, the specific observation approach should be selected

depending on whether researchers are interested in inter- or intraindividual variability in flow. From the results of this dissertation, it can also be concluded that individuals can promote their flow by using mental contrasting. However, using an adaptive mechanism for individualized intervention provision does not outperform static provision of the intervention and may only be helpful in the long run.

In summary, this dissertation contributes a three-dimensional framework as a foundation for systematically engineering flow-promoting interventions. It also provides recommendations for selecting an observation approach to capture flow in everyday life and offers a valid and reliable measure that is shorter than common scales, reducing the burden for participants. Additionally, it provides an effective intervention that individuals can easily and autonomously acquire and apply without requiring managerial involvement. Future research should address the dissertation's limitations by combining self-reports with objective data to infer flow, integrating a self-tracking feature of flow experiences to enhance self-efficacy, improving the adaptive mechanism to integrate contextual information, and transitioning to investigations in teams.

Zusammenfassung

Im sogenannten „Flow“ erleben Personen völlige Versunkenheit bei flüssiger Bearbeitung einer anspruchsvollen Aufgabe. Das Flow-Erleben ist mit Vorteilen für die Person und die Organisation wie Leistungssteigerung oder Stressabbau verbunden. Die Förderung von Flow-Erleben ist jedoch komplex, da Flow in unterschiedlichen Kontexten und Aufgaben auftritt, was zu hoher inter- und intraindividueller Variabilität im Flow-Erleben führt. Um diesen Schwierigkeiten zu begegnen und die erwarteten positiven Folgen der Förderung von Flow-Erleben zu nutzen, zielt diese Dissertation darauf ab, eine Intervention zu entwickeln, die Flow-Erleben in Wissensarbeit fördert.

Dafür wird eine konzeptionelle Analyse auf der Grundlage eines Literaturüberblicks von Forschung zum Ablauf von Flow-Erleben und zu Flow-fördernden Interventionen durchgeführt. Die identifizierten Wirkmechanismen von Flow-fördernden Interventionen für den Arbeitsplatz werden in einem dreidimensionalen Modell abgebildet. Basierend auf dieser theoretischen Grundlage wird eine Smartphone-basierte Intervention zur Anwendung durch die Zielpersonen selbst entwickelt. Diese Intervention regt zur Nutzung des Mentalen Kontrastierens, einer metakognitiven Strategie zur Verstärkung der empfundenen Zielverpflichtung, an. Um das Flow-Erleben nur bei Bedarf zu unterstützen und zu vermeiden, dass Teilnehmende die Intervention als lästig empfinden, beinhaltet die Intervention einen adaptiven Mechanismus. Dieser berücksichtigt das individuelle Flow-Erleben und fordert in Abhängigkeit dessen zur Anwendung des Mentalen Kontrastierens auf. Um die Wirksamkeit dieser Intervention zu bewerten, wurden zwei experimentelle Feldstudien durchgeführt. In beiden Studien wurde über mehrere Tage hinweg Ambulatory Assessment eingesetzt, um das momentane Erleben der Teilnehmenden, die regelmäßig Wissensarbeit leisten, parallel zum Alltag zu erfassen. In Studie 1 (N = 39 Teilnehmende) wird untersucht, wie die Wirkung von Interventionen auf das Flow-Erleben gemessen werden kann, ohne die Konformität und Nutzerfreundlichkeit bei der Teilnahme zu beeinträchtigen oder die Selbstberichte zu verzerren. In Studie 2 (N = 59 Teilnehmende) werden die aus den Ergebnissen von Studie 1 abgeleiteten methodischen Empfehlungen angewandt und untersucht, ob die adaptive Aufforderung zum Mentalen Kontrastieren förderlich für das Flow-Erleben ist.

Die Studien dieser Dissertation zeigen, dass Flow-fördernde Interventionen je nach Zweck, Ziel und Ausführendem kategorisiert und evaluiert werden können. Sie zeigen auch, dass die Unterschiede in den Beobachtungsansätzen, die zur Erfassung des alltäglichen Flow-Erlebens verwendet werden könnten, keinen Einfluss auf die Konformität bei der Teilnahme haben. Vielmehr sollte der spezifische Beobachtungsansatz in Abhängigkeit davon gewählt werden, ob die Forschenden an der intra- oder interindividuellen Variabilität des Flow-Erlebens interessiert sind. Aus den Ergebnissen dieser Dissertation lässt sich zudem schließen, dass Mentales Kontrastieren das Flow-Erleben fördern kann. Die Verwendung eines adaptiven Mechanismus für die individualisierte Bereitstellung von Interventionen erscheint nicht förderlicher als die standardisierte Bereitstellung, könnte jedoch langfristig hilfreicher sein.

Zusammenfassend stellt diese Dissertation ein dreidimensionales Modell als Grundlage für die systematische Konstruktion von Flow-fördernden Interventionen bereit. Sie gibt Empfehlungen für die Auswahl eines Beobachtungsansatzes zur Erfassung von alltäglichem Flow-Erleben und bietet einen validen und reliablen Flow-Fragebogen, der kürzer ist als gängige Varianten und dadurch die Belastung bei Beantwortung reduziert. Darüber hinaus stellt die Dissertation eine wirksame Intervention vor, die sich Mitarbeitende schnell und selbstständig aneignen und anwenden können, ohne dass eine Beteiligung der Führungskraft erforderlich ist. Zukünftige Forschung sollte die Limitationen der Dissertation adressieren, z. B. durch Kombination von Selbstberichten mit objektiven Daten, Zugriff der Teilnehmenden auf eine Übersicht ihres individuellen Flow-Erlebens zur Unterstützung ihrer Selbstwirksamkeit, Verbesserung des adaptiven Mechanismus durch Berücksichtigung kontextbezogener Informationen und Durchführung von Untersuchungen in Teams.

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To Luki, words cannot describe how lucky I am to have you by my side and what it means to me to be loved by you every single day. Where you are, there is my favorite place to be.

Contents

List of Abbreviations

AA	Ambulatory Assessment
APS	Association for Psychological Science
FKS	Flow Short Scale
FQ	Flow Questionnaire
HCI	Human-Computer Interaction
ICC	Intraclass Correlation Coefficient
IS	Information Systems
JITAI	Just-In-Time Adaptive Intervention
MC	Mental Contrasting
SAA	Society for Ambulatory Assessment
SMART	Specific, Measurable, Attainable, Relevant, and Time-Bound
r-FKS	Reduced Flow Short Scale
RQ	Research Question
R&R	Revised and Resubmitted

List of Figures

List of Tables

CHAPTER 1

Introduction

1.1 Motivation

> *"Contrary to what we usually believe, moments like these, the best moments in our lives, are not the passive, receptive, relaxing times* (…). *The best moments usually occur when a person's body or mind is stretched to its limits in a voluntary effort to accomplish something difficult and worthwhile."*
> (Csikszentmihalyi, 2002, p. 3)

Despite the current trend of new work concepts that emphasize self-determined work on individually fulfilling tasks (Bergmann, 2019), employee engagement at work remains low. For example, in 2022, only 16 % of employees in Germany were engaged in their work, while another 16 % were actively disengaged, indicating not only employees' lack of enthusiasm for their jobs but also an active display of their dissatisfaction (Gallup, 2022). This frustration may be rooted in today's fast-paced, digital world of work, where individuals are expected to quickly adapt to increasing demands, often blurring the lines between work and personal life (Marsh et al., 2022). Dealing with these demands, such as constant distractions from digital technology, can have detrimental effects on mental health (Marsh et al., 2022). In line with this assumption, the number of days absent from work due to stress-related disorders, such as burnout, has increased more than tenfold from 2005 to 2022 (Statista, 2024a). Increases in number of burnout disorders and a lack of work engagement may then have undesirable consequences for both organizations and individuals. These consequences include decreased performance and personal initiative, long-term absenteeism from work, and general health decline (Bakker et al., 2014; Hakanen & Schaufeli, 2012; Leijten et al., 2015; Neuber et al., 2022; Schaufeli et al., 2009; Wingerden & Stoep, 2018).

Experiencing flow can serve as a powerful buffer against these alarming developments and the associated negative side effects as it has been found to decrease burnout symptoms and increase work engagement (Aust et al., 2022; De Fraga & Moneta, 2016; Mosing et al., 2018; Weintraub et al., 2021). Flow, as originally introduced by Csikszentmihalyi (1975), is often described as the state of being "in the zone" (Engeser et al., 2021, p. 19). During a state of flow, an individual is perfectly challenged by the current task, experiencing complete absorption and fluency in the task (Engeser & Rheinberg, 2008; Moneta, 2021).

Specifically, these major cognitive components of flow, absorption and fluency, entail that flow involves a high level of concentration and a sense of control, where action and awareness merge, leading to a loss of self-consciousness and a distorted temporal experience (Bassi & Delle Fave, 2012; Delle Fave & Massimini, 2005; Engeser & Rheinberg, 2008; Nakamura & Csikszentmihalyi, 2012). Apart from the mitigating effects of flow on burnout symptoms and lack of work engagement, research has shown that flow at work can also enhance performance, stimulate creativity, and increase energy levels after work (Demerouti et al., 2012; Engeser & Rheinberg, 2008; Zubair & Kamal, 2015). Hence, both organizations and individuals would profit from promoting flow at work to an appropriate degree (i.e., without overstimulating it and risking negative side effects such as exhaustion; Zimanyi & Schüler, 2021).

It is important to note that individuals often recall leisure activities as the source of their flow experiences though because they find them enjoyable and are intrinsically motivated to pursue them (Delle Fave & Massimini, 2005; Engeser & Baumann, 2016). This pursuit of the activity just for the sake of doing it is described as the autotelic component of flow (Abuhamdeh, 2020; Peifer et al., 2022). Actually, however, flow experiences occur more often at work than during leisure activities (Csikszentmihalyi & LeFevre, 1989; Engeser & Baumann, 2016). This phenomenon, known as the paradox of work (Engeser & Baumann, 2016), may be due to the fact that people often fail to create challenging situations during leisure time. Instead, they tend to engage in passive activities such as watching TV, which impede the emergence of flow (Csikszentmihalyi & LeFevre, 1989). In fact, experiencing flow is especially likely when individual skills and task demands exceed the individual average (Rheinberg & Engeser, 2018). Therefore, this dissertation focuses on knowledge work that involves cognitively demanding tasks related to “finding, creating, packaging, and applying knowledge” (Kelloway & Barling, 2000, p. 301). These tasks typically require active cognitive engagement, thereby providing a solid foundation for inducing flow. Importantly though, this does not imply that engaging in knowledge work always results in a flow experience. For example, in the workplace, individuals often have limited autonomy in task choice. As a result, some tasks may be perceived as boring and lack flow, while others may be more conducive to it. Hence, although the paradox of work demonstrates the

possibility of experiencing flow while working, individuals need help to consistently achieve flow in the generally flow-conducive conditions of knowledge work.

In view of this need and the expected individual and organizational benefits of flow, one might anticipate a plethora of interventions to promote flow in knowledge work. However, as this dissertation will demonstrate, fostering flow is a complex task due to several reasons. First, it is not simply a matter of distinguishing individuals who experience flow from those who do not, and then solely focusing on the latter. Although some individuals may be more prone to experiencing flow (Baumann, 2021), each person's experience of flow also largely depends on their momentary circumstances. For example, the presence of other individuals and interactions with them can significantly impact the experience of flow (Aubé et al., 2014; Schutte, 2020). Overall, in everyday knowledge work, flow occurs in a complex setting with various interplaying factors (Ceja & Navarro, 2011). More specifically, workplaces differ between organizations, individuals vary in their proneness to experiencing flow, and situational demands are constantly changing. Hence, an effective intervention for promoting flow should ideally be applicable to everyone in any situation. This claim for completeness significantly increases the complexity of intervention development, thereby discouraging researchers from trying to promote flow in knowledge work.

Additionally, a significant constraint in promoting flow is the fact that flow is a state of complete absorption (Engeser & Rheinberg, 2008; Moneta, 2021). This implies that an intervention will immediately disrupt flow when it is already present (Bartholomeyczik et al., 2022; Züger et al., 2017). To prevent these interruptions, scholars from Information Systems (IS) and Human-Computer-Interaction (HCI) research have already initiated real-time flow detection based on behavioral or neurophysiological data (Brown et al., 2023; Rissler et al., 2018; Tozman et al., 2015). Gathering real-time insights into an individual's state allows for the employment of adaptive mechanisms that recognize these individual states. This can help avoiding intervention when a person is already in flow and target moments when they do not experience flow (Nadj et al., 2023; Züger et al., 2017). Given their ubiquity in everyday life, smartphones may facilitate the deployment of such adaptive mechanisms. Due to the ability of smartphones to continuously gather data, their convenience, and ease of usage, smartphone-based interventions are increasingly recognized in the health

domain as a means to enhance physical and mental health (Wall et al., 2023). This trend aligns with the current boom of the digital health industry. In Germany, revenue from digital fitness and well-being is projected to increase by 12.6 % in 2024 (Statista, 2024b). This growth may be attributed to the fact that digital health support is no longer limited to healthcare professionals or individuals' personal lives. Instead, smartphone-based interventions are increasingly implemented in the workplace to support employees' well-being and health (Karlsen et al., 2022; Moe-Byrne et al., 2022). For instance, Junker et al. (2023) found that an app that gave advice on how to improve medical check-up results positively influenced the physical health of knowledge workers. Similarly, Weber et al. (2019) found a positive effect of a mental health app for the workplace that provided psychoeducational content on nine topics, including relationships at work and rumination.

Despite these promising results and the aforementioned benefits of experiencing flow in knowledge work, there is currently no smartphone-based intervention aimed at increasing flow in knowledge work by use of an adaptive mechanism. The following paragraphs will illustrate how the present dissertation sets out to develop such an intervention and which research questions are posed.

1.2 Research Agenda

This dissertation aims to explore how to promote flow in everyday knowledge work using a smartphone-based intervention with an adaptive mechanism. To achieve this objective, three main research questions (RQs) will be addressed, concerning the current state of the theoretical and empirical field (RQ 1), methodological choices for intervention evaluation and adaptivity (RQ 2), and the effectiveness of the specific intervention type and its adaptivity (RQ 3). Each RQ and its underlying argumentation will be explained in detail below.

1.2.1 Current State of Research on Flow-Promoting Interventions

Developing an intervention to promote flow in everyday knowledge work first requires an overview of the current state of knowledge and availability of suitable interventions. As introduced earlier, it is widely agreed that flow in knowledge work is highly beneficial for both individuals and organizations (Peifer & Wolters, 2021). Despite this agreement, there

is no comprehensive research agenda that offers advice on how to systematically proceed with developing flow-promoting interventions for the work domain. Rather, it is common to suggest single intervention strategies based on the characteristics of flow. For instance, researchers have developed a tool for preventing interruptions by co-workers based on the notion that flow is a state of high concentration (Züger et al., 2017). Although these single findings of successful intervention strategies are promising indicators that flow can be fostered, a one-size-fits-all approach may not be effective or efficient. This is due to the fact that flow is subject to strong inter- and intraindividual variability (Ceja & Navarro, 2011). Hence, it is likely that different interventions will be helpful depending on the specific person and situational requirements. Therefore, before proceeding to develop a flow-promoting intervention, this dissertation aims to answer the following RQ:

RQ 1: What modes of action can interventions use to promote flow in everyday knowledge work, and how can researchers determine which one to apply?

1.2.2 Methodological Choices for Intervention Evaluation and Adaptivity

Developing and testing a specific intervention requires an understanding of how flow can be measured in everyday life for two reasons. First, testing an intervention involves examining its effectiveness in promoting flow, which can only be achieved by measuring flow after applying the intervention. Second, the intervention can only be provided adaptively if information about the individual's state is available. Unfortunately, translating measurement methods from laboratory flow experiments to measurements in everyday knowledge work is problematic. This is because laboratory settings usually do not resemble everyday work. For instance, laboratory experiments are typically conducted in single cabins, without unexpected interruptions, and for a short duration of time to ensure high internal validity of the findings (e.g., Engeser & Rheinberg, 2008; Keller et al., 2011). Additionally, in the laboratory, researchers can introduce breaks between tasks to allow for the application of flow measures (e.g., Bartholomeyczik et al., 2022). In contrast, individuals in everyday knowledge work often switch between tasks or engage in multiple tasks simultaneously (Czerwinski et al., 2004; Kirchberg et al., 2015). They may also be interrupted frequently (Marsh et al., 2022; Nadj et al., 2023) and cannot take long breaks to fill out a questionnaire.

Therefore, it is crucial to identify measurement methods that are specifically suitable for capturing flow in everyday life which may also enhance external validity of the findings.

The term ambulatory assessment (AA) unites methods that meet this condition. In AA, researchers typically measure everyday experiences multiple times per day, nowadays often using portable devices, such as smartphones, with low invasiveness to everyday life (Trull & Ebner-Priemer, 2014). AA can capture both subjective data, such as self-reports (traditionally paper-and-pencil versions, now commonly digitized), and objective data, such as (neuro-)physiological or log data (Trull & Ebner-Priemer, 2014). Since a reliable, objectively measurable indicator of flow has not yet been identified (Peifer et al., 2022; Peifer & Tan, 2021), this dissertation focuses on measuring flow via self-reports. In AA, self-reports can be gathered through various observation approaches, varying for example in their reference (asking about momentary states or very recent experiences) or in the frequency of requests for self-reports (Trull & Ebner-Priemer, 2014). Due to these differences, the observation approach may influence an individual's compliance and perceived burden, or even alter the measurement itself, introducing bias into the self-reports (Eisele et al., 2022; Hasselhorn et al., 2022). However, no one has yet investigated the impact of differences in observation approaches on compliance, burden, and biases in self-reports when measuring flow in everyday knowledge work.

In addition to the observation approach, the conclusions regarding the effectiveness of the intervention that can be drawn from the self-reports depend heavily on how flow is operationalized (Peifer & Engeser, 2021). For example, when operationalizing flow as a categorical construct (in that individuals can either be in flow or not experience it at all), researchers can conclude whether an intervention increases the frequency of flow experiences (Peifer & Engeser, 2021). To operationalize flow, researchers have already developed various flow questionnaires and scales (for an overview, see Moneta, 2021). For measuring flow in laboratory and field experiments, the two most commonly used scales are the Flow Short Scale (FKS[1], Engeser & Rheinberg, 2008; Rheinberg, 2015) and the Flow State Scale (Jackson & Eklund, 2002), each consisting of at least nine items. However, AA requires

[1] Although the abbreviation FSS would be more intuitive, researchers have commonly used this abbreviation for the Flow State Scale (Jackson & Eklund, 2002). Thus, in the following, the abbreviation FKS will be used building on the original German version of the Flow Short Scale (*Flow Kurzskala*; Rheinberg et al., 2003).

repeated requests for self-reports, so a briefer measure would be particularly helpful to decrease the burden of the measurement method and reduce interruptions in flow. Therefore, to comprehensively address the importance of the measurement method for evaluating the intervention effectiveness and implementing an adaptive mechanism, this dissertation also aims to answer the following RQ:

RQ 2: What is the most informative and least invasive method of measuring flow in everyday knowledge work to evaluate and adapt a flow-promoting intervention?

1.2.3 Adaptivity and Type of Flow-Promoting Interventions

Interventions with adaptive mechanisms, so-called just-in-time adaptive interventions (JITAIs), allow to acknowledge that flow fluctuates depending on the person, time, and task (Ceja & Navarro, 2011; Fullagar & Kelloway, 2009). Thereby, JITAIs can address the issue of interrupting flow, intervening exactly when a person has not experienced flow for a while. Due to the aforementioned numerous advantages, researchers have mostly utilized smartphones to implement JITAIs (Hardeman et al., 2019; Perski et al., 2022). In the work domain, JITAIs have already been successfully developed and tested for increasing mental and physical health, such as decreasing sedentary behavior or stress (Howe et al., 2022; Huang et al., 2019). To specifically promote flow, Züger et al. (2017) developed a JITAI that adapted to individual computer interaction data, indicating externally when co-workers should not interrupt a person. However, there is no JITAI yet that provides a flow-promoting strategy to the individual themselves rather than adjusts the context. This JITAI would enhance autonomy of the individual and allow for application across contexts.

Developing such an individually-targeted JITAI for promoting flow in knowledge work requires consideration of two aspects. The first one is the definition of the adaptive mechanism, specifying when and depending on which variable intervention is necessary. The second one is the specific intervention type that should be presented within the adaptive mechanism. Flow can only emerge when its preconditions, especially the balance between individual skills and task demands, are met (Engeser & Rheinberg, 2008; Keller, Ringelhan, et al., 2011; Keller & Bless, 2008). As will be discussed in more detail in Chapter 2, therefore, these preconditions must be established first. Mental contrasting (MC), an imagination

technique originally developed in motivation psychology (Oettingen, 2000), may be helpful to establish the skill-demand-balance. MC prompts individuals to identify a wish and imagine the desired outcomes of this wish as well as potential inner obstacles (Oettingen, 2000). Thereby, it encourages disengagement from goals when obstacles outweigh outcomes, and enhances commitment to goals that appear feasible and desirable (Oettingen, 2000; Oettingen et al., 2001). MC can be acquired as a metacognitive strategy, enabling individuals to apply it in various tasks and situations (Oettingen et al., 2015). This makes it especially promising for an application in everyday knowledge work since individuals typically are exposed to various contextual and task-related changes throughout a normal workday. Consequently, the final RQ of this dissertation is formulated as follows:

RQ3: Can a smartphone-based just-in-time adaptive intervention (JITAI) that encourages the use of a metacognitive strategy promote flow in knowledge work?

1.3 Dissertation Structure

The objective of this dissertation is to investigate how to promote flow in everyday knowledge work by using a smartphone-based JITAI. Figure 1 illustrates the overall structure of this dissertation, which includes three scientific articles that each address one of the previously posed RQs.

The present Chapter 1 introduces the concept of flow, motivates the importance of promoting flow in knowledge work, and provides a research agenda for developing a JITAI to achieve this goal. For that, it poses three RQs that are addressed in the following three chapters. These chapters may be read on their own but build on each other in terms of the underlying RQs.

Chapter 2 provides a conceptual analysis of the theoretical and empirical field. Based on a narrative literature review of the concept of flow and the availability of flow-promoting interventions for the workplace, it outlines the modes of action flow-promoting interventions may apply in a comprehensive framework. This provides a theoretical foundation for the two empirical studies included in this dissertation.

Chapter 3 presents the first of these studies (Study 1), which investigates how to measure and operationalize flow in everyday knowledge work. Study 1 was conducted using AA over the course of six days and included $N = 39$ participants who regularly engaged in knowledge work. It sheds light on which observation approach allows to capture flow in knowledge work without decreasing compliance, increasing perceived burden, or biasing flow reports. Study 1 also addresses whether shortening a validated and commonly used flow scale negatively impacts its psychometric properties for use in AA. Additionally, it explores the operationalization of flow as a categorical or continuous construct and the implications of this decision.

Chapter 4 empirically investigates whether a JITAI promotes flow in everyday knowledge work. In this study (Study 2), AA was conducted over the course of five days. Study 2 involved $N = 59$ knowledge workers who participated in an intervention that taught them to apply MC or a control metacognitive strategy before beginning work. The study aims to explore whether MC promotes flow in knowledge work compared to the control strategy. Additionally, it determines whether providing the metacognitive strategies as a JITAI or non-adaptively is more helpful for promoting flow.

Chapter 5 comprehensively summarizes the results of this dissertation and elaborates on its overall contributions for research and practice. Additionally, it discusses limitations of the present dissertation and makes suggestions on how these may be addressed in future research.

Chapters 2, 3, and 4 consist of research articles submitted for publication in scientific outlets. The article included in Chapter 2 has already been published, while the articles from Chapters 3 and 4 are currently under review. Publication details and author contributions can be found at the beginning of each chapter. Appendix A1 also provides an overview over the articles and the respective outlets. The references and appendices for each chapter are listed jointly at the end of this dissertation.

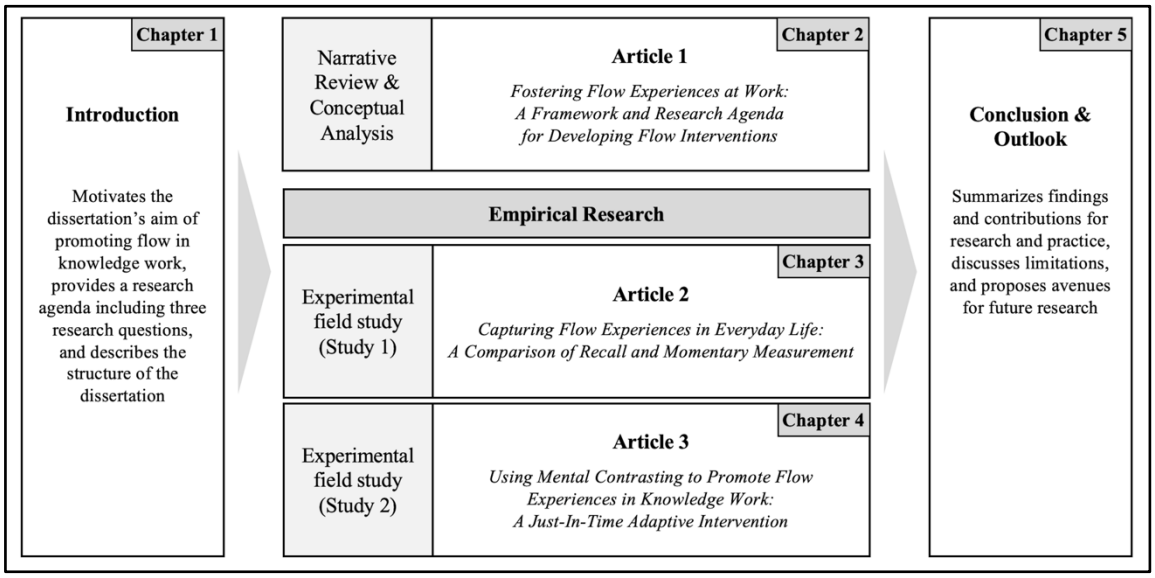

Figure 1 Dissertation structure

CHAPTER 2

Framework and Research Agenda for Promoting Flow in Everyday Knowledge Work

This chapter is based on a peer-reviewed article entitled “Fostering Flow Experiences at Work: A Framework and Research Agenda for Developing Flow Interventions”. The article was co-authored by Dr. Michael T. Knierim and Prof. Dr. Christof Weinhardt and is published in Frontiers in Psychology under a Creative Commons Attribution 4.0 International License (https://creativecommons.org/licenses/by/4.0/).

Tables and figures have been systematically renamed, reformatted, and appropriately referenced to conform to the overall structure of the dissertation. To further improve clarity and consistency, wording, formatting, and referencing style were adjusted and references were updated.

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Weinhardt, C.: Resources, Supervision, Funding acquisition

2.1 Introduction

With the average adult with a full-time job spending 8.5 hours at work each weekday (U.S. Bureau of Labor Statistics, 2021), the overall well-being of most employed people is strongly influenced by their job satisfaction (Bowling et al., 2010). Organizations have recognized the influence of well-being on job performance (Ford et al., 2011; Kansky & Diener, 2017; Wright & Cropanzano, 2000) and employee turnover (Richer et al., 2002; Wright & Bonett, 2007). Thus, management increasingly shifts its attention to a more people-centric organization by making efforts to promote individual job satisfaction, work engagement and general mental health (Aarons-Mele, 2018; Spreitzer & Porath, 2012). In this rise of a positive work environment, the concept of flow by Csikszentmihalyi (1975) became popular. Flow is the intrinsically motivating state of optimal experience in which an individual fully concentrates on the current task (Nakamura & Csikszentmihalyi, 2012). Research found that this state occurs more frequently and intensely during work than leisure time (Csikszentmihalyi & LeFevre, 1989; Engeser & Baumann, 2016). However, flow in general is a rare experience that most people struggle with entering intentionally (Ceja & Navarro, 2011; Wilson & Moneta, 2016). Thus, academic literature as well as popular media outlets (e.g., Fisher, 2010; Kotler, 2014; Peifer & Wolters, 2021) call for fostering flow at work to capitalize on its benefits for the individuum (e.g., increased well-being; Bryce & Haworth, 2002) and the organization (e.g., increased performance and creativity; Engeser & Rheinberg, 2008; Zubair & Kamal, 2015).

Despite these repeated calls to increase flow at work, research has only begun to develop and evaluate flow-promoting interventions. For example, in a recent experience sampling study, workers were prompted on five consecutive mornings to write down three goals for the day (Weintraub et al., 2021). This goal-setting nudge increased flow at work, which led to lower levels of stress and enhanced work engagement and performance. However, Weintraub et al. (2021) identified only one other empirical examination of a flow-promoting intervention at work by Costantini et al. (2020). This intervention involved a series of behavior change techniques which led to higher absorption at work, a core facet of flow. Based on Weintraub et al.'s (2021) claim of a small empirical field, we conducted a related literature search and identified only two additional intervention studies in the context of

flow at work (Bartzik et al., 2021; Drozd et al., 2014). In contrast, there is a larger set of interventions with demonstrated effectiveness for increasing flow in other domains. A recent review from the sport and exercise domain identified 29 studies with interventions (most common: mindfulness interventions, 31%; hypnosis, 17%; imagery techniques, 14%) that were at least modestly successful in increasing flow (Goddard et al., 2021). However, the activities in which flow is experienced during sport and exercise differ substantially from work tasks. While sport and exercise involve high levels of physical activity, every other employee has a (computer-based) desk job (Bitkom Research, 2018). Hence, the interventions from the domain of sport and exercise are hardly applicable to the workplace, as, for example, the use of imagery strategies is difficult in the light of predominantly cognitive job-related tasks. Importantly, 41% of the studies identified by Goddard et al. (2021) also had a single-case design and thus lacked sufficient power to transfer the results to other domains. Nevertheless, the findings from the domain of sport and exercise show that flow is modifiable in principle. In sum, even though earlier evidence indicates that flow at work can be supported, there remains a striking lack of empirical research on flow-promoting interventions in this domain.

We attribute the hesitance of the empirical field to address this line of research to three main reasons. First, the empirical field is still debating a common conceptualization of flow (Peifer et al., 2022), especially with regard to its operationalization as continuous or discrete (Abuhamdeh, 2020). However, agreement on how to measure flow in different settings is necessary for the evaluation of intervention effectiveness. Second, flow states at work are highly variable within- and between-persons (Ceja & Navarro, 2011; Fullagar & Kelloway, 2009). Moreover, individual characteristics as well as the type of task determine the overall likelihood of experiencing flow (Nielsen & Cleal, 2010; Tse et al., 2021), thereby making it difficult to find an intervention that is effective across individuals and jobs. Reducing this complexity in designing flow-promoting interventions requires breaking down the end goal into less complex subgoals, thereby providing an anchor for where to start. In fact, Nakamura and Csikszentmihalyi (2012) have already suggested two approaches to fostering flow: targeting the environment or the individual. Both are valuable strategies because flow arises when there is a fit between situational and individual characteristics (Peifer & Wolters, 2021). However, a framework that integrates different goals of

interventions with respect to the individual flow state (currently being in flow or not) as well as to distinct environmental or individual targets is still missing. This lack of a framework further impedes the systematic development and evaluation of suitable interventions.

Therefore, we aim to systematize future empirical research on fostering flow at work by providing a comprehensive framework for the scope of flow-promoting interventions in this domain. To accomplish this, we first review the concept of flow at work. Based on Walker and Avant's (2005) concept analysis process, we identify the antecedents, defining attributes, and consequences of flow in a narrative review. We then consolidate the insights from this review into what we call the sequence of experiencing flow. We also illustrate the flow concept in a model case and discuss its empirical referents. We then use the sequence of experiencing flow to build our framework, that systematically describes the potential modes of action of flow-promoting interventions. To do so, we take into account a person's current position in the flow sequence, the potential addressees of interventions, and the initiators of interventions at work. Thus, our framework includes three modes of action: (1) the aim, (2) the target, and (3) the executor of the flow-promoting intervention. For each mode, we provide exemplary interventions based on the theoretical arguments and/or empirical evidence. We then use these modes to derive guiding questions and a research- and practice-oriented agenda for fostering flow at work. In addition, we discuss the need to consider these modes when evaluating the effectiveness of a flow-promoting intervention.

Our article contributes to the flow literature in psychology and management in three major ways. First, by providing three guiding questions based on our framework, we enable researchers to strategically design flow-promoting interventions for work. This increases the interventions' potential taking into account specific goals and situational characteristics. Second, our framework puts forward a concrete research agenda that emphasizes the importance of ensuring that the flow antecedents are met. Finally, we provide recommendations for selecting an appropriate flow operationalization to evaluate the effectiveness of an intervention. Thereby, we enable thorough assessments of proposed interventions in terms of increasing the duration, frequency, or intensity of flow depending on the person's current state. In addition to these implications for researchers, our article also contributes to fostering flow at work in practice. First, we emphasize the importance of targeting the group as

a time- and cost-efficient approach to increasing flow, regardless of whether the organization or the employees execute the intervention. Also, we sensitize practitioners to recognize interindividual differences in flow proneness and provide recommendations for integrating them in flow-fostering initiatives.

In the following paragraphs, this chapter will proceed as follows. First, we will review the literature on the concept of flow and summarize it in the sequence of experiencing flow at work. Second, we will present our framework for flow-promoting interventions at work. Finally, we will discuss the framework's implications for researchers and practitioners, as well as its limitations.

2.2 The Sequence of Experiencing Flow

2.2.1 Antecedents, Attributes, and Consequences of Flow

Given the ongoing debate about the conceptual modelling and operationalization of flow, for the purposes of this chapter we follow the argument of Abuhamdeh (2020, p. 9) that "the term flow comes with Csikszentmihalyi's conceptualization 'pre-installed' ". According to this original concept, flow has six defining attributes: high concentration, merging of action and awareness, loss of self-consciousness, sense of control, distorted temporal experience, and an autotelic (i.e., enjoyable) state. These flow attributes are discriminated from three antecedents, namely clear goals, immediate feedback, and balance of skills and demands (Nakamura & Csikszentmihalyi, 2012) (Figure 2).

In addition to these originally defined flow antecedents, flow researchers have identified a number of other variables that are associated with the emergence of flow. In the context of work, Peifer and Wolters (2021) distinguish three spheres of these variables, namely social/organizational, job/task-related, and individual variables. Following the original flow concept, we maintain the distinction between the mandatory antecedents (i.e., clear goals, immediate feedback, and skill-demand-balance) and these additional influential variables by including the latter as moderators in the sequence of experiencing flow. This is consistent with previous research showing that these variables, e.g., the task importance, moderate the relationship between the original antecedents and flow (Engeser & Rheinberg, 2008).

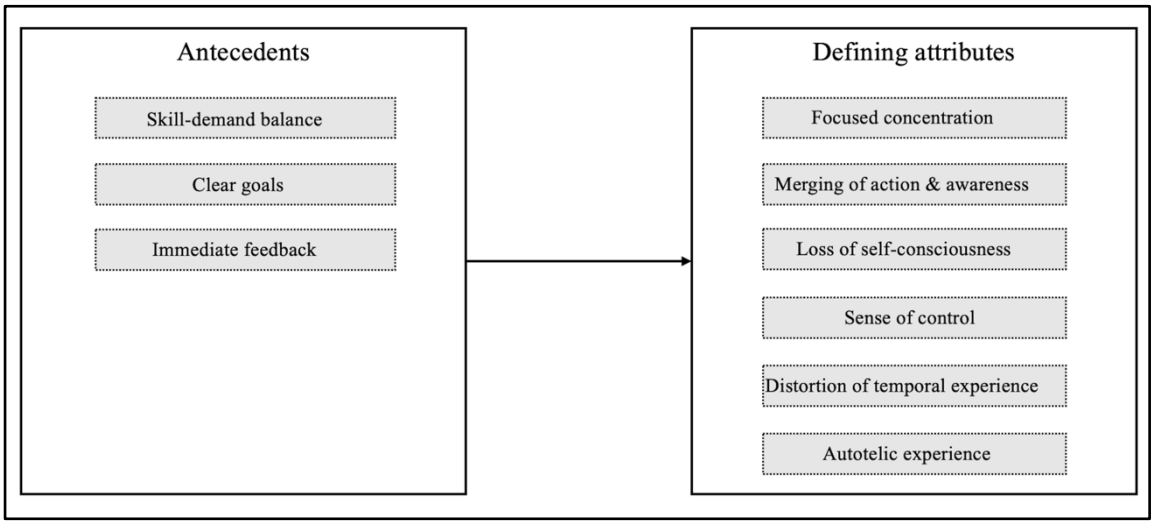

Figure 2 Overview over the flow antecedents and the defining attributes

Flow also leads to a series of consequences, such as performance or well-being. These are also important for the development of flow-promoting interventions, as they will be affected as a result of intervention-induced increases in flow. For the context of work, Peifer and Wolters (2021) aggregated the consequences of flow into the aforementioned three spheres which underlines the potential benefits of fostering flow on an individual, team-related, and organizational level.

In sum, the flow literature reveals a sequence of experiencing flow with a progression from its antecedents through moderating influences to the defining attributes of the state itself and its associated consequences (Abuhamdeh, 2020; Barthelmäs & Keller, 2021; Peifer et al., 2022) (Figure 3). In the next paragraph, we will further illustrate this sequence with a model case.

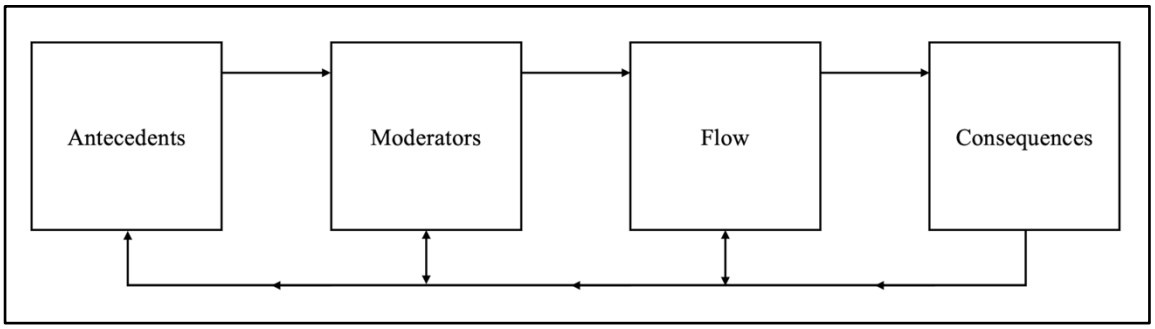

Figure 3 The complete sequence of experiencing flow as a foundation for building a framework for flow-promoting interventions at work

2.2.2 A Model Case of Flow at Work

Hannah works as a data analyst for a large technology company. One of her favorite tasks is programming a data analysis pipeline to predict the success of her client's advertising campaigns. When she writes the code, she does not have to think twice about how to approach the problem, she just knows what to do. She becomes so absorbed in the task that she stops noticing anything around her. One day, she even missed an important client call because she did not hear the phone. She was too focused to notice the constant ringing. When her colleagues ask her to join them for lunch, she only then realizes that she has not eaten for hours. Sometimes, her partner gets upset on these programming days (she calls them fun days) because she often does not leave in time to make it to their dinner plans.

This model case represents a typical flow experience at work with all its defining attributes. While programming, Hannah is highly concentrated and fully absorbed in the task. Her actions run fluidly without her having to think about it. She feels in full control, experiences time in a distorted way and enjoys the state. She can experience flow in programming because all required antecedents are met. She has clear goals (writing a code that can make accurate predictions), receives immediate feedback (error messages from the programming software), and the task is challenging, but not too difficult for her. Repeatedly experiencing flow in programming allows her to perform well and feel satisfied with her job.

2.2.3 The Empirical Referents of Flow and their Relevance for Intervention Evaluation

Since flow is a subjective experience with strong intraindividual variability (Fullagar & Kelloway, 2009), it is commonly assessed in daily life using self-report measures (Moneta, 2021). Importantly, however, the empirical field has not yet agreed on whether flow is a discrete or continuous construct, that is, whether there are only two states, flow and nonflow, or whether there is a continuum of flow intensities between these two extremes (Abuhamdeh, 2020; Peifer & Engeser, 2021). Even though Csikszentmihalyi originally defined flow as a discrete state (Abuhamdeh, 2020), most operationalizations of flow are continuous (e.g., the FKS; Engeser & Rheinberg, 2008; Rheinberg, 2015). Both conceptualizations bear certain limitations for the evaluation of flow-promoting interventions. If flow was defined as discrete (with two states: nonflow and flow), flow-promoting interventions could

only increase the frequency or total duration of these states. In contrast, if flow was defined as continuous, interventions could increase the intensity (or the duration of flow at a specific intensity level), but the overall duration and frequency of flow could not be assessed (Peifer & Engeser, 2021). This would require the establishment of a specific threshold to distinguish flow from nonflow. Such a distinct boarder not only seems unlikely to exist in work scenarios, but also entails the risk of setting a suboptimal threshold (Abuhamdeh, 2020). Hence, we adopt flow as a yes-or-no continuous phenomenon, i.e., a person experiences the state of nonflow until a threshold is reached, from which the flow state gradually increases on a continuum (Peifer & Engeser, 2021). This is to acknowledge that there are states in which flow is not attainable due to the absence of the antecedents that are, by definition, mandatory for flow to arise (Fullagar & Kelloway, 2009). In our discussion, we will argue how the evaluation of flow-promoting interventions in terms of increasing frequency, duration, or intensity depends on the current flow state of the person.

2.3 From the Sequence of Experiencing Flow to a Framework for Flow-Promoting Interventions

For effective intervention development, it is necessary to circumscribe how an intervention strategy influences the target concept (O'Cathain et al., 2019). With respect to fostering flow, the empirical field has taken two approaches to making this connection. First, it has based interventions on parallelisms between flow attributes (e.g., focused concentration) and the intervention strategy (e.g., a mindfulness exercise). However, this approach lacks a specification of how the intervention works, i.e., a specification of its modes of action (Goddard et al., 2021). Second, the empirical field has recently started to translate knowledge about the flow antecedents into interventions (Peifer & Wolters, 2021), for example, by teaching goal-setting strategies to facilitate the availability of clear proximal goals as one major precondition of flow (Weintraub et al., 2021). This approach provides an explanation for the modes of action by arguing that establishing the antecedents of flow should result in a higher likelihood of entering flow. Therefore, it should be favored over the first approach. Following this, we systematically describe the potential modes of action of flow-promoting interventions based on the sequence of experiencing flow with distinct

antecedents, moderators, and inherent attributes. We do this by clustering the modes of action into a three-dimensional framework, which we present in the following paragraphs.

2.3.1 Aims of Flow-Promoting Interventions

To foster flow, one can have several goals in mind: increasing the frequency of flow experiences, extending the duration of a flow episode, or intensifying the strength of a flow experience regardless of duration and frequency. Thereby, what a specific intervention can accomplish depends on the person's current flow state. If a person is currently experiencing nonflow, the antecedents are unlikely to be met because their absence diminishes the probability of the occurrence of flow. Conversely, if a person is currently in flow, the antecedents are necessarily given, regardless of the intensity of the state (Fullagar & Kelloway, 2009). Moderators cannot substitute these antecedents or prohibit flow, but they can facilitate entry into flow and influence flow intensity (e.g., Bricteux et al., 2017). Therefore, the components in the sequence of experiencing flow constitute an anchor for the development of flow-promoting interventions. We propose that interventions for fostering flow at work can pursue three goals depending on the person's current flow state and the component on which they focus: (1) entering, (2) boosting, or (3) maintaining flow. Hence, our framework incorporates the intervention aim as the first dimension for classifying flow-promoting interventions at work (Figure 4).

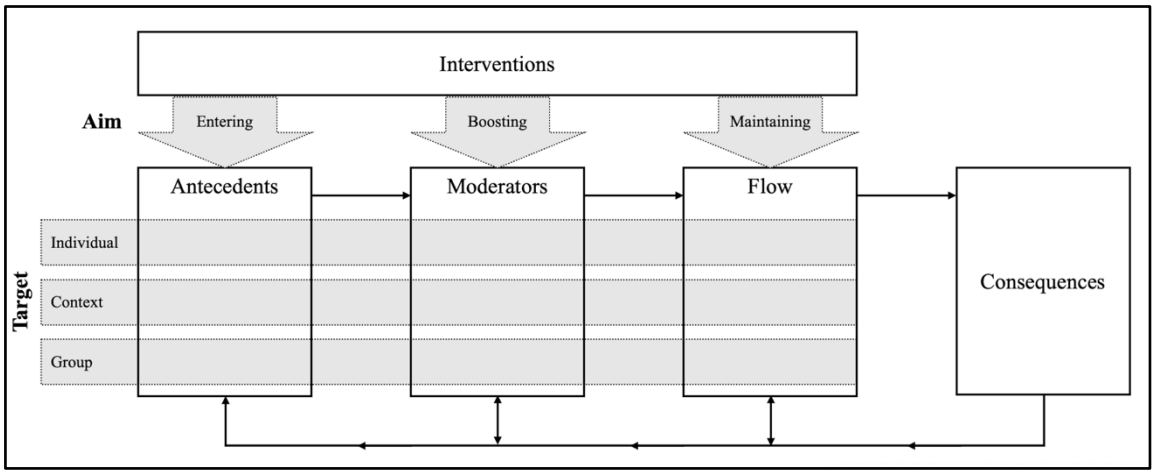

Figure 4 The first and second dimension of the framework for flow-promoting interventions at work

2.3.1.1 Entering Flow

Since the antecedents form the basis for the emergence of flow, modulating these variables is necessary to enable crossing the threshold from nonflow to flow. Consequently, these modulations can increase the frequency of flow experiences by increasing the frequency of this transgression. Also, the presence of the antecedents determines the total duration of flow because their withdrawal causes the threshold to be crossed again. Thus, we propose that interventions designed to establish the antecedents pursue the aim of entering flow (Figure 4).

An example of an intervention aimed at entering flow is the aforementioned nudge for setting attainable goals (Weintraub et al., 2021). It aims to establish the flow antecedent of clear proximal goals. Also, previous empirical evidence provides promising starting points for increasing flow by giving feedback, another antecedent in the original flow concept (Hohnemann et al., 2022; Peifer et al., 2020). Thus, establishing structured and regular feedback mechanisms in an organizational context could be effective in enabling people to enter flow at work more often. Finally, presenting tasks with a level of difficulty fitted to the individual's skill-demand-balance is conducive to experiencing flow in experimental settings (Huskey et al., 2018). Thus, management could assign tasks with gradually increasing difficulty depending on individual skills.

2.3.1.2 Boosting Flow

In the sequence of experiencing flow, moderators strengthen the relation between the antecedents and flow. Therefore, modulating them cannot only facilitate the transgression from nonflow to flow provided the antecedents are fulfilled (i.e., influence flow frequency), but also allows to increase the intensity of the subsequent flow states. Hence, we propose that interventions designed for altering the moderators pursue the aim of boosting flow (Figure 4).

As mentioned before, the empirical field for flow-promoting interventions at work is still small, but researchers have already suggested different interventions that would conform to this idea. For example, Peifer and Engeser (2021) discuss that providing rewards could foster flow by extrinsically motivating a person to perform an activity that ultimately leads

to flow. In addition, Bakker and van Woerkom (2017) argue that job crafting can enhance flow by allowing a person to shape the job to be meaningful and suitable for her. Thereby, job crafting can increase the perceived task importance, a confirmed moderator of the relationship between antecedents and flow (Engeser & Rheinberg, 2008). Additionally, research has identified a set of moderators for the emergence of flow that are related to inter-individual differences (e.g., flow metacognitions; Wilson & Moneta, 2016). We will further discuss their potential in the section on targets of flow-promoting interventions.

2.3.1.3 Maintaining Flow

Interventions with the above aims, entering and boosting, both apply when a person is not in flow. In contrast, modulating the attributes of the state is only a suitable intervention strategy when the person is currently experiencing flow. In contrast to allowing the transition from nonflow to flow, thereby affecting the frequency and total duration of flow, these interventions can alter the intensity of the current flow experience. Additionally, they can prolong the duration of staying at a specific intensity level, i.e., they can prevent declines on the flow continuum. Hence, we propose that interventions that address the flow attributes pursue the aim of maintaining flow (Figure 4).

An interesting idea for such an intervention in an applied context comes from IS and HCI research. Based on real-time classification of flow using neurophysiological measures, a light could indicate whether a person is currently experiencing flow, thereby preventing interruptions by co-workers (Rissler et al., 2017; Züger et al., 2017). In addition to providing diagnostic criteria for flow states, neurophysiological correlates could also constitute intervention targets. For example, Gold and Ciorciari (2019) found that transcranial direct current stimulation increased flow in a computer-based game task. Also, externally evoked changes in the activation of the autonomic nervous system altered the experience of flow (Chin & Kales, 2019; Colzato et al., 2018). However, even though these methods yield promising results in experimental studies, they still need to be translated into interventions that are applicable in the workplace.

2.3.2 Targets of Flow-Promoting Interventions

The aforementioned interventions for the three aims differ in their target. For example, while stimulating the autonomic nervous system focuses on the person experiencing flow, blocking interruptions targets the situational context. Therefore, as mentioned above, Nakamura and Csikszentmihalyi (2012) proposed to differentiate flow-promoting interventions according to whether they induce changes in the individual or in the environment. The three-spheres framework by Peifer and Wolters (2021) takes on this distinction and further differentiates between external variables related to the job/task or the social/organizational context. Hence, we adopt these earlier differentiations by proposing the intervention target as the second dimension in our framework for classifying flow-promoting interventions at work distinguishing between targeting (1) the individual, (2) the group, or (3) the context (Figure 4).

2.3.2.1 Targeting the Individual

We have already touched on empirical evidence that targeting the individual can affect flow (e.g., by teaching goal-setting strategies, Weintraub et al., 2021). Consistent with Person-Environment-Fit Theory (van Vianen, 2018), flow arises when situational and individual variables are aligned (Peifer & Wolters, 2021). Hence, targeting the individual should be especially effective in stimulating flow when individual attributes are modulated to fit the context. For example, nurturing the skills of a person to meet task-related demands may provide the skill-demand-balance necessary to evoke flow. This could be done through coaching or training. Importantly, while demographic variables such as gender and socio-economic status do not strongly predict flow (Isham & Jackson, 2023), individual differences in personality are associated with flow proneness. For example, Ullén et al. (2016) conducted a large-scale twin study and found that dispositional traits explained one-third of the variance in flow proneness. These findings are consistent with Csikszentmihalyi's (1997) concept of an autotelic personality. Autotelic individuals have a high “need to seek difficulty…and the ability to master it” (Baumann, 2021, p. 237). Empirical research confirms that both high achievement motivation and strong self-regulatory skills moderate the emergence of flow from a skill-demand-balance (e.g., Eisenberger et al., 2005; Engeser & Rheinberg, 2008; Keller & Bless, 2008). Thus, some people may be more responsive to flow-promoting interventions or already seek out flow-fostering conditions on their own

(Baumann, 2021). Therefore, Wilson and Moneta (2016) argue that training a person to believe in her ability to self-regulate flow helps her to experience flow. However, facilitating long-term counterdispositional behaviors through interventions is more complex than inducing situational changes (Rebele et al., 2021). We will elaborate on this when we discuss the practical implications and limitations of our framework.

2.3.2.2 Targeting the Context

To establish a person-environment fit, one can also target the other side, i.e., the situational context. One of the most prominent models on the influence of the job design is the Job Characteristics Model (JCM; Hackman & Oldham, 1975), which conceptualizes how contextual variables on a job and task level induce psychological states and thereby cause different work-related outcomes. Specifically, it differentiates five job characteristics (skill variety, task identity, task significance, autonomy, and feedback) that lead to certain psychological states (e.g., experienced meaningfulness of work). These psychological states then determine, for example, job satisfaction and performance. Maeran and Cangiano (2013) incorporated flow as one of the psychological states in the JCM and showed that job characteristics, especially feedback and task significance, predict flow at work (see also Engeser & Rheinberg, 2008; Hohnemann et al., 2022; Peifer et al., 2020). Hence, flow-promoting interventions that intentionally shape these characteristics should be effective for fostering flow at work. However, to date, no study has evaluated this as a work intervention. Importantly, the feasibility of interventions targeting the context reaches beyond the initiative of the management. The aforementioned job crafting is a perfect example of an intervention that allows a person to change their perceived job significance without requiring the organization's commitment. Further experimental studies confirm that not only contextual changes at the job and task level, but also configurations of the setting, such as working in a virtual reality environment or in a closed compared to an open office, can increase flow (Ruvimova et al., 2020; Schutte, 2020). The social and organizational context also plays an important role in the occurrence of flow (Peifer & Wolters, 2021). For example, since focused concentration is one of the core attributes of flow, blocking interruptions from coworkers could be an effective strategy for fostering flow. However, current presence of others does not necessarily interfere with flow (Walker, 2021). In the next paragraph, we

will elaborate on how promoting interactive teamwork by targeting the group rather than the individual can further enhance flow at work.

2.3.2.3 Targeting the Group

Work by its very nature involves social situations, i.e., people are constantly interacting with others at work. While solitary flow is characterized by the absence of interruptions by others, social flow (also called group or team flow) is a collective, interactive state (van den Hout et al., 2016; Walker, 2021) that "occurs because of the presence of others" (Walker, 2021, p. 264). The emergence of social flow largely depends on situational characteristics (Knierim et al., 2019; Walker, 2021) and can therefore be targeted independently of individual traits. Previous research suggests that flow is not only more intense in interactive compared to solitary tasks (Magyaródi & Oláh, 2017) but also perceived as more enjoyable (Walker, 2010). Hence, facilitating a collective flow experience for all group members may be particularly fruitful for promoting work performance, creativity, and intrinsic motivation (van den Hout et al., 2016; Walker, 2010). Social flow builds on the antecedents and attributes of individual flow, but comes with additional prerequisites, such as perceived psychological safety, or strong identification with the common goal in the group (van den Hout et al., 2016; Walker, 2021). Thus, targeting the group goes beyond the aforementioned individual or contextual targets for fostering flow. Group-targeting flow-promoting interventions should first generally increase opportunities for social flow by assigning shared tasks with high interdependence among group members (Aubé et al., 2014; Walker, 2010, 2021). In addition, interventions could apply team goal-setting strategies to increase commitment to common goals (Aubé et al., 2014), or facilitate role clarification to enable effective task division (Shuffler et al., 2011). Basing rewards on team rather than individual performance or rewarding strong social networks among employees may also provide strategies for reinforcing social flow (Aubé et al., 2014; May et al., 2004; Newman et al., 2017; Walker, 2021).

In sum, each component of the sequence of experiencing flow bears individual, contextual and group-related targets. Thus, interventions with either target can be applied for each aim, i.e., for entering, boosting, or maintaining flow. Of note, all targets should be considered as having equivalent weight. First, there is a necessary fit of the context and the individual as

one precondition of flow. Thus, changes on either side (context or individual) can establish this fit because both can be adjusted to the given state of the other. Besides that, targeting the group further fosters flow by facilitating collective flow experiences.

2.3.3 Executors of Flow-Promoting Interventions

Given the hierarchical dependencies common in the workplace, one may argue that often only management is entitled to employ intervention changes. This assignment of the worker to the role of a passive recipient, rather than an active agent, greatly restricts the applicability of flow-promoting interventions at work. However, Bakker and van Woerkom (2017) have proposed the Self-Determination Theory of Flow, arguing that a person can also shape the job and tasks on their own responsibility, thereby allowing them to proactively foster their flow. Hence, in the following paragraphs we introduce a third dimension for classifying flow-promoting interventions at work, the intervention executor (Figure 5). In doing so, we build on a review that distinguishes between bottom-up and top-down interventions to increase work engagement (Knight et al., 2019). Proactive initiative of the respective individual characterizes bottom-up interventions, whereas the management applies top-down interventions in a larger organizational context (Hornung et al., 2010).

2.3.3.1 Top-down Execution

Traditionally, interventions at work have been initiated in a top-down manner and were mostly oriented towards increases in work performance (Hornung et al., 2010). However, with the current rise of a people-centric organization, managers have increasingly sought to enable workplaces that also promote individual well-being. With regard to targeting the context, management could, for example, instantiate the aforementioned job characteristics that have been found to predict flow, such as feedback or task significance (Engeser & Rheinberg, 2008; Hohnemann et al., 2022; Maeran & Cangiano, 2013; Peifer et al., 2020). Also, de Sampaio Barros et al. (2018) propose that enhancing autonomy increases the subjective importance of the task. Thus, by allowing the person to work on a task of her own choice, the organization could grant a higher level of autonomy, thereby fostering flow. Besides, organizations could provide quiet workspaces that prevent interruptions, thereby allowing the person to fully focus on their tasks (Rissler et al., 2017). In addition to employing such contextual changes, organizations could target the individual directly, for

example, by offering coaching or teaching. This enables enhancements in the skills of the respective person, thereby allowing them to meet the job demands. By encouraging teamwork and fostering information exchange in interdependent tasks (i.e., targeting the group), organizations can also facilitate the emergence of social flow. In sum, because top-down interventions can be directed at the antecedents (e.g., by assigning challenging but achievable tasks), moderators (e.g., by providing performance-based rewards; Peifer & Engeser, 2021), or at the flow state itself (e.g., by blocking interruptions through adaptive information systems; Rissler et al., 2017; Zueger et al., 2017), they can be implemented not only for each target (i.e., individual, group, or context), but also for each aim (i.e., entering, boosting or maintaining) of fostering flow at work.

2.3.3.2 Bottom-up Execution

Analogous to these top-down approaches, we have already discussed examples of bottom-up interventions with contextual, individual, and group targets. For targeting the context, the strategy of strengths use is a promising tool for fostering flow that transfers the agency to the individual (van Woerkom et al., 2016). It involves the identification of tasks within the given scope of the job that allow the application of individual strengths. In doing so, it induces a subjectively experienced skill-demand-balance, which is a major precondition of flow. Moreover, these strengths use interventions can also target the individual by supporting the person identify their individual strengths in the first place. Indeed, strengths use has been found to be associated with flow at work (Liu et al., 2021). To date, strengths use interventions have only been evaluated with regard to flow-related concepts, such as work engagement (Bakker & van Wingerden, 2020; Donaldson et al., 2019). Work engagement is a positive state of vigor, dedication, and absorption in the task (Schaufeli et al., 2006). Even though it closely resembles flow, it is a more perseverant state that lacks the peak experience characteristic of flow (Hallberg & Schaufeli, 2006; Schaufeli et al., 2006). Hence, while strengths use strategies appear to be promising tools for fostering flow, they still need to be empirically evaluated for accomplishing this goal. As top-down interventions, bottom-up approaches can be implemented for all aims, but there is a peculiarity with regard to the aim of maintaining flow. As discussed, interventions with this aim apply when the person is currently experiencing flow. Since flow is characterized by complete absorption in the task (Nakamura & Csikszentmihalyi, 2012), any conscious activity unrelated to

that task would immediately disrupt the person's flow. Behavioral and neurophysiological evidence, however, shows that highly automated, habitual tasks can be performed without distraction from the actual task (Lisman & Sternberg, 2013). Hence, bottom-up interventions can be used for the aim of maintaining flow, but only if the respective person has learned to execute them before entering flow. For example, they could learn to adaptively increase the height of their standing desk. Thereby, they could modulate their neurophysiological activation (Labonté-LeMoyne et al., 2020) to maintain the optimal physiological activation for flow (Peifer & Tan, 2021). However, this would only be an efficient strategy for maintaining flow if they had learned to do this without directing their attention to it.

In sum, we believe that it is important to investigate both bottom-up and top-down interventions because this empowers individuals and organizations alike. As described above, both types of executors can apply interventions with regard to each aim and target, i.e., across the other two dimensions of our framework.

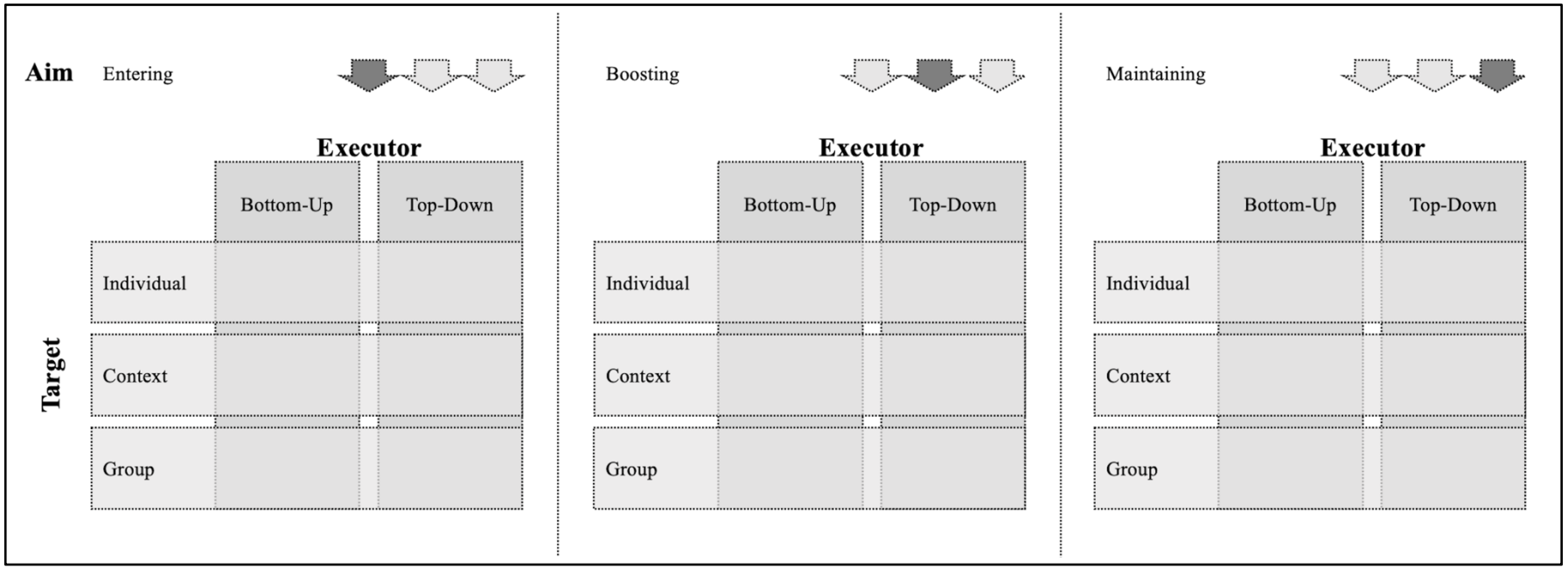

Figure 5 The second and third dimension of the framework for flow-promoting interventions at work

2.4 Discussion

In this chapter, we propose a three-dimensional framework for fostering flow at work based on a narrative review of research on the sequence of experiencing flow. Our framework classifies flow-promoting interventions by distinguishing between the dimensions of the intervention aim (entering, boosting, or maintaining flow), target (context, individual, or group), and executor (top-down or bottom-up). We sourced our proposals by showing how primary empirical studies and conceptual proposals for intervention strategies fit into the framework's structure. In the following paragraphs, we will further discuss how our framework contributes to research and practice by providing concrete recommendations for its theoretical and practical application.

2.4.1 Theoretical Implications

Our framework contributes to the literature on flow at work in three major ways. As a first contribution, it provides a structure for developing flow-promoting interventions by equipping researchers with three guiding questions (Table 1). First, researchers should answer what the goal of the intervention is, i.e., whether the intervention aims to support people who are not experiencing flow at all in their current work situation, to enable deeper or more frequent flow experiences, or to help sustain flow. This is consistent with the idea of programme theory, i.e., "developing a causal modal linking programme inputs and activities to a chain of intended or observed outcomes, and then using this model to guide the evaluation " (Rogers, 2008, p. 30). Clearly identifying the aim of an intervention and how it can achieve that aim in a particular setting is a key step in intervention development (O'Cathain et al., 2019). Second, researchers should consider what kinds of changes are possible in the workplace they are focusing on, specifically whether it is possible to modify external factors related to the work setting or the job itself. Finally, researchers need to answer whether they want to develop a strategy for implementation by the management or by the individual worker. It is important to consider not only the likelihood of change in a particular organization, but also whether the intervention will be applied across a number of organizations. This question also determines the potential impact of an intervention, because organizational efforts are directed at large-scale change, whereas bottom-up execution requires educating each individual to adopt the intervention strategy (Hornung et al.,

2010). However, a review of the impact of interventions on the flow-related concept of work engagement found that bottom-up interventions were more effective than top-down ones (Donaldson et al., 2019). The authors argue that this may be due to a greater likelihood of implementation errors in top-down approaches and a lack of individual autonomy. Nevertheless, bottom-up execution may be limited in its effect because individuals can only change their immediate environment (Donaldson et al., 2019). Since this limitation exists even if each person were to target her group, a combination of both bottom-up and top-down initiatives may be most effective in inducing change (Hornung et al., 2010).

In addition to providing these guiding questions for intervention design decisions, our framework also demonstrates a concrete research agenda for future studies on flow-promoting interventions. Because it would not be helpful to design interventions to maintain flow if a person is not experiencing flow at all in their current job, our framework highlights the importance of first establishing the antecedents. In line with the initial empirical studies of flow, which assumed that flow could only be experienced if the antecedent of a skill-demand-balance was present (Csikszentmihalyi & LeFevre, 1989), we argue for a thorough evaluation of the state of the antecedents before implementing an intervention. This is particularly important to avoid misleading interpretations of intervention effectiveness evaluations. For example, the lack of a significant effect of an intervention aimed at the attributes of flow (i.e., aiming for maintaining flow) could be due to the actual ineffectiveness of the intervention, but also to the absence of one of the three flow antecedents. Hence, researchers should not only design flow-promoting interventions that first aim to establish the antecedents, but then also carefully ensure that all antecedents are consistently met when evaluating interventions to boost or maintain flow.

	Guiding questions	Options	Important considerations
1st dimension	What does the intervention aim for?	Entering, Boosting, Maintaining	Current flow state
2nd dimension	What does the intervention target?	Context, Individual, Group	Fix variables; Organizational restrictions
3rd dimension	Who executes the intervention?	Top-down, Bottom-up	Scope of impact; Comprehensiveness versus organizational specificity

Table 1 Guiding questions for developing flow-promoting interventions

Finally, our framework sheds light on when interventions can increase the duration, intensity, or frequency of flow. This provides researchers with guidance on which flow operationalization to use when evaluating the effectiveness of an intervention. As noted above, we adopt flow as a yes-or-no continuous phenomenon (Peifer & Engeser, 2021), such that the presence of the antecedents determines whether flow can occur at all. Thus, interventions that attempt to establish these antecedents may influence the frequency and total duration of flow experiences. It is important to note that earlier empirical studies have often adopted an exclusively continuous flow operationalization to evaluate flow-promoting interventions and then analyzed increases in flow intensity (e.g., Weintraub et al., 2021). However, this does not allow conclusions about whether an intervention supports entry into flow in the first place (i.e., crossing the threshold from nonflow to flow). Therefore, evaluations of the effectiveness of interventions that target the antecedents of flow should rather use a discrete flow measure (e.g., the Flow Questionnaire, FQ; Csikszentmihalyi & Csikszentmihalyi, 1988) to make inferences about the transition from nonflow to flow states. In contrast, interventions that modulate the moderators should be evaluated using a combination of continuous and discrete flow measures. Specifically, they should apply continuous flow measures only when a discrete flow measure indicates a flow state (Peifer & Engeser, 2021). This makes it possible to assess whether the moderator-directed intervention strengthens the relationship between the presence of the antecedents and the occurrence of flow, either by increasing the likelihood of transgression to flow, i.e., the frequency of flow experiences (assuming the antecedents are met), or by increasing the intensity (assuming the person actually experiences flow). For example, Engeser and Rheinberg (2008) applied the continuous FKS to show that a skill-demand-balance leads to a high flow intensity when the task is perceived as important. Applying an additional categorical flow measure could provide further insight into whether increasing task importance is helpful in facilitating the emergence of flow from a skill-demand-balance. As we have argued, interventions that occur when a person is currently in flow cannot affect the total frequency of flow experiences (i.e., how often the person enters flow), but rather modulate the intensity and the duration of the current flow experience. Thus, we have argued that these interventions aim for maintaining flow. Although continuous measures alone can capture changes in flow intensity (Abuhamdeh, 2020), researchers should also assess the effectiveness of these interventions using the combination of continuous and discrete flow measures

discussed above. For example, Collins et al. (2009) assessed flow intensity only on days when participants reported the presence of flow. Hence, our proposed dimension of the intervention aim directly corresponds to the person's current flow state and, together, provides the guiding principle for how changes in flow due to an intervention should be assessed.

2.4.2 An Exemplary Application of the Framework in Research

To substantiate our aforementioned theoretical contributions with concrete guidance for the scientific field, we would like to provide an example. Imagine a researcher who decides to investigate how reducing interruptions at work fosters flow. This approach directly relates to the flow characteristic of high concentration. Hence, we can infer from our framework that the aim is to maintain flow. This aim presumes that the antecedents are fulfilled. Therefore, we recommend testing this assumption first. To do this, the researcher should conduct a pilot study that examines the presence of the antecedents in the particular setting. If a pilot study is not feasible, the researcher should at least include a control questionnaire that asks about the status of the antecedents. Next, the researcher considers the actual intervention strategy in terms of its target. A straightforward intervention to reduce interruptions for focused immersion in a task would be to target the environment by providing isolated workstations. Suppose, however, that given spatial allocations limit these changes. So the researcher decides to target the employees instead. To do so, they design a tool that helps schedule tasks depending on when the office is least busy. Lastly, the researcher considers the third dimension, the executor, which directly relates to the potential scope of the application. Since they want to evaluate the effectiveness of their tool across organizations, they decide to recruit teams from different organizations and ask the management to provide the tool for the employees as a top-down intervention. Lastly, to evaluate the intervention's effect on flow, the researcher can follow from the aim of maintaining flow that they should use a combination of a discrete and a continuous measure, e.g., a combination of the FQ with the FKS as proposed by Peifer and Engeser (2021). As you can see from this example, following the three guiding questions (Table 1) points the researcher to necessary considerations and equips them with concrete instructions for meeting constraints and evaluating the effectiveness of their study.

2.4.3 Practical Implications

In addition to the theoretical contributions and implications for researchers, our framework also bears implications for practitioners. As proposed for flow researchers, organizations that want to increase the flow experiences of their employees should first and foremost strive to meet the three flow antecedents. If these antecedents are not met, efforts to increase flow will always fall short. In addition to initiating contextual changes (e.g., assigning different tasks), managers should target the individual person, for example, by providing autonomy in task choice, offering opportunities for self-learning, or allowing employees to set individual goals. Targeting the group rather than the individual may be especially promising for organizational efforts, as it allows influencing more than one person at a time. Especially with regard to today's common collaboration in virtual teams, increasing social flow, for example by strengthening collective goal commitment or trust between group members, is important to enhance performance (Aubé et al., 2014; Breuer et al., 2016). In addition to group targeting as an effective top-down approach, this approach can also be part of bottom-up initiatives. When individuals themselves apply group-targeted strategies, they not only foster their own flow, but this effect is also transmitted to their team members. In this way, a bottom-up, group-targeted intervention becomes a time- and cost-efficient tool for enabling change on a larger scale. Generally, our framework highlights that individuals can self-initially build up their flow experiences. Hence, managers should empower their employees to take responsibility for their flow by educating them about the beneficial effects of flow and potential flow-fostering strategies. Importantly though, this does not absolve organizations from their responsibility to creating the necessary foundations for flow to arise.

As mentioned before, "individuals greatly differ in the need to seek and in the ability to create flow experiences" (Baumann, 2021, p. 251). This can lead to frustrated reactions to flow-promoting interventions (e.g., reward systems based on flow experiences) by persons high and low in flow proneness. For instance, employees who do not experience flow easily may feel discriminated against by these reward systems. Therefore, employment protection policies need to establish guidelines for recognizing individual baselines. That said, the use of extrinsic rewards for flow may also negatively affect individuals who self-initiate tasks that allow them to experience flow. Since these individuals are already intrinsically

motivated, the extrinsic reward could undermine their motivation (Deci et al., 1999). Thus, practitioners should always begin with an analysis of the status quo of flow experiences in their target group. As part of this initial assessment, they should also analyze whether flow is mostly experienced in solitary or interactive tasks. This will help determine if and in what situations individuals are already experiencing high flow. If they experience flow only when working alone, it may be promising to address group-related targets, such as assigning interdependent tasks, for fostering social flow. In contrast, if there is high interindividual variability in flow, it would be more appropriate to use an individualized approach that targets each person directly.

Since flow at work not only improves performance, but also increases individual job satisfaction and general well-being (Peifer & Wolters, 2021), it is of great societal interest to foster flow across work domains. To this end, our framework also provides a starting point for training initiatives in education that go beyond educating managers to empower their employees. For example, by applying strengths use interventions and promoting self-regulation skills in adolescents, schools can already help students with choosing work domains that allow them to experience flow more often.

2.4.4 Limitations and Avenues for Future Research

As with any model, our framework entails certain limitations. First, we aimed to generate a framework with strong heuristic value, thus minimizing the number of dimensions for classification. However, this meant neglecting other potential dimensions, such as the targeted timeframe. In order to provide flow-specific guidance, we also omitted classifications related to general intervention format, such as type of delivery (e.g., web-based, paper-based). Although we recognize the resulting loss of an all-encompassing classification, we strongly advocate that future research first focus on developing flow-promoting interventions with careful consideration of content. Only then should they investigate whether the effectiveness of an intervention changes due to modulations in format. By that, the effectiveness of a specific intervention can be validated without confounding it with format-related influences.

A second limitation of our framework emerges from the theoretical overlap between flow and other work-related concepts (e.g., work engagement). Because of this overlap, future empirical research may find that strategies for fostering these concepts are largely similar to those for flow. However, since flow is not synonymous with these concepts, especially in terms of its conceptualization as an optimal state, we do not assume that any intervention for similar concepts could induce this particular experience. Nevertheless, we suggest evaluating the influence of a flow-promoting intervention on closely related concepts as well. Since organizations cannot implement an infinite number of interventions due to limitations in resources and time, strategies that simultaneously affect more than one desirable outcome are especially likely to be applied in the workplace.

Third, the proposition to implement flow-promoting interventions from the bottom-up could be interpreted as implying that the person is responsible for not experiencing flow. They would then be to blame for missing out on the benefits associated with flow. This assumption is one of the most harmful interpretations of strategies that stress the importance of individual agency because it completely ignores the causal strength of contextual factors (e.g., socioeconomic status). Their constitution can impede a person's well-being regardless of how much effort that person puts into improving their state. Thus, the categories of our framework's dimensions should not be interpreted as a range of options from which researchers or practitioners should choose only one. Instead, strategies for fostering flow can only help if they are part of a comprehensive approach that targets each side of the coin.

Fourth, successfully fostering flow is not necessarily a morally good thing, especially if flow is experienced in unethical activities (Zimanyi & Schüler, 2021). Independent of the specific task, flow does not have only beneficial effects, but also bears certain dangers (for a full discussion of potential harms, see Zimanyi & Schüler, 2021). For example, in order to experience a balance between skills and demands at work, a person needs to tackle challenging tasks. This increases the likelihood of making mistakes because failure to achieve this balance can result in a state of excessive demand. Also, although flow feels effortless (Moller et al., 2013), it is an energy-consuming state that can lead to severe exhaustion (Zimanyi & Schüler, 2021). In particular, if an organization strongly promotes flow-promoting interventions, this will probably exert pressure on employees because it implies that

they should be in flow all the time. However, since flow is an optimal state, this is neither likely nor desirable. Also, since flow is an intrinsically motivating state, experiencing it in certain tasks may incline a person to neglect other tasks. Thereby, flow can resemble and be conducive to addiction (Zimanyi & Schüler, 2021). Hence, organizations and individuals should refrain from concluding that flow should be fostered at all costs, but rather carefully evaluate when and why flow experiences are desirable.

Lastly, flow is a highly fluctuating state with significant individual and situational variability (Ceja & Navarro, 2011; Fullagar & Kelloway, 2009). Hence, an overarching framework for systematizing flow-promoting interventions may neglect the fact that flow-fostering strategies need to be adaptive to the individual and the situation. This does not only relate to the already discussed differences in general flow proneness. For example, although flow at work is associated with higher energy levels in leisure time (a strong individual benefit), this depends on whether the person succeeds at psychologically detaching from work at home (Demerouti et al., 2012). Similarly, whether a person has a harmonious or obsessive passion for a task (Vallerand, 2015) determines the relationship of that task with experiencing flow, as well as detrimental effects on experiencing flow in other tasks (Carpentier et al., 2012). As discussed above, interventions that apply when a person is currently experiencing flow, may even immediately disrupt the experience. Hence, it is not only ineffective, but potentially harmful to apply similar interventions across individuals and situations. We thus encourage future research to develop flow-promoting interventions with adaptive mechanisms that, for example, only apply when a person is not currently in flow. The detection of (neuro-)physiological correlates of flow (for a review see Peifer & Tan, 2021) as objective and high-frequency flow markers for real-time measurements is a promising starting point to enable these adaptive mechanisms.

2.5 Conclusion

In sum, we have proposed a three-dimensional framework with strong heuristic value that allows the systematization of flow-promoting interventions according to their specific aim, target, and executor. We advocate that future research should first develop interventions to establish the antecedents of flow before moving on to the inherent attributes of flow experiences. By acknowledging the individual and situational variability of flow, we emphasize the importance of developing adaptive mechanisms in the application of interventions. While being in flow all the time cannot and should not be the ultimate goal, we believe that these adaptive flow-promoting interventions will ultimately increase organizational performance and help individuals thrive at work.

CHAPTER 3

Capturing Flow in Everyday Knowledge Work

This chapter is based on a manuscript entitled “Capturing Flow Experiences in Everyday Life: A Comparison of Recall and Momentary Measurement” that was under review when this dissertation was submitted to the examination committee. A revised, peer-reviewed version of this manuscript has been published in the Journal of Happiness Studies under a Creative Commons Attribution 4.0 International License (https://creativecommons.org/licenses/by/4.0/). The article was co-authored by Dr. Michael T. Knierim, Prof. Dr. Christof Weinhardt, Prof. Dr. Gabriele Oettingen, and Prof. Dr. Ulrich Ebner-Priemer.

Tables, figures, and appendices have been systematically renamed, reformatted, and appropriately referenced to conform to the overall structure of the dissertation. To further improve clarity and consistency, wording, formatting, and referencing style were adjusted and references were updated. The supplementary material of the manuscript can be found in Appendix A2.

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3.1 Introduction

Flow, the experience of complete absorption and fluency in the current activity (Engeser & Rheinberg, 2008), arises when skills and demands are perfectly balanced (Csikszentmihalyi, 1975; Moneta, 2021; Peifer & Engeser, 2021). Since flow is associated with positive outcomes on an individual, task-related, and social level (e.g., increases in job satisfaction, seeking supporting resources, or improved team cohesion, Peifer & Wolters, 2021), research has already begun to explore strategies for increasing flow in everyday life (e.g., teaching goal setting, Weintraub et al., 2021). Importantly, flow states vary greatly depending on time, situation, and personal characteristics (Ceja & Navarro, 2011; Fullagar & Kelloway, 2009; Nielsen & Cleal, 2010; Tse et al., 2021). Due to this high volatility in flow states, flow-promoting interventions need individualized formats, i.e., they need to become adaptive. Flow-promoting interventions with adaptive mechanisms could tailor to differences between persons (e.g., only target people who do not experience flow at work) and individual states (e.g., not interrupt a person if they are already in flow), as implemented in JITAIs in general (Nahum-Shani et al., 2018). For building flow-promoting interventions with adaptive mechanisms, researchers first need to be able to capture flow fluctuations in everyday life without interrupting flow experiences altogether. For that, researchers have to make decisions not only about the operationalization of the target concept, i.e., flow, but also about the general measurement method for capturing everyday states in real-time. In the following sections of the introduction, we will present theoretical literature and previous empirical research on both of these aspects before we dive more deeply into the aim and concept of the present study.

It is important to note the ongoing debate about how flow can be best conceptualized (Abuhamdeh 2020; Peifer et al., 2022). In this article, we adopt flow as a state of high concentration and sense of control, merging of action and awareness, loss of self-consciousness, and distorted temporal experience (Nakamura & Csikszentmihalyi, 2012) based on its original conceptualization by Csikszentmihalyi (1975). According to Engeser and Rheinberg (2008), we posit that these flow characteristics can be condensed into the flow components of fluency and absorption. These two components should be differentiated from the primary flow precondition of a balance between skills and demands. Although flow can be a

gratifying and enjoyable experience (known as an autotelic experience) (Abuhamdeh, 2020, Peifer et al., 2022), earlier research suggests that these affective and motivational components of flow do not appear similarly across different domains (Bassi & Delle Fave, 2012; Csikszentmihalyi & LeFevre, 1989; Delle Fave & Massimini, 2005). Experiencing flow in both productive and leisurely activities involves cognitive components such as feeling in control (Bassi & Delle Fave, 2012; Delle Fave & Massimini, 2005). On the contrary, leisurely activities are associated with a stronger autotelic experience next to the cognitive components (Delle Fave & Massimini, 2005). Therefore, in this study, we operationalize flow by measuring fluency and absorption as the core cognitive components of flow experiences.

3.1.1 Measurement Methods for Everyday States

Even though flow is not conceptualized as an affective state per se (Engeser et al., 2021), it has originally been investigated alongside affect using measurement methods for everyday states (Csikszentmihalyi & Larson, 1987). Hence, in the following we will discuss the benefits and limitations of these measurement methods for inferring flow. Researchers have used different terms to describe measurement methods for quantifying individual states in everyday life (e.g., experience sampling method, Csikszentmihalyi & Larson, 1987; ecological momentary assessment, Stone et al., 2002). We adopt ambulatory assessment (AA, Fahrenberg et al., 2007; Wilhelm et al., 2012) as an umbrella term for the nowadays mostly digitized versions of methods for measuring everyday experiences (Trull & Ebner-Priemer, 2014). Even though AA can be targeted at measuring objective markers of individual states, such as neurophysiological correlates, we focus on use of self-reports to capture the subjective experience of flow.

When using self-reports, AA can differ in terms of the observation approach. The observation approach defines the reference that self-reports pertain to (e.g., the last hour), thereby determining how conclusions about the total observation period (e.g., one day) can be reached. There are two options for the observation approach: Participants can provide self-reports about their current state, i.e., momentarily, or about very recent experiences, i.e., by recall (Trull & Ebner-Priemer, 2014). In assessment of momentary states, participants are prompted repeatedly across the day to report on their current state (Csikszentmihalyi &

Larson, 2014). If these prompts are distributed randomly over time, it is possible to generalize about all experiences over the entire time period. This approach can be compared to taking a random sample from a larger population and then extrapolating the sample-based findings to the entire population. A set of empirical flow studies have already used this approach building on the original work of Csikszentmihalyi and Larson (1987). In these studies, researchers sent queries randomly in time with a fixed total study duration and amount of observations per day (e.g., Engeser & Baumann, 2016; Johnson et al., 2014). Alternatively, they collected information about each participant's individual working hours and sent queries during those exact times (Fullagar & Kelloway, 2009). Importantly, asking about momentary flow does not necessarily include randomization of observations. For example, Rivkin et al. (2018) asked participants about their current task absorption once per day at noon over the course of ten working days. However, dismissing the randomization impedes generalizations to the full observation period.

In general, inquiring about momentary states bears strong advantages for assessing flow. First, it diminishes retrospective memory biases, thereby allowing to capture the experiential nature of the current state (Lucas et al., 2021; Robinson & Clore, 2002). Second, retrospectively recalling individual fluctuations in flow levels, i.e., recalling whether flow intensity varied across the recall period, is difficult for participants. Indeed, research shows that within-subjects variability is higher when using assessment of momentary states compared to recall (Diener & Tay, 2014). Nevertheless, capturing momentary states of flow does not come without downsides. For example, flow has been conceptualized as an optimal state (Nakamura & Csikszentmihalyi, 2012) that individuals may only occasionally experience during the day (Ceja & Navarro, 2011). Random momentary observations might accidentally miss these occasions. Most importantly, flow is a state of high concentration and immersion (Nakamura & Csikszentmihalyi, 2012). Thus, frequent prompts for providing self-reports about the current state might disrupt momentary flow. Then, the assessment of flow would be heavily biased, in that the measurement itself would lead to decreases in flow.

AA that captures the observation period by use of recall alleviates some of these challenges. The coverage approach enables conclusions about individual states by retrospective recall

not of the full time period (as in traditional trait questionnaires) but by dividing the full observation period into blocks. For example, in a study by Collins et al. (2009), participants reported retrospectively in the evening whether they had experienced flow on that day across ten days in total. By that, the authors avoided the problem of missing scarce states. Similarly, in Kahneman et al.'s (2004) Day Reconstruction Method, participants divide the previous day into activity-related episodes and report how they felt at that time. The major issue with recall is that the experiential nature of a momentary experience can never actually be relived (Robinson & Clore, 2002). This is due to the fact that recall is not only influenced by current emotions or general traits (Levine & Safer, 2002), but also by memory. First, episodic memory shapes our recollections in a way that introduces bias. This is due to the fact that significant moments have a greater impact on how we retrospectively rate our emotional experiences (Robinson & Clore, 2002). Second, biases linked to semantic memory emerge as episodic details become less available over time. This results in an elevated trust in beliefs about emotions, ultimately distorting the way memories are recalled (Robinson & Clore, 2002). According to Robinson and Clore (2002), these beliefs can be normative (e.g., "One needs to be concentrated at work"), but also situation-specific (e.g., "Performing chores is boring") or identity-related (e.g., "I am easily stressed"). These beliefs may not be true. For example, one might intuitively believe that flow is more prominent during leisure than during work. Based on this belief, one might overestimate one's flow during leisure, especially when compared to work tasks. However, research suggests the opposite, i.e., higher levels of flow during work than during leisure (Csikszentmihalyi & LeFevre, 1989; Engeser & Baumann, 2016). In other words, the generalized belief about common flow-inducing activities may bias the recall of the actual experience. Hence, choice of the observation approach (i.e., assessing momentary states or using coverage) does not only depend on the aforementioned (dis-)advantages of the respective options in general, but also requires considerations with regard to the specific concept under investigation, here flow.

3.1.2 Operationalizing Flow in Ambulatory Assessment

Initially, the subjective experience of flow was operationalized by asking participants about the challenges and skills in their current activity multiple times per day for a week. The scores for challenges and skills were z-standardized and the weekly average was calculated

for each participant. The researchers assumed that a participant was in a state of flow during each observation in which both their scores (i.e., for challenges and skills) exceeded their average and in which their scores matched (i.e., when participants rated challenges and skills similarly) (Csikszentmihalyi & LeFevre, 1989; Csikszentmihalyi & Larson, 1987; see Moneta, 2021, for an overview of this so-called quadrant model and its further advancement). Some empirical research still builds on this original operationalization, e.g., in studies with nurses (Bringsén et al., 2011) or students (Johnson et al., 2014). However, flow researchers now commonly agree that inferring flow solely based on the presence of a skill-demand-balance does not holistically capture the state and conflates the precondition of a skill-demand-balance and the inherent characteristics of flow (Moneta, 2021). Therefore, later empirical studies built on the approach of assessing momentary states but applied questionnaires operationalizing flow as a multi-componential concept, e.g. the FKS (Engeser &, 2008; Rheinberg, 2015), the Flow State Scale (Jackson & Eklund, 2002; Jackson & Marsh, 1996) or the Work-Related Flow Inventory (Bakker, 2008). These componential measures differ in their domain specificity and their underlying flow concept, i.e., in whether they integrate affective and motivational flow components. For example, the Flow State Scale acknowledges whether flow was perceived as intrinsically motivating, while the FKS only integrates the flow components of fluency and absorption. Since these componential operationalizations turn flow into a continuous construct by calculating the flow score as a mean across items, they might impose flow on a person even if they would not report a flow experience themselves (Abuhamdeh, 2020). For example, this could be due to reports of high task absorption that increase the mean flow score while other flow components are actually absent in that particular moment. A measure for capturing flow in everyday activities that allows a dichotomization, in that a person could be either in flow or not experience it altogether, while incorporating characteristics of flow experiences apart from skill-demand-balance, is the FQ (Csikszentmihalyi & Csikszentmihalyi, 1988). For example, Collins et al. (2009) applied an adapted version of the FQ that showed two quotes describing flow to participants at the end of each day asking whether they had experienced a similar state on that day. However, the FQ was criticized because its quotes address mostly the absorption component of flow (Moneta, 2021). Importantly, both operationalizations, i.e., measuring flow continuously or categorically, allow different interpretations. Continuous scores indicate flow intensity, whereas dichotomic results can be used to infer flow

presence, thereby indicating probability of flow states. Thus, adopting flow as a yes-or-no continuous phenomenon using a combination of both operationalizations is a meaningful integration that has been called for in recent theoretical outlines (Peifer & Engeser, 2021). This combination implies that an individual can experience flow or not, and if they do, the intensity of flow may vary (Peifer & Engeser, 2021). The combined operationalization simplifies the development of flow-promoting interventions with adaptive mechanisms by enabling the identification of the appropriate time for intervention (e.g., when an individual is not experiencing flow at all, or when they are, but flow intensity is low) and the anticipated impact of the intervention on flow. The anticipated impact determines which intervention to use. In order to increase the probability of flow experiences, the flow preconditions must be established. To increase flow intensity, moderating variables could be modulated (see Chapter 2; Bartholomeyczik et al., 2023).

3.1.3 The Present Research

In the present chapter, we build on the aforementioned literature on measuring flow with AA covering three exploratory research questions. The first aim of our study is to explore how capturing momentary states compared to using coverage in AA influences participants' flow reports, compliance, and perceived burden. More specifically, we aim for comparing assessment of momentary states with recall of the time period since the last observation. For both approaches, we use repeated observations per day. Thereby, we increase closeness in time between the reference and the self-report in the coverage approach to limit memory biases due to recall (Robinson & Clore, 2002). This is especially important since time is experienced in a distorted way during flow (Nakamura & Csikszentmihalyi, 2014). For example, if a person feels like time has been flying today, this might cause them to report high levels of flow for the full day when asked about only once in the evening, even though they might have experienced high levels of flow only in the morning. To ensure that both observation approaches cover the same observation period, we schedule the repeated observations differently depending on the approach. For the momentary states approach, we randomize the observations in time to be able to generalize to the entire observation period. In the coverage approach, we schedule the observations in fixed time intervals assuming that it is easier to recall what one has done since a certain time of day than since the last observation query. It is important to note that the differences in sampling (fixed versus

random) do not represent an additional manipulation, but rather are inherent to the observation approaches (momentary states versus coverage) used to draw conclusions about similar time periods.

As argued before, one issue with AA is its inherent interruption in current tasks. However, earlier research suggests that increases in the number of items per observation are more detrimental for compliance and biases in reports than increases in total number of observations (Eisele et al., 2022). Thus, the second aim of our study is to identify if a flow scale commonly used in AA can be shortened without negatively impacting its psychometric properties. We decided to focus on the FKS (Engeser & Rheinberg, 2008; Rheinberg, 2015) because it is a validated flow measure that can be applied across domains (Rheinberg et al., 2007). In contrast to the Flow State Scale, it captures only the flow components of fluency and absorption (without addressing the autotelic component) and does not conflate the precondition of a skill-demand-balance with the inherent characteristics of flow (Moneta, 2021; Engeser & Rheinberg, 2008). Even though the FKS has already been designed as a short measure, it still consists of ten items. In this study, we condense it to a three-item version and evaluate its within-and between-subjects reliability and validity.

The third aim of our study is to combine categorical and continuous operationalizations of flow to empirically evaluate the proposition of flow as a yes-or-no continuous phenomenon (Peifer & Engeser, 2021). Apart from keeping flow as a state of optimal experience (Abuhamdeh, 2020), this allows conclusions about flow probability and intensity, thereby allowing flow-promoting interventions directed at a particular outcome of interest. Even though we acknowledge that as part of the ongoing debate about the composition of flow (Abuhamdeh, 2020; Peifer et al., 2022) both measures have been criticized to neglect certain flow components (Moneta, 2021), we combine the FQ (categorical) with the FKS (continuous) to evaluate a novel combination of two commonly used measures. To our knowledge, only one AA study has used a similar operationalization (Collins et al., 2009). However, participants in this study only provided one self-report per day, thereby lacking information on everyday within-subject fluctuations. Using repeated observations per day as in the present work allows to overcome this limitation.

In sum, our study contributes to research on AA of flow in at least three major ways. First, we aim to provide recommendations for the choice of the observation approach, thereby supporting researchers in capturing within- and between-subjects fluctuations in flow while limiting decreases in compliance and biases in reports. Second, we reduce problematic side effects of interruptions caused by AA by developing a shorter version of a commonly applied flow scale. Lastly, we provide a first empirical examination of flow as a yes-or-no continuous phenomenon, thereby allowing to infer conclusions about flow intensity and probability.

3.2 Method

3.2.1 Participants and Procedure

We recruited participants from a pool of individuals who were compensated for their participation in online and onsite experimental studies hosted by the Karlsruhe Institute of Technology. The local data protection office and ethical committee approved the study on July 12th, 2022. Due to limited capacity of study smartphones, participants took part in the study in two waves of two weeks each. Based on power estimates from Monte Carlo simulation (Arend & Schäfer, 2019)[2], we aimed for at least 30 participants. The overall sample consisted of $N = 38$ participants ($n_{female} = 15$, $M_{age} = 23.8$, $SD_{age} = 2.7$). The majority of participants were students (97.4 %), with 63.2 % of them having a side job, except for one full-time employee. To ensure consistency in the tasks completed by participants throughout the study, we asked them to work on mental tasks (e.g., preparing for an exam, writing a final thesis, or programming code) for at least four hours per day. As aimed for, 59.1 % of the observations were reported as work. In comparison, 18.7 % were reported as leisure, 9 % as obligations, and 13.2 % as other types of tasks. In the first session (on Monday), we informed participants about the study and provided them with a smartphone (Android system) with the pre-installed app movisensXS (version 1.5.23, Movisens GmbH, Karlsruhe, Germany, 2022). After giving informed consent, participants provided demographic information. Then, smartphone-based AA took place across the following two weeks in two

[2] We consulted simulation-based estimates that acknowledged our primary interest in Level 1 effects (see section "Data Analyses" below), a target statistical power of at least .80, an expected small to medium intraclass correlation coefficient (Engeser & Baumann, 2016; Fullagar & Kelloway, 2009), and conservatively expected effect sizes (i.e., small effects) due to the exploratory nature of our study.

blocks of three days. The first block started on Tuesday morning after the first session and finished on Thursday evening (same weekdays in the second week to control for possible differences in daily schedules). On Friday in the second week, participants returned the smartphone, filled out a feedback questionnaire and provided their payment details. The reward was based on local minimum wage and contingent on how often they had answered the e-diaries. 89.5 % of participants received the full payment of 45 EUR (for answering at least 65 % of e-diaries). We provided an incentive of additional 10 EUR if more than 80 % of e-diary queries were completed. 78.9 % of participants received the additional incentive.

3.2.2 Ambulatory Assessment Procedure

Since flow involves complete absorption in the current task, we captured participants' flow with a time-based approach. Pending queries were announced via an acoustic notification on the smartphone and participants could postpone answering an e-diary query for ten minutes. E-diary queries were prompted between 9 am and 7 pm on each day[3] (according to regular local working hours). In the e-diaries, participants answered questions about their task, flow, stress, mind-wandering, skill-demand-balance, and autotelic experience. There were two within-subject conditions for the e-diary queries, *momentary states* and *coverage*. For each block of three consecutive study days, one condition remained. We randomized their order between participants to rule out sequence effects.

The conditions differed regarding the observation approach, i.e., the reference of the provided questions, which was linked to differences in observation frequencies (e-diaries to fill out per day) and type of sampling (fixed versus random timing of observations). In the momentary states condition, questions referred to the current activity, i.e., to what participants were doing right before the e-diary query. In the coverage condition, questions were asked retrospectively about the last two hours, i.e., about the time since the last alert. We chose the interval of two hours for the coverage condition in order that participants could still accurately recall their activities. Also, when we decided about the reference (i.e., the time periods the recall refers to), it is necessary to consider the estimated frequency of the variable of interest occurring. Earlier research shows that flow consistently occurs during

[3] There were also two additional questionnaires each day (at 8.30 am and 7.30 pm respectively) asking for sleep, work performance, boredom, and affect. We do not report on these variables in this chapter.

work (Engeser & Baumann, 2016). However, people are often interrupted during work, then taking them some time to get back to the initial activity (Mark et al., 2005). Thus, we opted for five e-diary queries per day in the coverage condition with fixed sampling (queries at 11 am, 1 am, 3 pm, 5 pm, 7 pm). Based on the assumption that momentary states allow generalizations about the full time period when using frequent observations with random timing, we doubled the number of e-diary queries in this condition (ten e-diary queries per day with random sampling and at least 30 minutes between two e-diary queries) to make inferences about similar time periods (i.e., 9 am to 7 pm) in both conditions. As intended, in the momentary states condition, the mean time between two observations on one day was M = 1.01 hours (SD = 0.37) with no significant difference in time of observation between days (p = .875, see Appendix 2.1). The distribution of e-diary queries throughout the day differed significantly between conditions (p < .001, see Appendix 2.1), indicating an average shift of one hour later in the time of observation in the coverage compared to the momentary states condition. On the last day of each block of three days (i.e., after each condition had been completed), a feedback query was added in the evening (at 7.30 pm) asking about subjective perception of burden in the preceding days (see Appendix 2.2 for visualization of overall sampling procedure and differences in e-diary queries between conditions).

Over all six days, participants answered N = 1508 queries (n = 1442 e-diary queries[4], n = 66 feedback queries). The mean compliance rate was M = 84.9 % (SD = 13.2) across all queries with a range from 51.1 to 100 % depending on participant. All except for one participant answered at least one e-diary query on all days[5], and at least one of the two feedback queries. Since one of the aims of our study was to assess whether the assessment of flow in everyday life would raise problems with compliance, we did not exclude participants with lower compliance. Overall, participation was highest on the first day of each block and lowest on the last day of each block.

[4] There were 6 additional observations with missing responses in the sense that participants did not complete all items. Since these observations belonged to different participants and did not occur on similar days, we assumed that they were missing at random. Thus, we treated them similarly to e-diary queries to which participants had not responded at all and excluded them from the dataset.

[5] One participant did not answer any e-diary queries on the last day of observation. As a result, this participant had the lowest compliance rate across all queries (51.1 %). We decided to keep this participant in the data analysis since they still completed more than 50 % of e-diary queries in total answering at least three e-diary queries on each of the other days.

3.2.3 Measures

Please refer to Appendix 2.9 for the exact wording of items, respective answer scales, and sources.

3.2.3.1 Flow

We operationalized flow as a yes-or-no continuous phenomenon (Peifer & Engeser, 2021) by using a continuous (FKS) and a categorical (adapted FQ) measure. In the momentary states condition, participants were asked to answer the FKS and the FQ with regard to their current activity, whereas in the coverage condition they referred to the last two hours.

The FKS asks participants to indicate their agreement with ten statements on a seven-point Likert scale from "not at all" (1) to "very much" (7) (Engeser & Rheinberg, 2008; Rheinberg, 2015). It has a two-factorial structure capturing the flow components absorption and fluency. In the coverage condition, we used the full ten item version. Due to the doubling of e-diary queries in the momentary states condition, thereby increasing time spent with answering, we used the reduced version (r-FKS) in that condition. The r-FKS consisted of the highest loading items (loadings derived from Rheinberg et al., 2003) for each of the two FKS factors, absorption and fluency (two for fluency and one for absorption according to the 2:1 ratio of items in the full version) . Specifically, the r-FKS included items 6, 8, and 9 of the original scale (e.g., "I am totally absorbed in what I am doing") (Engeser & Rheinberg, 2008; Rheinberg, 2015).[6] We computed the mean across items as an indicator for what we call *flow intensity* with higher scores indicating higher intensity.

The FQ consisted of a single dichotomic item asking participants whether they experience flow (coded as 1) or not (coded as 0), thereby providing a variable for what we call *flow presence*. In the first session, we told participants that by flow, we refer to experiences as described in these quotes (Moneta, 2012, p. 494; adapted from Csikszentmihalyi & Csikszentmihalyi, 1988): "My mind isn't wandering. I am totally involved in what I am doing, and I am not thinking of anything else. My body feels good … the world seems to

[6] The English version of the FKS (Engeser & Rheinberg, 2008) has been made publicly available for free use by Rheinberg (2015). In addition, the German scale (see Rheinberg et al., 2019; https://doi.org/10.23668/psycharchives.4488) has been shared under a Creative Commons ShareAlike 4.0 License (https://creativecommons.org/licenses/by-sa/4.0/).

be cut off from me … I am less aware of myself and my problems." "My concentration is like breathing … I never think of it … When I start, I really do shut out the world." "I am so involved in what I am doing … I don't see myself as separate from what I am doing." During AA, these quotes were not presented to the participants each time they answered the FQ. However, they were available on the smartphone by pressing the button "What is Flow?" to ensure that participants were able to access the correct definition at any time.

3.2.3.2 Task

In the momentary states condition, participants were asked to indicate their current task, whereas in the coverage condition, they reported their main task within the last two hours. The question was provided as a single-choice item with possible answers being work, obligations (e.g., laundry, grocery shopping), leisure and other.

3.2.3.3 Flow-Associated Constructs

To assess validity of the r-FKS, we also included a set of flow-associated constructs in the e-diaries. For all constructs, we used seven-point Likert scales (similarly to the FKS) and different references (current state versus the last two hours) depending on condition. First, since the FKS only captures the flow components of fluency and absorption, we used the mean across three items from Abuhamdeh and Csikszentmihalyi (2012) as an indicator for the autotelic experience: "I am enjoying myself." "I find my current activity interesting." "I find my current activity exciting." Reliability was good to excellent within- (ω = .869) and between-subjects (ω = .916). The flow precondition of a skill-demand-balance was captured by one item that allowed participants to indicate the perceived height of the demands with regard to them personally from "too low" (1) to "too high" (7) (Engeser & Rheinberg, 2008). Lastly, due to the conceptualization of flow as a state of high absorption with effortless attention (Engeser & Rheinberg, 2008; Hommel, 2010; Peifer et al., 2014), we expected stress and mind-wandering to be discriminant to flow. Since earlier work indicates that stress can be adequately captured by a single item (Elo et al., 2003; Katana et al., 2019), we used the item "I feel stressed" (Linnemann et al., 2018). Mind-wandering was measured with the two items "I was thinking about something other than my current activity" (Killingsworth & Gilbert, 2010; Lambert & Csikszentmihalyi, 2020) and "My mind has wandered to something other than what I am currently doing" (adapted from Kane

et al., 2007; McVay et al., 2009). Due to the two-item structure of mind-wandering, reliability could not be assessed. Spearman-Brown correlation between the two items (recommended as a reliability measure for two-item scales, Eisinga et al., 2012) was high within- (p = .92) and between-subjects (p = .96).

3.2.3.4 Perceived Burden

In the feedback query at the end of each block of three days, participants indicated the perceived observation frequency, as well as the amount of perceived interruption of flow and work on a five-point Likert scale with reference to the past three days with AA.

3.2.4 Data Analysis

All data analyses were performed in R Studio (Version 2022.12.0) with the packages multilevelTools (Wiley, 2020), misty (Yanagida, 2023), esmpack (Viechtbauer & Constantin, 2023) and lme4 (Bates et al., 2023).

For testing the influence of the condition on flow reports, we computed two-level models to account for the nested data structure with repeated observations (level 1, n = 1442) within participants (level 2, N = 38). For assessing flow intensity as the outcome variable, we employed a linear mixed model, whereas we used a generalized linear mixed model with a logit function for flow presence due to the dichotomic outcome variable. Specifically, we included fixed effects for the condition (0 = momentary states, 1 = coverage), their order (0 = group that participated in momentary states condition first, 1 = coverage condition first) and daytime (centered for middle of the day, 0 = 2 pm), as well as a random effect for the condition. Due to problems with model fit (no convergence of the model), we excluded this random effect in the generalized linear mixed model. To assess the influence of the condition on compliance, we computed the compliance rate (in %) for each condition and person. Due to the absence of normal distribution (Shapiro-Wilk: p = .04), we compared differences in compliance between conditions with a one-tailed Wilcoxon test for paired samples assuming that compliance would be lower in the momentary states than in the coverage condition because of the differences in frequency of e-diary queries. For evaluating the influence of the condition on burden, we computed one-tailed Wilcoxon tests for paired samples (Shapiro-Wilk: all $p < .05$) assuming that the perceived observation

frequency as well as the interruption of work and flow would also be higher in the momentary states compared to the coverage condition.

We evaluated the psychometric properties of the r-FKS in the coverage condition since it allowed direct comparison with the full scale by aggregating mean scores (1) for all ten FKS items and (2) only for the three items of the r-FKS for each observation and person. We computed McDonald's Omega ω (Geldhof et al., 2014) to assess reliability. We used multilevel Pearson correlation coefficients for assessing the relationship between the r-FKS and the full version (concurrent validity) and between the r-FKS and flow-associated concepts (congruent/discriminant validity).

For testing whether flow could be operationalized as a yes-or-no continuous phenomenon by combining categorical and continuous measures, we computed two-level linear mixed models (separately for momentary states and coverage due to differences in reported flow), so that we could account for the nested data structure with repeated observations (level 1, momentary states: $n = 955$, coverage: $n = 487$) within participants (level 2, both: $N = 38$). Specifically, we investigated whether flow intensity differed depending on the answer to the categorical measure. Thus, we used flow intensity as the outcome variable and included fixed effects for the FQ (split into a within- and between-subjects component), the condition order and daytime, as well as a random effect for the FQ (within-subject component).

3.3 Results

Descriptive statistics for the variables measured in the e-diary and feedback queries are presented in Table 2. Overall, participants experienced moderate levels of flow intensity (M_{FKS} = 4.69). For the majority of observations, they did not report presence of flow (FQ = 0; 57.70 % of observations). 94.7 % of the participants (n = 36) reported presence of flow at least once. The null model (two-level linear mixed model without predictor variables) revealed that less than 30 % of variability were due to between-person differences in flow presence and intensity (ICC_{FQ} = 0.23, ICC_{FKS} = 0.21). This indicates that within-person fluctuations made up the major portion of variability in flow reports, thereby supporting the need for AA to capture everyday flow.

	M_{Total} (SD)	M_C (SD_C)	M_S (SD_S)	ICC_{Total}	ICC_C	ICC_S
Flow						
Probability[a]	42.30 %	52.77 %	36.96 %	0.23	0.24	0.22
Intensity	4.69 (1.18)	4.52 (1.02)	4.77 (1.24)	0.21	0.18	0.27
Autotelic experience	4.39 (1.49)	4.55 (1.45)	4.32 (1.51)	0.19	0.15	0.24
Skill-demand-balance	3.96 (1.26)	3.98 (1.25)	3.94 (1.27)	0.13	0.19	0.14
Stress	2.82 (1.50)	2.94 (1.52)	2.77 (1.48)	0.21	0.27	0.23
Mind-wandering	3.81 (1.71)	3.73 (1.65)	3.84 (1.74)	0.09	0.08	0.10
Burden						
Observation frequency	3.81 (0.69)	3.43 (0.92)	4.26 (0.82)	-	-	-
Work interruption	3.64 (0.63)	3.23 (0.97)	4.06 (0.57)	-	-	-
Flow interruption	3.19 (1.06)	2.74 (1.22)	3.61 (1.12)	-	-	-

Table 2 Descriptive statistics of variables assessed in e-diary and feedback queries compared between conditions

Note. Flow, autotelic experience, skill-demand-balance, stress, and mind-wandering (rated on a seven-point Likert scale from one to seven) were reported in the e-diaries (Level 1, n = 1442; momentary states: n = 955, coverage: n = 487 observations) by the participants (Level 2, N = 38). Perceived observation frequency, work interruption, and flow interruption (rated on a five-point Likert scale from one to five) were reported in the feedback queries (Level 1, n = 66; momentary states: n = 31, coverage: n = 35 observations) by the participants (Level 2, N = 37). Please note that one participant did not answer the feedback queries at all. ICC = Intraclass correlation coefficient, S = Momentary states, C = Coverage.
[a] Proportion of "Yes" responses reported instead of mean scores and standard deviations due to the dichotomic variable (FQ)

3.3.1 Comparison Between Use of Coverage and Momentary States

Figure 6 illustrates within- and between-subject variability over time in comparison between conditions. Within-subject variability in flow intensity was higher in the momentary states (σ^2_{FKS} = 1.130) compared to the coverage condition (σ^2_{FKS} = 0.856) which ties in with the higher frequency and the current reference of observations in the momentary states condition. Visual inspections did not indicate linear decreases in flow intensity over time in both conditions. This suggests that the interruption by the e-diary queries did not result in reduced flow experiences over time, even if the observation frequency was increased (for additional statistical tests of influence of time via multilevel modeling see Appendices 2.3 and 2.4).

Results of the multilevel models estimating the influence of the condition on flow intensity and presence (controlling for the daytime and the order of conditions) are depicted in Table 3. In the momentary states condition, flow intensity of a typical person was 4.85 (possible values between one and seven) when all other predictors were zero (i.e., in the group in which the momentary states condition took place first and when daytime equaled middle of the day). There was no significant difference in flow intensity between the coverage and the momentary states condition ($B_{\text{Condition}}$ = -0.18, p = .145). The order of the conditions neither had a significant direct effect on flow intensity (B_{Order} = -0.14, p = .522), nor interacted significantly with the condition ($B_{\text{ConditionxOrder}}$ = -0.13, p = .426). This indicates successful randomization of participants to different orders of conditions and implies that their perception of the first condition did not bias reported flow intensities in the subsequent condition. In contrast to flow intensity, the probability of reporting flow was significantly higher in the coverage compared to the momentary states condition (66 % compared to 46 % of observations reported as flow presence; $B_{\text{Condition}}$ = 0.86, p < .001, OR = 2.36) when all other predictors where zero. There was also a significant difference in flow presence depending on the order of conditions, in that flow probability was lower in the group of participants that did the coverage condition first (B_{Order} = -1.09, p = .001, OR = 0.34). However, there was no significant interaction between condition and order ($B_{\text{ConditionxOrder}}$ = -0.12, p = .649, OR = 0.87) indicating that this group of participants generally reported presence of flow more often independent of the condition.

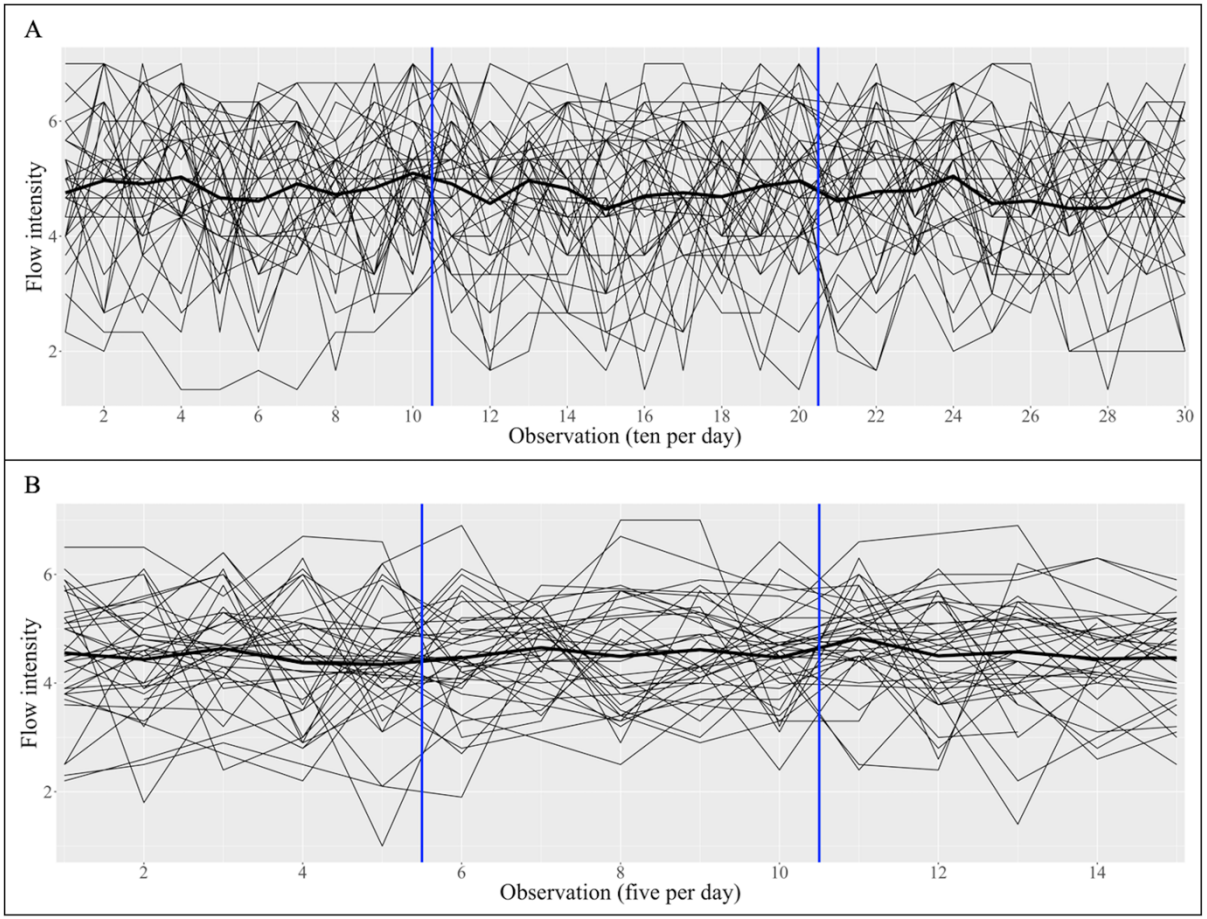

Figure 6 Spaghetti plot for flow intensity over time in momentary states (A) and coverage (B) condition

Note. Flow intensity was measured with the FKS (A: reduced version, B: full version). Thin black lines indicate individual change over time; thick black lines indicates mean change over time; blue lines indicates transgression between days.

	Flow intensity			Flow probability		
	Estimate	(*SE*)	95 % CI [LL, UL]	Estimate	(*SE*)	95 % CI [LL, UL]
Intercept	4.85***	0.16	4.55, 5.16	-0.18	0.22	-0.62, 0.26
Condition	-0.18	0.12	-0.42, 0.06	0.86***	0.17	0.52, 1.20
Order	-0.14	0.22	-0.59, 0.31	-1.09**	0.32	-1.75, -0.46
Daytime	-0.01	0.01	-0.03, 0.01	0.02	0.02	-0.02, 0.06
Condition x Order	-0.13	0.18	-0.48, 0.20	-0.12	0.25	-0.61, 0.38

Table 3 Influence of condition on flow intensity and probability

Note. Level 1: n = 1442 observations; Level 2: N = 38 participants. Dichotomic variable for condition (0 = momentary states, 1 = coverage). Flow intensity measured by FKS in the coverage condition (momentary states condition: r-FKS). Flow probability measured by FQ. Models included controls for order and daytime effects. Dichotomic variable for order of conditions (0 = group that participated in momentary states condition first, 1 = coverage condition first). Centered variable for daytime (0 = middle of observation period, 2 pm). CI = Confidence interval, LL = Lower level, UL = Upper level.
$^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$

Since the number of e-diary queries was twice as much in the momentary states compared to the coverage condition, we expected increased burden in the momentary states condition. In line with that, means of all indicators for perceived burden were higher in the momentary states compared to the coverage condition (Table 2). Wilcoxon tests for paired samples confirmed significantly higher perceived observation frequency (V = 184.0, $p < .001$), interruption of work (V = 148.0, $p < .001$) and interruption of flow (V = 213.5, $p < .001$) in the momentary states condition compared to the coverage condition.

Independent of these differences in perceived burden, participants responded to similar portions of e-diary queries in the momentary states (mean of individual compliance rates: 83.9%) and the coverage condition (86.7%). Statistical analyses also did not indicate a significant difference in compliance between conditions (V = 355.5, p = .256). Similarly, visual inspections did not imply an effect of the order of conditions on compliance (see Appendix 2.5). Statistically comparing the difference in compliance (momentary states versus coverage condition) between groups with different order of conditions confirmed the absence of an order effect (W = 149.5, p = .372). This indicates that the transgression between conditions from the first to the second week, i.e., whether participants experienced an increase or decrease in number of observations per day, did not influence their compliance.

In sum, flow presence was higher in the coverage compared to the momentary states condition, whereas there was no significant difference in flow intensity between conditions. Even though the momentary states condition was associated with increased burden (including perceived interruption of flow) compared to the coverage condition, this did not have an influence on actual participation in the study (i.e., compliance) or led to decreases in flow intensity or presence over time.

3.3.2 Psychometric Properties of the Reduced Scale

In the following paragraphs, we present results for the coverage condition only since it allowed us to compare the psychometric properties of the r-FKS with those of the full scale. However, similar analyses in the momentary states condition did not reveal differences in tendencies of effects (Table 4). Within-subject reliability of the r-FKS was acceptable ($\omega_{coverage}$ = 0.67, $\omega_{momentary}$ = 0.68), but smaller than for the full version of the scale ($\omega_{coverage}$ = 0.86). By contrast, between-subjects reliability was good for the r-FKS ($\omega_{coverage}$ = 0.85, $\omega_{momentary}$ = 0.87) and for the full version ($\omega_{coverage}$ = 0.82).

As reported in the previous paragraph, there was no difference in flow intensity between the momentary states and the coverage condition, i.e., between the conditions that used the reduced and the full version of the FKS. Visual inspection of flow intensity computed as a mean across the full version of the scale and solely the items of the r-FKS in the coverage condition also indicated a positive relationship between the two scores (Figure 7). This correlation was strong within- (r = .86) and between-subjects (r = .90) (Table 4). This denotes that scores on the additional items in the full compared to the reduced scale did not largely increase or decrease mean flow intensity, thus suggesting strong concurrent validity of the r-FKS. Within-subject correlations between the reduced and the full version of the scale were also strongly positive when computed separately for the scale factors ($r_{absorption}$ = .81; $r_{fluency}$ = .78). This supports our goal of capturing both factors in the r-FKS as in the full scale.

Since we are interested in evaluating the r-FKS for use in AA, we are especially interested in its validity with regard to within-subject fluctuations. Within-subject associations between flow intensity measured with the r-FKS and flow-associated concepts are visualized

in Appendix 2.6. Flow intensity was moderately positively associated with autotelic experience and moderately negatively associated with mind-wandering and stress on a within-subject level. Thus, the higher the flow intensity of a person was, the more they enjoyed their activity and the less they experienced simultaneous mind-wandering or stress. These correlations had similar tendencies for both scale versions but were slightly lower for the r-FKS than the FKS (Table 4). For computing the association between flow intensity and skill-demand-balance, we squared the latter variable due to the expected inverted-u-shaped relationship between these two variables (Engeser & Rheinberg, 2008). In line with that expectation, within-subject correlations between flow intensity and the squared skill-demand-balance were moderately negative for the r-FKS and the FKS (Table 4). In other words, participants reported highest flow intensity when skills and demands were perfectly balanced. In sum, these results indicate convergent and discriminant validity of the r-FKS.

	(1)	(2)	(3)	(4)	(5)	(6)
(1) r-FKS	-	0.86	0.51 (0.44)	-0.27[b] (-0.17)[b]	-0.37 (-0.42)	-0.49 (-0.41)
(2) FKS	0.90	-	0.60	-0.30[b]	-0.39	-0.60
(3) Autotelic experience	0.38 (0.66)	0.52	-	-0.07	-0.28	-0.47
(4) Skill-demand-balance	0.17[a] (-0.07)[a]	-0.07[a]	0.10	-	0.31	-0.21
(5) Stress	-0.25 (-0.61)	-0.17	-0.17	0.66	-	0.12
(6) Mind-wandering	-0.12 (-0.51)	-0.36	-0.33	-0.30	-0.05	-

Table 4 Level-specific bivariate correlations between flow intensity and flow-associated concepts in the coverage condition

Note. Correlations above the diagonal indicate correlations at the within-person level (Level 1, n = 487); correlations below the diagonal indicate correlations at the between-person level (Level 2, N = 38). Correlations between the r-FKS and the associated concepts in the momentary states condition are reported in parentheses. The r-FKS consisted of three items, whereas the FKS consisted of ten items. Correlations between the FKS and flow-associated concepts could not be computed for the momentary condition because the full scale was only used in the coverage condition.

[a] Correlation between grand-mean centered squared skill-demand-balance and grand-mean centered flow due to inverted u-shaped association between skill-demand-balance and flow

[b] Correlation between person-mean centered squared skill-demand-balance and person-mean centered flow due to inverted u-shaped association between skill-demand-balance and flow

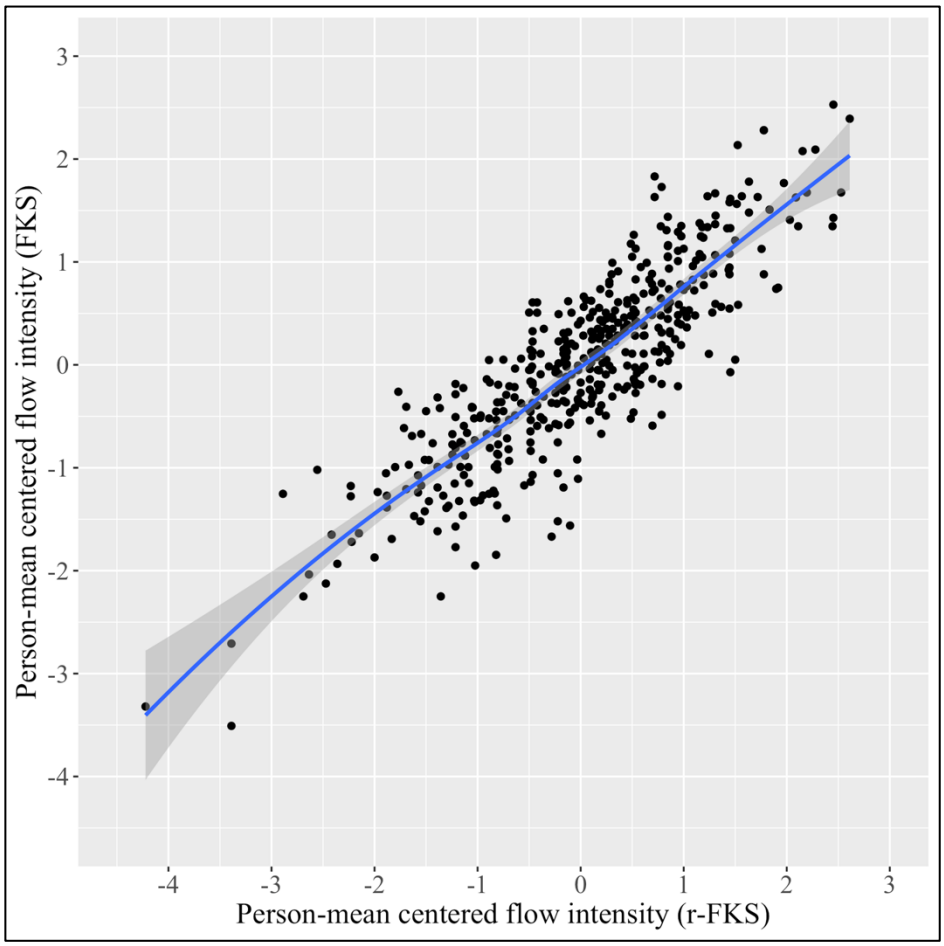

Figure 7 Within-subject associations between flow intensity scores computed based on the full and the reduced version of the FKS

Note. Associations in the coverage condition. Blue line indicates mean with confidence intervals.

3.3.3 Differences in Flow Intensity Depending on Flow Presence

Mean difference between flow intensity in observations reported as presence or absence of flow was positive in the momentary states (M_{Yes} = 5.29, M_{No} = 4.62) and the coverage condition (M_{Yes} = 5.04, M_{No} = 4.06), indicating that flow intensity was higher when participants reported presence of flow. This was confirmed by results of our multilevel models (Table 5) showing that if a person reported presence compared to absence of flow, flow intensity increased by two-thirds to one unit (momentary states: $B_{Presence\_w}$ = 0.65, p < .001; coverage: $B_{Presence\_w}$ = 0.94, p < .001). Results of the models also show between-subjects effects, in that persons who reported presence of flow more often than average also reported generally higher flow intensity (momentary states: $B_{Presence\_b}$ = 2.05, p < .001; coverage: $B_{Presence\_b}$ = 1.23, p < .001). In addition, we computed 25th percentiles of flow intensity

separately for each individual as an exploratory cut-off between presence and absence of flow. Indeed, a majority of the observations for which flow intensity did not exceed this individual cut-off was reported as absence of flow (momentary states: 85 % of observations with intensity below individual cutoff; coverage: 72 %). Hence, particularly low intensity scores of a person seem to provide a marker for the absence of flow.

Due to the focus of the FQ on the absorption component of flow, we additionally computed the multilevel models solely with the FKS factor absorption as the outcome variable. Indeed, these models resulted in stronger direct fixed effects for the within- and the between-subjects component of flow presence on absorption intensity (for model results see Appendix 2.7). This denotes that the answer to the FQ ties in more strongly with the current absorption in the task than the perceived fluency (for model results for fluency see Appendix 2.8).

	Momentary states			Coverage		
	Estimate	(*SE*)	95 % CI [LL, UL]	Estimate	(*SE*)	95 % CI [LL, UL]
Intercept	4.66***	0.14	4.38, 4.94	4.53***	0.11	4.32, 4.74
Presence_w	0.65***	0.11	0.43, 0.86	0.94***	0.13	0.68, 1.21
Presence_b	2.05***	0.53	0.98, 3.13	1.23**	0.33	0.56, 1.90
Order	0.24	0.22	-0.20, 0.68	0.01	0.16	-0.31, 0.34
Daytime	0.00	0.01	-0.02, 0.02	-0.02	0.01	-0.05, 0.00

Table 5 Reported presence of flow as a predictor for flow intensity

Note. Level 1: $n_{momentary}$ = 955 observations, $n_{coverage}$ = 487 observations; Level 2: N = 38 participants. Flow intensity measured by FKS in the coverage condition (momentary states condition: r-FKS). Flow presence measured by FQ. Variable for flow presence split into within- (presence_w) and between-subjects (presence_b) components. Models included controls for order and daytime effects. Dichotomic variable for order of conditions (0 = group that participated in momentary states condition first, 1 = coverage condition first). Centered variable for daytime (0 = middle of observation period, 2 pm). CI = Confidence interval, LL = Lower level, UL = Upper level.
$^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$

3.4 Discussion

In a real-life study using time-based AA, we compared two observation approaches, momentary states, and coverage, to capture within- and between-subject fluctuations of flow. Despite the differences in reference between these approaches that were linked to differences in observation frequency, we found no effect on compliance, flow intensity reports, or flow reports over time. However, flow probability, within-subject variability in flow reports, and perceived burden differed between the approaches. In addition to finding support for the potency of both approaches, we found that the FKS can be shortened to a three-item version without substantial detriments in its psychometric properties. In the following, we will further discuss the contributions of these results as well as limitations of our study.

3.4.1 Contributions for Research and Practice

Our findings contribute to the literature on flow measurement and on assessment of everyday states in at least three ways. First, our comparison of two observation approaches allows us to speculate about recommendations for when to use which approach when measuring flow in everyday life. Based on our findings, we recommend capturing momentary states if researchers need fine-grained analyses of individual fluctuations in flow, e.g., when investigating physiological correlates of flow (e.g. Peifer et al., 2014). Especially since this approach captures higher within-subject variability (as in similar findings on current compared to retrospective assessments; Diener & Tay, 2014), this approach is particularly useful for developing flow-promoting interventions with adaptive mechanisms. By allowing real-time assessment of individual states, it enables researchers to intervene in a targeted and time-based way. In contrast to the concern that frequent prompts for providing self-reports about the current state might disrupt momentary flow, we found no evidence that the increased observation frequency linked to momentary assessment biases reports of flow intensity. By contrast, even though participants noticed the differences in observation frequency between the two approaches and associated higher frequency with increased burden, noticing the differences neither influenced their actual participation in the study nor altered their flow reports over time. This result is in line with an earlier study by Hasselhorn et al. (2022) that identified no differences in compliance due to differences in assessment frequency. However, our findings do not imply that the coverage approach is not preferrable

in certain cases. If researchers are mainly interested in interindividual differences, e.g., when testing the effect of an intervention with a control group (e.g. Weintraub et al., 2021), the coverage approach comes with a lower number of observations, thus is more cost-efficient and less intrusive than assessing momentary states. Meanwhile, it still allows for capturing within-subject variability due to the repeated observations per day, thereby providing a compromise between extensive momentary assessment and single, trait-oriented observations. Importantly, the coverage approach should also be the method of choice if a total number of flow experiences per day is needed. While randomly distributed momentary assessments only allow generalizations about the entire observation period (i.e., making an informed guess about periods between observations), the coverage approach captures the entire observation period without any disregarded periods in between.

Our finding of lower flow probability in the momentary states approach directly ties in with the aforementioned problem of missing scarce states, in that coverage increases the likelihood of capturing all flow experiences, whereas momentary, random sampling can miss them by chance. However, the difference in number of reported flow experiences between the two observation approaches could also be due to normative beliefs prompted by recall (e.g., „I should experience flow at work", „I have not experienced flow today, that can't be true."), thereby biasing the estimation (Robinson & Clore, 2002). In contrast to commonly discussed limitations of recall (e.g., Kahneman et al., 2004; Lucas et al., 2021; Robinson & Clore, 2002), its application in the coverage approach does not seem to lead to a loss of access to the experiential nature of flow though, in that there were no differences in reported flow intensity between the momentary states and the coverage approach. Even though we acknowledge that earlier studies even found recall biases for very recent experiences (e.g., see literature on the peak-end-rule; Fredrickson, 2000; Kahneman et al., 1993), we assume that the two hour intervals of reports and the assessment during everyday life (i.e., typically without exceptionally affective events) allow to prevent such biases. Hence, we recommend maintaining short time windows when opting for the coverage approach.

As a second major contribution, we have shown that the three-item version of the FKS neither loses reliability nor validity compared to the full scale in our AA study. Most importantly, we found an almost perfect conformity between sum scores on the full and the

reduced version of the scale, thus concluding that the additional seven items of the full scale do not provide sufficiently high added value to justify their use in AA. Reducing the length of the flow measure for AA allows more frequent observations per day (e.g., important for gaining a large number of labels for neurophysiological data) and during a larger variety of tasks (e.g., allowing analyses in work settings with frequent meetings in which it would be inconvenient to fill in longer questionnaires). Also, very short scales such as the r-FKS are especially promising with regard to the use of novel, user-friendly devices for assessing everyday experiences, such as smartwatches (Volsa et al., 2022). Prompting short e-diaries on such unobtrusive devices, researchers cannot only increase interest in participating in AA studies, thereby enlarging potential sample sizes, but also prolong study duration due to the decrease in participants' burden. Since we investigated flow in everyday life, future research needs to evaluate whether our findings on comparable validity and reliability between the full and the reduced scale also translate to laboratory flow research. In addition, we encourage researchers to incorporate measures for intrinsic motivation and skill-demand-balance in e-diaries to capture the main flow preconditions and consequences (Abuhamdeh, 2020). This is especially relevant with regard to the on-going debate about the need for conceptually separating flow characteristics from preconditions and consequences in flow operationalizations (Abuhamdeh, 2020; Peifer et al., 2022).

As a third major contribution, we empirically evaluated the theoretical proposition of assessing flow as a yes-or-no continuous phenomenon. As suggested by Peifer and Engeser (2021), the combination of categorical and continuous flow measures allowed us to draw conclusions about flow intensity and probability. If we were applying a flow-promoting intervention with an adaptive mechanism, this would enable us to intervene in situations where participants do not experience flow and evaluate whether that intervention increases the probability of experiencing flow. We could also intervene in situations with low levels of flow to evaluate the intensity increases resulting from the intervention. As a third option, we could choose not to intervene in situations with high levels of flow to avoid decreases in flow intensity.

Even though we chose the combination of the FQ and the FKS based on the theoretical proposition by Peifer and Engeser (2021), we do not recommend this combination for

future studies. Our study confirms the common criticism that the FQ neglects the fluency component of flow (Moneta, 2021) by showing a stronger prediction of absorption than fluency when flow was reported. Thus, if researchers aim for combined conclusions about flow intensity and probability, we suggest using a dichotomic item asking about flow presence based on the flow concept applied in the FKS in combination with the continuous FKS instead. As argued before, continuous scales bear the risk of imposing flow on participants (Abuhamdeh, 2020; Moneta, 2021). In the majority of observations in our study, reports of flow absence accompanied low flow intensity scores. Indeed, evaluating the flow intensity scores alone would lead to interpretations of low levels of flow in these cases, although the categorical measure suggests a complete absence of flow. However, a relevant portion of observations that belonged to the lowest range of reported flow intensity (i.e., for which reported flow intensity was within the individually lowest quantile of intensity scores) were simultaneously labeled as presence of flow (momentary states: 15 %; coverage: 28 %). This observation disagrees with the notion that flow scales generally impose flow on participants. Interpreting flow as a yes-or-no continuous phenomenon suggests that the reports on the continuous flow measure should only be interpreted if flow presence was reported on the categorical measure (Peifer & Engeser, 2021). This would come with a significant decrease in number of observations for the continuous variable though, thereby decreasing statistical power of analyses. Since our findings suggest that absence of flow (indicated by the categorical measure) is associated with low intensity scores, this interdependence in presentation of the flow measures is not necessary though. Rather, our study provides first insights into another approach for reaching conclusions about flow intensity and probability in a single study without two distinct measures. Using the individually lowest intensity scores (e.g., below the individual 25^{th} percentile) as a cut-off between presence and absence of flow is time- and cost-efficient because it only requires one measure while allowing conclusions about both flow probability and intensity. Even though this cut-off might not perfectly distinguish states of flow and nonflow, it incorporates individual differences in general flow propensity and is conservative, in that it rather under- than overestimates flow presence. Nevertheless, this approach does not solve the problem of imposing flow on participants who would not report flow at all (Abuhamdeh, 2020; Moneta, 2012). Therefore, we advocate the use of this cut-off method only when a combination with a categorical measure is not feasible due to time or resource constraints. In such cases, we suggest

administering a trait flow questionnaire before commencing AA to differentiate individuals who generally experience flow from those who do not.

3.4.2 Limitations and Future Research

In the following paragraphs, we need to highlight some limitations of our study as they can provide interesting starting points for future research. Most importantly, we did not separate differences in observation frequency (ten versus five per day) from distinct references (current state versus recall of last two hours) by using a 2x2 design. Since we decided to use a within-subjects design to control for individual flow propensity, this would have significantly increased burden for participants requiring them to participate in four conditions, i.e., over the course of four weeks. Also, we argue that the use of different references is directly linked to differences in observation frequency in that for conclusions about similar time periods, we need to adapt the sampling accordingly. Thus, we attributed the differences between the conditions to the differences in reference (e.g., when arguing about the cause for higher flow presence in the coverage approach). However, the momentary states and coverage conditions also differed with respect to questionnaire length, i.e., the use of the reduced versus the full version of the FKS (three versus ten items). Previous research has been inconsistent on whether questionnaire length affects compliance, perceived burden, and within-person variability (Eisele et al., 2022; Hasselhorn et al., 2022). In these studies, the number of items in the shorter questionnaire condition is higher and the differences in number of items between the short and the long questionnaires are greater than in our study. Nevertheless, we cannot rule out the possibility that in our study the increased variability of flow reports in the momentary states compared to the coverage condition is due to the shorter questionnaire length, i.e., to the lower number of items, rather than to the measurement of momentary states (Hasselhorn et al., 2022). Because of this conflation of potential confounds in the two conditions, future research would benefit greatly from analyzing the most efficient and effective (i.e., unobtrusive but informative) number of observations per day and number of items separately for each observation approach.

In addition, although power estimates from Monte Carlo simulations suggest that the Level 1 sample size (i.e., the number of observations) was large enough to detect small Level 1 effects with high statistical power (Arend & Schäfer, 2019), the Level 2 sample

size (i.e., the number of participants) was only sufficient to detect large between-subjects effects with acceptable statistical power. For analyses of our multilevel data, we were primarily interested in Level 1 effects (examining within-person differences in the effect of condition on flow reports and within-person associations between flow reports and associated concepts). Thus, we would not expect changes in results with more participants. However, the effect of the condition order on flow reports was a Level 2 effect. Thus, the interpretation of the results regarding this potential confound may be influenced by the limited number of participants.

Directly related to that, one of the two participant groups (differing in the order of conditions) generally reported more presence of flow than the other. Despite the random assignment to these groups, this suggests presence of relevant covariates. Since flow is influenced by a range of internal (e.g., level of expertise in the task, interest in the task, general flow proneness; Bricteux et al., 2017; Rheinberg & Engeser, 2018; Wilson & Moneta, 2016) and external factors (e.g., receipt of feedback or not, Hohnemann et al., 2022), we cannot pinpoint the exact reason for these differences. In addition, differences in reported flow presence could also be due to factors that are completely unrelated to flow, such as a generally higher tendency of answering with "Yes" in one of the groups. Also, two participants never reported presence of flow. However, both belonged to the group that reported more flow in total, so these outliers also cannot account for the differences. Thus, even though this group difference calls for further investigations into individual differences in flow, our finding of a group effect on flow presence but not on intensity further supports that the two flow measures do not completely coincide.

Consistent with the payment schemes in previous studies (e.g., reducing the payout when compliance was below thirty-three percent, Eisele et al., 2022; providing an additional reward for answering more than 80 % of queries, Hasselhorn et al., 2022) that analyzed differences in compliance, we compensated participants monetarily and offered an additional incentive for high compliance. While meta-analyses conclude that compliance does not depend on whether participants receive a fixed or a compliance-based payout (de Vries et al., 2021; Ottenstein & Werner, 2022), they do not agree on whether the amount of the incentive impacts compliance (Ottenstein & Werner, 2022; Vachon et al., 2019). In general, monetary

compensation seems to be more effective in increasing compliance than other rewards, such as feedback or vouchers (Harari et al., 2017; Ottenstein & Werner, 2022). Therefore, the lack of a difference in compliance between the two observation approaches in our study may result from the generally high compliance caused by the monetary incentives. Thus, future research could evaluate how differences in compensation impact the effect of the observation approaches on compliance. An interesting avenue for future research may also be to evaluate differences in effects when participants can track their current level of compliance (Trull & Ebner-Priemer, 2020).

In addition, qualitative feedback of participants at the end of the study revealed an important limitation of the coverage approach. The majority of the participants reported difficulties with providing estimations about their flow if they had switched repeatedly between tasks in the two hours asked about in recall. In addition, we had initially incorporated a question about the number of experienced flow states in the last two hours (in case the FQ had been answered with "Yes") in the coverage approach. However, participants reported strong difficulties in estimating this frequency, so we did not evaluate these data further. Thus, we recommend paying particular attention to the targeted sample and their expected everyday tasks. For participants who complete a very diverse set of tasks the coverage approach might not be suitable. To prevent this limitation, future research could focus on samples with homogenous tasks, e.g., collecting data in a working sample in a specific company instead of with students who often switch between work and leisure activities during the day.

Lastly, when asking repeatedly about flow, this might trigger participants to eventually say yes because they feel obliged to do so. This speaks in favor of continuous flow scales because they do not nudge people in that direction. However, even with these measures we cannot rule out subjective biases in self-reports. Therefore, flow research calls for more objective markers of flow (Peifer et al., 2022; Peifer & Engeser, 2021). However, despite promising advances in the last years, the current state of neurophysiological methods does not allow gathering these data unobtrusively in the field yet (Gold & Ciorciari, 2020; Peifer et al., 2022). Until then, we argue that self-report-based AA will remain the method of choice for evaluating everyday flow. Since our study focused on the absorption and fluency

components of flow, our conclusions are limited to this specific flow concept. When measuring flow experiences in leisurely everyday activities, future research should evaluate how these findings apply to self-report-based flow operationalizations that integrate the autotelic experience as a major element of flow.

3.5 Conclusion

Despite the aforementioned limitations, our study illuminates how to measure everyday flow in AA. Our findings show that random momentary sampling does not generally excel use of fixed recall periods for gathering information on flow fluctuations. Rather, we recommend choosing the observation approach for capturing everyday flow depending on outcome of interest (i.e., flow intensity or frequency across the day), targeted comparison (i.e., differences within- or between-subjects), concurrent application of neurophysiological measures, and expected task variability of participants. In addition, the present work eases obtrusiveness and burden of AA with self-reports by providing a short flow measure that can be used for conclusions about flow intensity as well as probability. Thereby, we contribute to a methodological basis for building flow-promoting interventions with adaptive mechanisms grounded in real-time insights into individual flow without the need for access to neurophysiological data.

CHAPTER 4

Adaptively Promoting Flow in Everyday Knowledge Work

This chapter is based on an article entitled “Using Mental Contrasting to Promote Flow Experiences in Knowledge Work: A Just-in-Time Adaptive Intervention” that is currently under review in the peer-reviewed journal Computers in Human Behavior Reports. The article was co-authored by Dr. Michael T. Knierim, Prof. Dr. Christof Weinhardt, and Prof. Dr. Gabriele Oettingen.

Tables, figures, and appendices have been systematically renamed, reformatted, and appropriately referenced to conform to the overall structure of the dissertation. To further improve clarity and consistency, wording, formatting, and referencing style were adjusted and references were updated. The supplementary material of the manuscript can be found in Appendix A3.

Author contributions:
Bartholomeyczik, K.: Funding acquisition, conceptualization, methodology, investigation, analysis, data curation, visualization, writing
Knierim, M. K.: Conceptualization, investigation, reviewing and editing
Weinhardt, C.: Resources, supervision, funding acquisition, reviewing
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4.1 Introduction

As reflected by the current discourse around the phenomenon of quiet quitting (Atalay & Dağıstan, 2023; Harter, 2022; Newport, 2022), only 23 % of employees worldwide were engaged in their work in 2022 (Gallup, 2022). This lack of work engagement negatively impacts performance and well-being, and increases turnover rates (Mazzetti et al., 2021). To counteract this trend, popular media outlets and scientific articles promote the idea of cultivating intrinsic motivation by allowing individuals to select tasks aligned with their skills (Fishbach & Woolley, 2022; Paulise, 2022). Given this demand to support employee engagement, the concept of flow which was originally coined by Csikszentmihalyi (1975) has regained popularity. Flow is an intrinsically motivating state of mind that emerges when a person's skills align perfectly with the demands of their task, in that the person feels neither bored nor overburdened (Nakamura & Csikszentmihalyi, 2012). In this state, individuals experience complete immersion in their current task which directly relates to beneficial work-related outcomes such as increases in performance, energy levels, or creativity (Demerouti et al., 2012; Engeser & Rheinberg, 2008; Zubair & Kamal, 2015).

Despite these flow-evoked benefits, interventions for promoting flow at work are still scarce (see Chapter 2; Bartholomeyczik et al., 2023). This scarcity is largely due to the strong variability of flow. Individuals differ not only in their general proneness to experiencing flow, but flow state also depends on the task, situation, and time (Ceja & Navarro, 2011; Fullagar & Kelloway, 2009; Nielsen & Cleal, 2010; Tse et al., 2021). Hence, interventions that cannot only adapt to interindividual differences (i.e., support individuals who hardly experience flow), but also to within-person changes (i.e., support individuals who work on tasks that hardly elicit flow in them) are needed. This is possible by using JITAIs which build on an "intervention design that employs adaptation to operationalize the provision of just-in-time support, namely to provide the right type (or amount) of support, at the right time, while eliminating support provision that is not beneficial" (Nahum-Shani et al., 2018, p. 450). Hence, developing a JITAI for promoting flow at work requires to decide which specific intervention type it should provide adaptively to the person. Then, it is possible to evaluate whether giving this intervention type adaptively is more beneficial for promoting flow than providing non-adaptive assistance. In the following sections, we will

examine both of these aspects with regard to theoretical literature and prior empirical studies. We will then explain the present research highlighting how it provides the first empirical investigation of how to promote flow adaptively in everyday knowledge work.

4.1.1 Use of Mental Contrasting as the Intervention Type

In our theoretical overview of flow-promoting interventions in the workplace (see Chapter 2; Bartholomeyczik et al., 2023), we propose selecting the intervention type based on its specific aim, target, and executor. We recommend focusing initially on establishing the necessary flow preconditions (skill-demand-balance, clear goals, and feedback; Nakamura & Csikszentmihalyi, 2012), as these factors are pivotal for the emergence of flow. Contextual factors dictate the constitution of these preconditions to some extent (e.g., when a job comes with certain tasks, or a manager assigns specific goals). However, individuals can also contribute to their fulfillment. For that, the intervention type should directly target and be executable by the individual. Thereby, employees can self-initiatively promote their flow regardless of organizational context (see Chapter 2; Bartholomeyczik et al., 2023).

In line with such an individual- rather than context-focused approach, a recent study by Weintraub et al. (2021) found that nudging workers to set goals according to the SMART acronym (commonly interpreted as specific, measurable, attainable, relevant, and time-bound goals; Rubin, 2002; Swann et al., 2022) increased daily flow at work. This association between goal-setting and flow (e.g., also see Oertig et al., 2014; Schweickle et al., 2017) arises because choosing goals increases goal commitment by enhancing perceived goal importance (Locke & Latham, 2002). Since goal importance is a known moderator for the emergence of flow, choice of goals might then also facilitate flow (Engeser & Rheinberg, 2008). Most importantly, setting clear goals helps people structure their tasks. Thereby, they feel more productive and as if their skills align with the task, a core precondition of flow (Bakker & van Woerkom, 2017; Csikszentmihalyi et al., 2014).

However, assuming that the structuring effect of goal-setting promotes flow presumes that the goal persists until it is fulfilled or deserted. However, goals may turn out to be non-achievable or they may become undesirable. This would require rethinking the goal and the

respective plan to pursue it. Acknowledging these processes of goal disengagement (Oettingen & Gollwitzer, 2022) is one peculiarity of mental contrasting (MC). MC is a stepwise procedure that lets individuals identify an important wish or goal and then mentally contrast the imagined best outcome of this wish with the anticipated main inner obstacle (Oettingen, 2000; Oettingen et al., 2009). Thereby, MC facilitates goal pursuit when the obstacle is surmountable. However, if the obstacle is too costly or insurmountable, MC encourages individuals to actively let go of their wish (Oettingen, 2000; Oettingen, Pak, & Schnetter, 2001). Individuals can learn MC in a short amount of time independent of the content of the wish. This quick learning prepares them to apply MC as a metacognitive strategy in various contexts (Oettingen et al., 2015). Earlier research indicates that MC can influence both behavior (e.g., attenuate procrastination; Oettingen et al., 2015) and emotions (e.g., decrease regret and disappointment; Krott & Oettingen, 2018).

The mental contrasting of the best outcome and the main obstacle distinguishes MC from goal-setting strategies (e.g., setting SMART goals). While these strategies emphasize setting attainable goals, they do not explicitly focus on obstacles or juxtapose them with the outcomes. This could add value to MC for its impact on flow in knowledge work for two reasons. First, deciding which wishes are worth pursuing based on the contrast between anticipated outcomes and obstacles lets individuals a priori choose tasks that align with their skills. Overall, the person then engages in balanced tasks more often which enhances the likelihood of experiencing flow. Second, deciding which goals to pursue and which to let go increases perceived autonomy. Earlier research indicates that autonomous choice of tasks can compensate for nonoptimal compositions of skills and demands, thereby allowing similarly high flow as would be expected for an optimal balance (Bartholomeyczik et al., 2022; de Sampaio Barros et al., 2018). Hence, especially at work where tasks are often extrinsically motivated (Peifer & Wolters, 2021), MC may increase perceived autonomy, thereby facilitating the emergence of flow.

4.1.2 Promoting Flow Adaptively

Since flow at work does not evolve similarly across individuals and situations (Engeser & Baumann, 2016), interventions should not be provided independent of these factors. Yet, in the aforementioned intervention study using SMART goal-setting to foster flow at work,

Weintraub et al. (2021) nudged all participants to apply the strategy every morning. This approach of using a static intervention, i.e., providing the intervention independent of the individual's state, comes with relevant disadvantages. For example, earlier research suggests that static interventions might cause intervention fatigue, "a state of emotional or cognitive weariness associated with intervention engagement" (Nahum-Shani et al., 2018, p. 450). Intervention fatigue arises when the demand of adhering to the intervention, alongside contextual demands during application, exceeds individual capacities such as affective and cognitive resources (Heckman et al., 2015). This is especially relevant in modern digital workplaces, where individuals frequently face a high number of demands competing for their attention (Marsh et al., 2022). In addition, research from the domain of eHealth suggests that users quickly stop using mobile applications if these do not adapt to their individual states (Christensen & Mackinnon, 2006; Eysenbach, 2005). This so-called law of attrition (Eysenbach, 2005) argues for adapting the support provision to the individual. Thereby, it is possible to avoid providing support in situations when individuals simply lack the capacity to adhere to the intervention (Nahum-Shani et al., 2018).

Apart from these outcome-unspecific disadvantages, static interventions bear additional downsides for the aim of promoting flow. First, repeatedly reminding people to apply the intervention reduces their autonomy. As discussed before, however, autonomy is a relevant determinant of flow (Bartholomeyczik et al., 2022; de Sampaio Barros et al., 2018). Also, while individuals may generally benefit from increased flow at work, on some days they may experience flow often enough to not need additional support. On these days, the intervention may lose its effect or, at worst, cause negative side effects. For example, too frequent or long states of flow might exploit individuals' attentional capacities causing exhaustion (Zimanyi & Schüler, 2021). Since static interventions do not consider whether a person already experiences flow frequently, they run the risk of overstimulating flow.

JITAIs could overcome these general and flow-specific limitations of static interventions by providing flow-supporting strategies only when needed. In the context of increasingly digitized workplaces, leveraging smartphone-based assistance could be a particularly appealing resource to realize this objective in real-world scenarios. For that, JITAIs include a decision rule that specifies a decision point (i.e., the time of decision) at which the value of

a tailoring variable is used as a determinant for which intervention option is offered (Nahum-Shani et al., 2018). To provide flow support only when needed, the tailoring variable needs to contain information about flow state during everyday work tasks. A suitable method for gaining such insights in an unobtrusive way is AA. AA allows to measure everyday experiences while individuals go about their day (Trull & Ebner-Priemer, 2014). Hence, digital self-reports on flow obtained through AA (which are also commonly used in non-interventional flow research; Moneta, 2021) may serve as the tailoring variable in an adaptive decision rule. Based on this information, flow-promoting interventions can be provided as needed to prevent intervention fatigue or overstimulation of flow.

4.1.3 The Present Research

Based on the aforementioned considerations with regard to the intervention type and adaptivity, we cover two major RQs in the present research. First, we aim for evaluating the flow-promoting effect of MC in knowledge work. Assuming that setting clear goals and disengaging from unattainable or undesirable goals enables individuals to autonomously engage in tasks with a higher likelihood of inducing flow, we expect that MC increases flow compared to a simple goal-setting strategy (Hypothesis 1). The second aim of our study is to evaluate whether a smartphone-based JITAI excels a static intervention with regard to its effect on flow at work. More specifically, we expect that the use of an adaptive decision rule for when the person receives support is more helpful for increasing flow compared to a static, non-adaptive prompt (Hypothesis 2).[7]

Our study contributes to flow research at the intersection of psychology, IS, and HCI in at least two major ways. First, by assessing the potential of the metacognitive strategy MC with regard to promoting flow in knowledge work, we provide a simple, time- and cost-efficient approach which can help knowledge workers autonomously influence their flow. Since smartphones are portable and ubiquitous in everyday work, we specifically provide a smartphone-based intervention, accelerating the potential of our approach for use in an applied context. As a second contribution, we evaluate the usefulness of an adaptive compared to a static decision rule for promoting flow at work. Identifying an appropriate

[7] Both hypotheses were preregistered on June 12th, 2023. Please note that the naming of the effects of interest was changed to enhance clarity (https://osf.io/a42xr/?view_only=294dc6d663a54fc29f1a15cc6b0adece).

tailoring variable and its respective decisive values for when to provide support as part of an adaptive decision rule is essential for building a comprehensive flow-adaptive system. This system could function as the underlying architecture for providing flow-promoting JITAIs in everyday life independent of specific intervention type.

4.2 Material and Methods

4.2.1 Procedure and Participants

The study took place in three waves[8] in July and August 2023. Each participant completed the study in two weeks, which started and finished with a session in the laboratory. In between these introductory and final sessions, we applied smartphone-based AA.

In the introductory session, after obtaining informed consent, we provided participants with a smartphone (Android system) with the pre-installed app movisensXS (version 1.5.23, Movisens GmbH, Karlsruhe, Germany, 2022). Alongside this, participants provided demographic data, completed a baseline measure of flow proneness, took part in a practice session for the intervention type (see Appendix 3.1 for full instructions), and received information for the next part of the study. The smartphone-based AA and application of the intervention type then took place over five consecutive workdays (Monday through Friday). After this part of the study, we instructed participants to return the smartphone to the lab, complete a follow-up measure of flow proneness, give feedback on the intervention type, and provide payment details. We determined compensation according to the local minimum wage and dependent on the amount of time devoted to answering the e-diaries. We offered an extra incentive of 10 EUR if participants completed more than 80 % of the e-diary queries.

Based on power estimates from Monte Carlo simulation (Arend & Schäfer, 2019)[9], we recruited $N = 59$ knowledge workers (26 females, $M_{age} = 23.1$, $SD_{age} = 3.1$) from a pool for experimental studies at the Karlsruhe Institute of Technology. To guarantee that

[8] We randomly distributed assignment of participants to the experimental conditions over all waves.

[9] We consulted simulation-based estimates that acknowledged our primary interest in Level 2 effects (see section "Data Analysis" below), a target statistical power of at least .80, an expected medium intraclass correlation coefficient (see results reported in Chapter 3), and medium expected effect sizes based on earlier studies evaluating the effect of MC (e.g., Oettingen et al., 2010).

participants were sufficiently engaged in knowledge work, we required them to perform mental tasks such as preparing for an exam or writing code for at least four hours per day during the study period of five days. In accordance with this expectation (since we observed a time period of 10.5 hours per day), participants reported to work at the time of observation in 58.3 % of observations (*SD* = 14.2 %). The study received approval from the local data protection office and ethics committee on April 19th, 2023.

4.2.2 Ambulatory Assessment Procedure

Since we were interested in participants' flow state during their everyday work tasks, we used time-based random sampling, i.e., we prompted eight e-diary queries per day between 9 am and 7.30 pm (regular local working hours) with at least 30 minutes between two queries. We announced pending queries via an acoustic notification on the smartphone. They could be postponed for ten minutes. In the e-diaries, we asked participants about their current task (i.e., what they were doing right before the query), flow state, and skill-demand-balance. Each day, there was an additional e-diary query at 7.30 pm (which participants could postpone for an hour) asking retrospectively about overall flow experience during the day.[10]

Over all five days, participants answered *N* = 2178 queries (*n* = 1886 e-diary queries during the day, *n* = 244 evening e-diary queries). The mean compliance rate was *M* = 80.23 % (*SD* = 15.06) across all queries with similar participation on all days.

4.2.3 Experimental Manipulation

For evaluating our two RQs, we experimentally manipulated the *intervention type* (MC or a control goal-setting strategy), and the *decision rule* determining when participants received flow support (adaptive or static). Thereby, there were four conditions (MC-adaptive, MC-static, control-adaptive, control-static) to which we randomly assigned participants in the introductory session (based on a computer-generated random number sequence; *n* = 15 in all groups except for control-static with *n* = 14). In sum, all participants acquired a

[10] This e-diary also included items on work performance and stress. As these measures were not relevant to the present RQs, we do not report them in this chapter.

metacognitive strategy for application in everyday life while the type of strategy and the mechanism for prompting the use of the strategy differed depending on condition.

4.2.3.1 Intervention Type

The introductory session included a practice session in which participants worked through written computer-based instructions (see Appendix 3.1) for acquiring the intervention type (MC or a control goal-setting strategy). In all four conditions, we told participants that they would learn a mental strategy to increase their motivation and change their behavior at work.

In the MC condition, participants learned how to apply MC according to the sequence used in prior research (e.g., Oettingen et al., 2010, 2015). For that, participants first identified their most important, yet attainable wish with regard to their work tasks in the upcoming week. Then, they needed to write down the very best outcome of fulfilling this wish in a few words and to vividly imagine this outcome in their mind. After that, they wrote down their thoughts and images in a few sentences. Lastly, they needed to identify the most important inner obstacle that may hold them back from fulfilling the wish, for example an emotion, a belief, or an ingrained habit. Again, we prompted them to vividly imagine this obstacle and then to write down their thoughts in a couple of sentences (for examples, see Appendix 3.2). Next, to strengthen the acquirement of MC as a metacognitive strategy (i.e., for applying it across contexts), participants completed a second written round of the aforementioned sequence, this time with regard to a wish about their interpersonal relations at work. Additionally, to illustrate that they can use MC just mentally (rather than writing down their thoughts and images) and with regard to shorter timeframes, we asked participants to complete a third round of MC. They should identify a wish relating to their work tasks in the next 24 hours. Then, we provided step-by-step instructions for vivid imagination again, but no instructions to write down their thoughts. Last, we reminded them of the three steps of the strategy (wish, outcome, obstacle).

Since Weintraub et al. (2021) found that setting SMART goals promoted flow at work, we decided to use this goal-setting strategy as an active control condition for evaluating the effectiveness of MC. In the control condition, participants learned how to set SMART goals

(i.e., specific, measurable, attainable, relevant, and time-bound goals) analogously to the MC condition, i.e., they completed three learning rounds in which they set goals with different content and timeframes.

At the conclusion of the practice session with a total duration of no longer than twenty minutes, we asked participants to apply the acquired strategy with regard to their work every day in the upcoming week. We reminded them of this request during their everyday life depending on decision rule (see below).

4.2.3.2 Decision Rule

In JITAIs, the decision rule operationalizes under which circumstances which intervention option is offered to the person (Nahum-Shani et al., 2018). In our study, independent of specific intervention type (MC versus control), there were two intervention options: either to prompt participants each day during the AA period of five days to apply the acquired intervention type, or to omit this prompt. If given, the prompt occurred in the morning (at 8.30 am) and reminded participants of the respective components of their acquired strategy. It asked them to apply the strategy on a work-related concern of their choice that they wanted to address over the course of the day. Since intervention options of JITAIs should be applicable in a short amount of time during everyday life (Nahum-Shani et al., 2018), we did not require participants to write down their thoughts, so that the whole response to the prompt would not last longer than a couple of minutes. Indeed, the maximum time spent with answering a morning prompt was 4.5 minutes. If participants received a prompt, they could postpone it for half an hour. We asked them to answer it before they started working.

We located the decision point for whether or not to present this prompt in the previous day. The decision rule also needs a decisive value, i.e., a cut-off in the tailoring variable that determines prompt presentation. Due to the risk of setting a suboptimal threshold when transforming continuous flow scores into categorical classifications (Abuhamdeh, 2020), we did not use the repeated reports of flow state over the day (reported on a continuous scale) as the tailoring variable. Instead, we used the retrospective categorical flow report provided once per day in the evening diary (see sections 4.2.2 and 4.2.4.1). Visual inspections implied that mean flow state during the day and the retrospective flow report in the

evening diary corresponded with each other (Figure 8). In line with that, Spearman-Brown correlation between mean flow state (aggregated per day) and the respective daily flow report was moderately positive (Cohen, 1992) within- (r = .47) and between-subjects (r = .54). This congruent estimation of daily flow by the two measures suggested that our tailoring variable provided a valid estimation of overall flow experience over the day for use in the adaptive decision rule.

The adaptive decision rule was as follows: If participants reported in the evening that they had experienced flow at most once during the day, they then received a prompt the morning after. If they had experienced flow more often than once, they did not receive a prompt in the next morning. By comparison, in the static condition, participants received the prompt every morning, i.e., independent of the answer to the tailoring variable (for an overview of decision rule in the adaptive compared to the static condition, see Figure 9). In sum, participants in all conditions received a prompt on Monday morning[11], whereas the presentation of prompts on the other days, i.e., Tuesday to Friday depended on the condition[12].

Participants in the static condition received M = 4.93 prompts compared to M = 3.77 prompts in the adaptive condition[13]. Statistical comparison of this difference with a Wilcoxon test (Shapiro-Wilk: $p < .05$) supported a significantly higher number of presented prompts in the adaptive compared to the static condition (W = 194, $p < .001$) indicating successful manipulation of decision rule. Since participants could ignore the prompt, the number of presented prompts could deviate from actual attendance to the prompts. On average, participants attended to 90.2 % of presented prompts. There was no statistically significant difference in attendance to presented prompts between the adaptive and the static condition (M_{static} = 90.5 %, $M_{adaptive}$ = 89.8 %; p = .233).

[11] Since there was no flow report from the preceding day available on the first study day (Monday), we presented a prompt to all participants on this day.
[12] If participants in the adaptive condition did not answer the tailoring variable in the evening, the prompt was shown by default in the next morning.
[13] Please note that there was a technical problem due to which two participants in the static condition did not receive a prompt on the last day of the observation period.

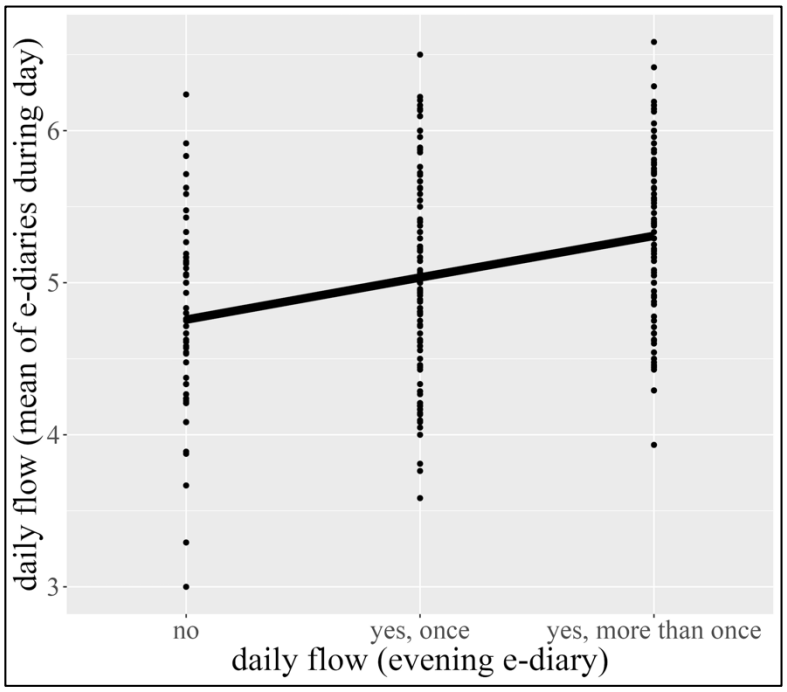

Figure 8 Association between flow reports (mean reported flow state during day compared to retrospective report of daily flow in the evening)

Note. Thick line indicates mean association.

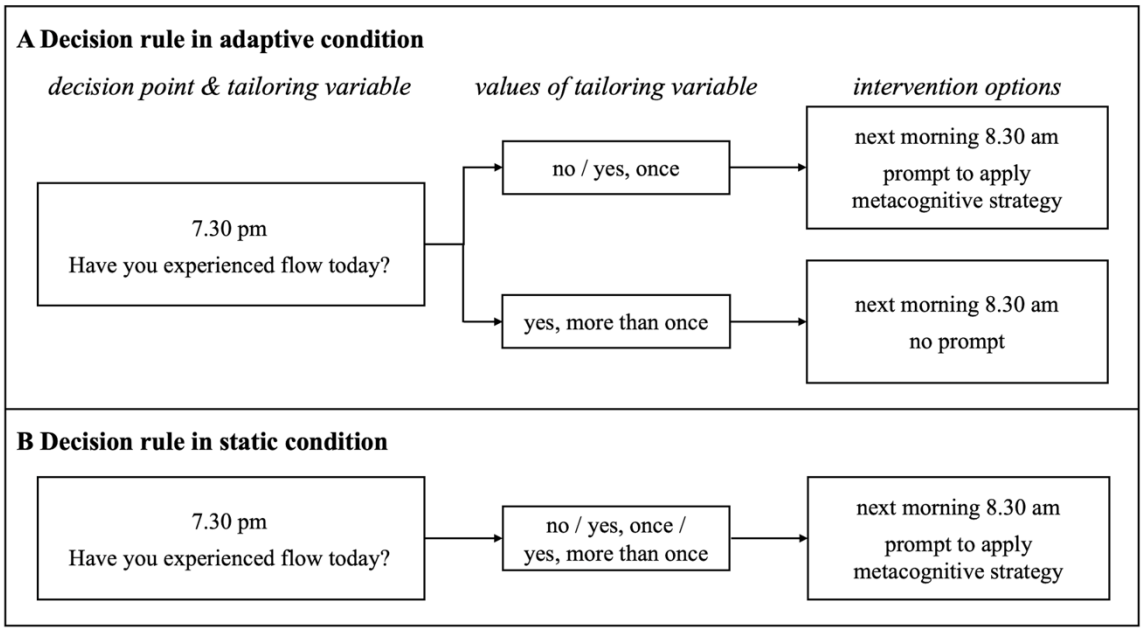

Figure 9 Decision rule in comparison between conditions

Note. In the adaptive condition (A), the morning prompt was presented to the participants depending on the answer to the tailoring variable "Have you experienced flow today?". In the static condition (B), the prompt was presented every morning independent of the answer to the tailoring variable.

4.2.4 Measures

Please refer to Appendix 3.9 for the exact wording of items, respective answer scales, and sources.

4.2.4.1 Flow

In the e-diaries during the day, we operationalized flow state with three items from the FKS (Engeser & Rheinberg, 2008; Rheinberg et al., 2015), specifically the highest loading items for each of the two factors of the original scale (Rheinberg et al., 2003). Study 1 (see Chapter 3) showed similarly good reliability and validity of this reduced scale compared to the full scale. The reduced scale consists of three statements (items 6, 8, and 9 of the original scale, e.g., "I am totally absorbed in what I am doing") (Engeser & Rheinberg, 2008; Rheinberg, 2015). [14] Participants indicate their agreement with these statements on a seven-point Likert scale from "not at all" (1) to "very much (7). We computed the mean across the three items with higher scores indicating higher flow state. Reliability (McDonald's Omega ω; Geldhof et al., 2014) was comparably high as in the validation study (within-subject: ω = .68, between-subjects: ω = .88).

In the evening e-diary, we additionally measured daily flow by using an ordinal item ("Have you experienced flow today?") with possible answers "No" (0), "Yes, once" (1), or "Yes, more than once" (2). We defined flow by showing different quotes to the participants in the introductory session (Moneta, 2012, p. 494; adapted from Csikszentmihalyi & Csikszentmihalyi, 1988): "My mind isn't wandering. I am totally involved in what I am doing, and I am not thinking of anything else. My body feels good … the world seems to be cut off from me … I am less aware of myself and my problems." "My concentration is like breathing … I never think of it … When I start, I really do shut out the world." "I am so involved in what I am doing … I don't see myself as separate from what I am doing."

[14] The English version of the FKS (Engeser & Rheinberg, 2008) has been made publicly available for free use by Rheinberg (2015). In addition, the German scale (see Rheinberg et al., 2019; https://doi.org/10.23668/psycharchives.4488) has been shared under a Creative Commons ShareAlike 4.0 License (https://creativecommons.org/licenses/by-sa/4.0/).

4.2.4.2. Proneness to Experiencing Flow at Work

To measure the general proneness to experiencing flow at work (i.e., independent of a particular event) as a baseline measure, we applied the full version of the FKS (Engeser & Rheinberg, 2008; Rheinberg, 2015; ten items with a two-factorial structure as described above) in the introductory session (before the practice session for the intervention type). To capture potential changes after the intervention, we reapplied the measure when participants returned the smartphone to the lab. We asked participants to indicate their agreement with the statements regarding their work-related activities. Reliability (McDonald's Omega ω; Geldhof et al., 2014) was good within- (ω = .87) and between-subjects (ω = .76).

4.2.4.3 Task

In the e-diaries during the day, we asked participants to indicate their current task. We provided the question as a single-choice item with possible answers being work, obligations, leisure and other. To measure the flow precondition of a skill-demand-balance, we also let participants indicate the perceived degree of the task demands with regard to them personally from "too low" (1) to "too high" (7) (Engeser & Rheinberg, 2008) with "just right" (4) indicating optimal balance. Since earlier studies show that flow declines for deviations from this balance in either direction (Huskey et al., 2018; Keller, Ringelhan, et al., 2011; Tozman et al., 2015), we subtracted ratings of 4 from the answers and computed absolute values so that zero equals optimal balance and positive values indicate deviation from this balance in either direction.

4.2.4.4 Feedback about Intervention Type

At the end of the study, we applied a feedback questionnaire in which participants indicated their satisfaction with the intervention type ("I will use the strategy again") on a five-point Likert scale from "completely disagree" (0) to "completely agree" (4). They also reported if they had fulfilled all their formulated goals yet and if they used the strategy more than once on a single day (0 = no, 1 = yes).

4.2.5 Data Analysis

We performed all data analyses in R Studio (Version 2023.06.2) with the packages multilevelTools (Wiley, 2020), misty (Yanagida, 2023), esmpack (Viechtbauer & Constantin,

2023), lme4 (Bates et al., 2023), and nlme (Pinheiro et al., 2023). For analyzing the AA data, we computed two-level linear mixed models to account for the nested data structure with repeated observations (level 1, n = 1886) within participants (level 2, N = 59). We used a stepwise approach to evaluate changes in flow state[15]. First, we computed the null model (random-intercept-only model) to evaluate within- and between-subject variability in flow state when none of the predictors of interest were included. We then entered the intervention type (0 = control, 1 = MC) and the decision rule (0 = static, 1 = adaptive) as predictors at Level 2, controlling for skill-demand-balance (person-mean centered, Level 1) and flow proneness at baseline (grand-mean centered, Level 2) (Model 1)[16]. Since the intervention type was prompted multiple times over the course of the AA period, we next added the effect of time (i.e., number of observations, Level 1) and two-way interactions between decision rule and time as well as intervention type and time to account for possible changes of effects over the week (Model 2). We centered the predictor time with zero being the last observation (i.e., the last e-diary query on Friday afternoon). This was due to the fact that all participants received a prompt on Monday morning independent of condition. Fisher's exact test did not indicate significant differences between the static and the adaptive condition in whether participants actually responded to this first prompt (p = .707). Thus, we could not interpret the effect of the decision rule for the first day (i.e., the first eight observations). Since participants had formulated the wishes or goals with regard to their work, we then added a fixed effect for the task type (0 = working, 1 = not working) to the model (Model 3). To further assess whether effects differed depending on flow proneness at baseline, we added this variable as a moderator for the effects of decision rule and intervention type as well as for the two-way interactions of these effects with time (Model 4). Lastly, we evaluated whether the effects of the intervention type and the decision rule on flow state interacted by adding a two-way interaction between rule and type to the model[17] (Model 5). All models included random effects for level 1 variables (see Appendix 3.3 for an overview of Models). We evaluated model fit with chi-square difference

[15] Please note that the preregistration reports the full model including all predictors of interest (as in Model 5).
[16] Please note that flow proneness, but not skill-demand-balance were preregistered as a potential control. When analyzing the data, we realized that we needed to control for this variable since flow depends on presence of a skill-demand-balance (Engeser & Rheinberg, 2008).
[17] We did not include the interaction effects with flow proneness (see Model 4) in this model due to convergence issues.

tests based on log-likelihood values comparing the nested models sequentially according to their increasing complexity (i.e., null model with model 1, model 1 with model 2, etc.).

4.3 Results

Descriptive statistics for the variables measured in e-diary queries, baseline and follow-up questionnaires are presented in Table 6. Overall, participants reported moderate flow state (M = 5.05, SD = 1.09). Accordingly, in the majority of evening e-diaries, they reported that they had experienced flow at least once (76.6 % of observations). According to the null model, less than 20 % of variability in flow state were due to between-person differences (ICC = 0.18). This dominance of within-subject variability supports our use of AA for measuring changes in flow state.

	M_{Total} (SD)	ICC	M_A (SD_A)	M_S (SD_S)	M_M (SD_M)	M_C (SD_C)
Flow state	5.05 (1.09)	0.18	5.04 (1.03)	5.06 (1.15)	5.02 (1.08)	5.08 (1.10)
Daily flow[a]	33.6 %	0.27	36.3 %	30.8 %	32.3 %	35.0 %
Skill-demand-balance	0.82 (0.83)	0.15	0.85 (0.83)	0.79 (0.84)	0.89 (0.83)	0.78 (0.83)
Flow proneness		-				
Baseline	4.05 (0.78)	-	4.23 (0.92)	3.87 (0.58)	4.00 (0.90)	4.11 (0.65)
Follow-up	4.33 (0.77)	-	4.39 (0.76)	4.26 (0.80)	4.20 (0.72)	4.47 (0.82)

Table 6 Descriptive statistics of variables assessed in e-diaries, at baseline and follow-up compared between conditions

Note. Flow state (rated on a seven-point Likert scale from one to seven) and skill-demand-balance (0 = balance; positive values indicate deviation from balance in either direction) were reported in the e-diaries during the day (Level 1, n = 1886 observations) by the participants (Level 2, N = 59). Daily flow (single-choice item with possible answers "No", "Yes, once", or "Yes, more than once") was reported in the evening e-diary (Level 1, n = 244 observations) by the participants (Level 2, N = 59). Flow proneness (rated on a seven-point Likert scale from one to seven) was reported at baseline (N = 59) and follow-up (N = 58). ICC = Intraclass correlation coefficient. A = adaptive, S = static, M = MC, C = control.

[a] Proportion of "Yes, more than once" responses reported instead of mean scores and standard deviations due to the single-choice variable

	df	AIC	BIC	χ^2	$\Delta\chi^2$	dfΔ	*p*
Null model	3	5416.75	5433.37	-2705.37	-	-	-
Model 1	10	5301.04	5356.47	-2640.52	129.70	7	< .001
Model 2	16	5285.88	5374.56	-2626.94	27.16	6	< .001
Model 3	21	5220.02	5336.41	-2589.01	75.86	5	< .001
Model 4	25	5219.03	5357.58	-2584.51	8.99	4	.061
Model 5	22	5220.46	5342.39	-2588.23	1.56	1	.212
Model 6	31	5292.58	5464.39	-2615.29	-	-	-

Table 7 Model fit information for the linear mixed models predicting flow state

Note. Chi-square difference tests indicate relative superiority to the next nested model (i.e., Model 1 compared to Null Model, Model 2 compared to Model 1, etc.). Model 5 was compared to Model 3 since it was not nested in Model 4. Model 6 was not compared to the other models with chi-square difference tests since it had a three-level structure instead of two levels. For an overview of models with included random and fixed effects see Appendix 3.3.

4.3.1 Changes in Flow State Due to Intervention Type and Decision Rule

Both the effects of the decision rule and the intervention type interacted significantly with time (Model 2, both $p < .05$) indicating that changes in flow state evolved differently over time depending on conditions (Figure 10). In line with that, including the effect of time and two-way interactions between time and the two predictors of interest (Model 2) significantly improved model fit compared to Model 1 that did not account for these time-related changes ($p < .001$, Table 7). Hence, we will first report the results of Model 2 in more detail before acknowledging differences in effects when including potential covariates.

For a typical person in the control condition who received prompts every morning, flow state was 5.24 when all other predictors were zero (i.e., at the last observation, for a person with average flow proneness, for an observation with individually average skill-demand-balance). Flow state did not differ significantly between this person and a person from the MC condition ($B_{\text{Type}} = 0.15$, $p = .357$). However, flow state was significantly lower for a person who received prompts adaptively ($B_{\text{Rule}} = -0.43$, $p = .012$, $d = -0.41$). Also, flow state increased significantly less over time for individuals receiving adaptive prompts (compared to static), $B_{\text{Rule X Time}} = -0.02$, $p < .001$, and significantly more for individuals applying MC (compared to control intervention type), $B_{\text{Type x Time}} = 0.01$, $p < .050$ (Table 8). Thus, these results confirm our first hypothesis indicating a significant advantage of MC

compared to control over time. They do not confirm our second hypothesis that the adaptive compared to the static decision rule significantly increases flow.

	Model 2			Model 3		
	Estimate	(*SE*)	95 % CI [LL, UL]	Estimate	(*SE*)	95 % CI [LL, UL]
Intercept	5.24***	0.14	4.95, 5.52	5.21***	0.14	4.93, 5.49
Rule	-0.43*	0.17	-0.77, -0.10	-0.43*	0.16	-0.75, -0.10
Type	0.15	0.16	-0.18, 0.48	0.10	0.16	-0.22, 0.42
Time	0.01	0.00	0.00, 0.01	0.01	0.00	0.00, 0.02
Task	-	-	-	0.12	0.08	-0.03, 0.28
Skill-demand-balance	-0.21***		-0.29, -0.12	-0.21***	0.04	-0.30, -0.13
Flow proneness (baseline)	0.27***		0.12, 0.43	0.28**	0.08	0.12, 0.43
Rule x Time	-0.02***	0.01	-0.03, -0.01	-0.02***	0.00	-0.03, -0.01
Type x Time	0.01*	0.01	0.00, 0.02	0.01	0.00	0.00, 0.02

Table 8 Influence of decision rule and intervention type on flow state over time

Note. Level 1: n = 1886 observations; Level 2: N = 59 participants. Dichotomic variable for decision rule (0 = static, 1 = adaptive), intervention type (0 = control, 1 = MC), and task (0 = work, 1 = other). Time centered for end of observation period (0 = last observation). Models controlled for skill-demand-balance and flow proneness at baseline. Person-mean centered variable for skill-demand-balance. Grand-mean centered variable for flow proneness at baseline. CI = Confidence interval, LL = Lower level, UL = Upper level.
$^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$

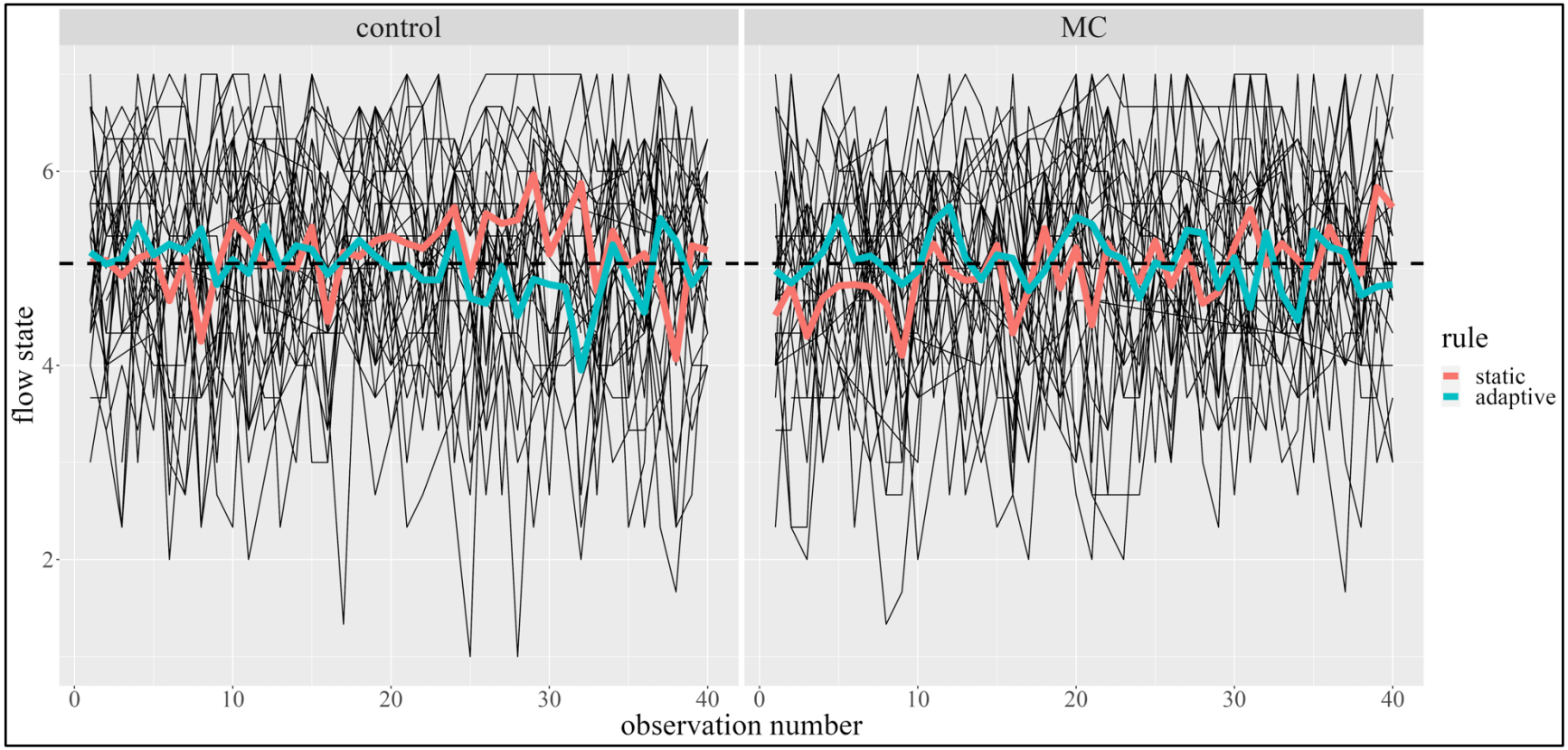

Figure 10 Spaghetti plot for flow state over time depending on intervention type and decision rule

Note. Thin black lines indicate individual change; thick colored lines indicate mean change; dashed line indicates average flow state. Flow state increased less over time for individuals receiving prompts based on the adaptive decision rule (compared to static), and significantly more for individuals applying MC (compared to control intervention type).

4.3.2 Potential Covariates and Their Effect on Flow

While the estimates of Model 2 apply for all observations independent of task type, the estimates of Model 3 apply for observations during work (because task type was coded as 0 indicating working) (see Table 8 for direct comparison between estimates of Models 2 and 3). Adding the effect of task type to the model (Model 3) significantly improved model fit ($p < .001$, Table 7). However, whether a person worked or not did not significantly influence flow state ($B_{Task} = 0.12$, $p = .122$). Since adding flow proneness as a moderator for the effects of decision rule and intervention type on flow change over time (Model 4) or adding a two-way interaction between decision rule and intervention type (Model 5) did not significantly improve model fit ($p = .109$ and $p = .212$, Table 7), we will not discuss the results of Models 4 and 5 further.[18]

One may assume that the significant negative effect of the adaptive decision rule on flow state does not necessarily point to a disadvantage of the adaption. Rather, this finding could indicate that it matters whether participants attended to the prompt for applying the intervention type. To rule out this explanation, we computed an additional exploratory three-level model (Model 6; Level 1: $n = 1886$ observations over day, Level 2: $n = 292$ daily observations, Level 3: $n = 59$ participants). The included predictors were similar to Model 2 except for the time variable (number of days instead of observations due to the three-level structure) and an additional predictor indicating whether participants received and then also attended to the prompt in the morning (0 = no[19], 1 = yes). Since this predictor remained constant over each day, the three-level structure was needed. Results showed that attendance to the prompt did not significantly influence flow state[20], $B_{Prompt} = -0.08$, $p = .396$. Most importantly, while controlling for this effect, the adaptive decision rule still significantly negatively influenced flow state compared to the static one ($B_{Rule} = -0.44$, $p = .008$, $d = -0.41$) (see Table 9 for complete results of Model 6).

[18] The interest reader may find the results of Model 4 in Appendix 3.4.
[19] "No" indicates that participants either did not receive a prompt in the first place (due to the adaptive condition) or they received a prompt but ignored it.
[20] When all other predictors were zero (i.e., last day of observation, average flow proneness, individually average skill-demand-balance, control intervention type).

	Estimate	(*SE*)	95 % CI [LL, UL]
Intercept	5.31***	0.16	5.00, 5.62
Rule	-0.44**	0.16	-0.76, -0.12
Type	0.12	0.15	-0.19, 0.12
Day	0.06+	0.03	-0.01, 0.13
Prompt	-0.08	0.09	-0.27, 0.10
Skill-demand-balance	-0.21***	0.04	-0.29, -0.12
Flow proneness (baseline)	0.28***	0.08	0.12, 0.44
Rule x Day	-0.15***	0.04	-0.23, -0.08
Type x Day	0.08*	0.04	0.01, 0.16

Table 9 Exploratory results from Model 6 controlling for the effect of prompting

Note. Level 1: n = 1886 observations over day; Level 2: n = 292 daily observations, Level 3: N = 59 participants. Dichotomic variable for decision rule (0 = static, 1 = adaptive), intervention type (0 = control, 1 = MC), and prompt (0 = no, 1 = yes). Day centered for end of observation period (0 = last day). Person-mean centered variable for skill-demand-balance. Grand-mean centered variable for flow proneness at baseline. CI = Confidence interval, LL = Lower level, UL = Upper level.
$^{+}p < .10$, $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$

4.3.3 Differences in Flow Proneness

A one-way ANOVA revealed no significant differences in proneness to experiencing flow at work between the four groups at baseline, $F(3, 55) = 1.19$, $p = .322$, indicating successful randomization of participants to conditions. Since all participants received an intervention, we generally expected increases in flow independent of the intervention type and the decision rule. In line with that, flow proneness was higher at follow-up compared to baseline over all participants ($M_{\text{Difference}} = 0.27$, $SD_{\text{Difference}} = 0.63$).[21] A one-tailed t-test for paired samples (Shapiro-Wilk: $p = .073$) confirmed significantly higher flow proneness at follow-up compared to baseline independent of conditions, $t(57) = 3.31$, $p = .001$.

4.3.4 Differences in Feedback About Intervention Type

Descriptive statistics from the feedback questionnaire can be found in Appendix 3.6. On average, participants planned to use the intervention type again after the study (M = 3.19

[21] Although this increase in flow proneness from before to after the intervention indicates the effectiveness of our intervention independent of the specific intervention type and decision rule, these changes could also arise because of changes in the understanding of the measure (i.e., for example because participants were more aware of their flow states at the end of the study since they had reported their flow repeatedly over the week). Hence, we do not report the full results on these changes in flow proneness here. The interested reader may find them in Appendix 3.5.

on a five-point Likert scale from 0 to 4) with no significant difference due to intervention type ($W = 318$, $p = .085$). However, participants reported significantly less often that they had used the strategy repeatedly per day in the MC compared to the control condition, $\chi^2(1) = 5.28$, $p = .022$. At the end of the study, most participants in the control condition reported that they had fulfilled all their formulated goals, whereas only half of the participants who used MC agreed with that. However, this difference in goal fulfillment was not significant, $\chi^2(1) = 1.96$, $p = .162$.

4.4 Discussion

In an AA study covering five consecutive workdays, we evaluated the flow-promoting effect of a smartphone-based JITAI that prompts the application of metacognitive strategies in knowledge work. Even though we found that using these strategies generally increased the proneness to experiencing flow independent of the specific type of strategy, our results indicate that in the long-term MC might be more helpful for increasing flow state than setting SMART goals. In contrast to what we expected, prompting the strategy adaptively, i.e., based on the person's previous flow experiences, was not beneficial for fostering flow. In the following sections, we will discuss how these results contribute to research and practice and review the limitations of our findings.

4.4.1 Contributions for Research and Practice

Our findings contribute to interdisciplinary research on the development of flow-promoting interventions for application in everyday life in two major ways. First, we showed for the first time that MC increases flow in knowledge work over the course of five consecutive workdays only. Since applying MC in the morning took only a minute on average and participants reported a high willingness to continue using the strategy after the study, our findings support MC as a user-friendly, digitally applicable, and quickly effective tool that can easily be integrated in everyday life without causing disruptions at work. In comparison with another goal-setting strategy already found to increase flow (setting SMART goals; Weintraub et al., 2021), our finding of a significant effect of the intervention type over time indicates that knowledge workers could especially benefit from using MC in the long run. Although the difference in goal fulfillment between intervention types was not statistically significant, the direction of the difference indicates that MC might encourage setting

preferences in terms of disengagement from goals for which outcomes are at odds with obstacles. Thereby, MC might grant higher autonomy than SMART goal-setting although this does not seem to impact flow state immediately. Possibly, setting SMART goals comes more easily, whereas participants may need a couple of tries to get involved with the more complex procedure of applying MC. Indeed, participants applying MC attended significantly longer to the morning prompt compared to participants setting SMART goals (see Appendix 3.7 for additional analysis). Importantly, while participants used MC significantly less often per day compared to SMART goal-setting, flow state increased more over time in the MC condition. Hence, our results indicate that even though it takes longer to follow the MC sequence, this strategy needs to be applied less often to be at least as effective as setting SMART goals (Weintraub et al., 2021). This is especially promising when aiming for applying the intervention in everyday knowledge work because multiple interruptions over the day are not necessary.

As a second major contribution and in contrast to what we expected, our findings show that providing the intervention independent of the state of the individual was more helpful for promoting flow than use of a JITAI. At first, this finding seems to contradict the assumption that static interventions cause intervention fatigue, thereby decreasing interventional effectiveness (Heckman et al., 2015; Nahum-Shani et al., 2018). However, the process of habit formation may offer insight into why this effect did not appear in our study. Research agrees that consistent repetition of a behavior in stable contexts serves as the basis for habit formation (Carden & Wood, 2018; Lally & Gardner, 2013). In our study, the static condition provided such a stable context in that participants expected to receive a prompt every morning. By contrast, in the adaptive condition, they were not aware on which days they would receive a prompt. Hence, by providing regular reminders, the static intervention might have facilitated repetition, in our case application of the metacognitive strategy, which in turn increased flow. Indeed, Stawarz et al. (2015) found that use of reminders in smartphone-based applications facilitates repetition of wanted behaviors. Importantly, in our study, the advantage of prompting strategy use every morning (instead of adapted to the individual) was independent of whether participants attended to the prompt. Hence, we assume that the expectancy to receive a regular prompt was decisive for strategy repetition that then

increased flow.[22] Importantly, research indicates that habits do not necessarily form due to repetition alone. They only evolve when behavior becomes automatic (Carden & Wood, 2018; Lally & Gardner, 2013). In line with that, the increased repetition of behaviors due to the smartphone-based reminders in the study by Stawarz et al. (2015) was not associated with increases in automaticity. Instead, researchers cautioned against the potency of regular reminders to cause dependencies, in that individuals might then solely engage in the behavior when reminded (Renfree et al., 2016; Stawarz et al., 2015). This ultimately increases the likelihood to disengage from app usage, then also undermining the targeted habits (Renfree et al., 2016). In the next section, we will elaborate why the duration of our study does not allow to assess whether the potential increases in repetition due to the regular reminders in the static intervention also bore this risk and impeded long-term strategy use.

4.4.2 Limitations and Future Research

We only assessed changes in flow state over the course of five days. Hence, even though in our study, the static intervention increased flow state compared to the JITAI and became more effective over time, this linear effect is only based on the data from the observation period. Since our results indicate that the main effects of the intervention type and the decision rule change over time, this time period might have been too short to allow final conclusions. For example, even though the effect might reverse in the long term due to increases in intervention fatigue, our study period does not allow to assess these potential shifts. Thus, future research should investigate the long-term differences in promoting flow between a JITAI and a static intervention. On the same note, we cannot assess whether the static intervention increases repetition of strategy at first but causes participants to neglect the application in the long-term. Based on earlier research indicating that strengthening interconnection between wanted behaviors and contextual cues increases habit formation compared to reminders alone (Stawarz et al., 2015; Wicaksono et al., 2019), we suggest future research to examine whether letting participants choose a contextual cue for applying

[22] One potential reason for this finding would be differences between conditions regarding the time spent with responding to the morning prompt (i.e., the time from opening to closing the query). However, the length of attendance to the prompt did not differ significantly depending on decision rule (see Appendix 3.7 for complete results of this exploratory analysis) indicating that participants did not attend to the prompt more shortly in the adaptive compared to the static condition.

the mental strategy (e.g., applying the strategy every time when starting the computer) increases strategy application, thereby enhancing the effect on flow.

The negative effect of the JITAI compared to the static intervention could also imply that our choice of the tailoring variable was not ideal. Particularly, one important limitation arose when participants did not answer the tailoring variable because we then lacked information for whether to present the prompt. Since we decided to provide the prompt in this case, this could have confounded the effectiveness of the adaptive mechanism. However, when excluding these observations from the dataset, the directions of effects do not change (see Appendix 3.8). Nevertheless, future research could use more objective measures for the tailoring variable so that it does not depend on individual compliance. For example, earlier research suggests that heart rate variability may inform about flow likeliness by indicating if a person is relaxed or stressed (e.g., Rissler et al., 2018; Tozman et al., 2015). Since novel technologies allow measurement of such physiological data in real-time using non-obtrusive devices such as smartwatches (Alugubelli et al., 2022; Dobbs et al., 2019), this approach would be easily integrable in everyday work.

Apart from these limitations regarding the adaptive mechanism, the just-in-time provision of support is a major determinant of the effectiveness of JITAIs (Nahum-Shani et al., 2018). In our study, we provided the strategy prompt in the morning assuming that this would be before participants started to work, thereby not intervening with their current flow. However, at the end of the study, some participants gave feedback that they worked different hours. Then, the morning prompt would either interrupt them or cause them to apply the strategy hours before they started working. Hence, we recommend incorporating individual working hours in the scheduling of the prompts, thereby improving the adaptivity as well as the just-in-time provision of support.

4.4.3 Conclusions

Despite these limitations, our findings from an AA study show that smartphone-based assistance can support flow in knowledge work by encouraging the use of metacognitive strategies. While the use of these strategies tends to enhance the likelihood of experiencing flow over the course of five workdays regardless of the specific type of strategy employed, our findings suggest that MC may be especially effective in fostering flow over the long term. In addition, our study highlights that adaptive support does not necessarily excel individual-independent support when aiming for promoting flow in knowledge work. Due to the exploratory nature of our intervention design, we argue though that this finding should not be interpreted as general advice against using interventions with adaptive mechanisms for promoting flow. Rather, we recommend evaluating longer periods of intervention application to examine differences between adaptive and static support regarding habit formation and intervention fatigue.

CHAPTER 5

Conclusion and Outlook

In today's digital world of work, individuals often experience a decrease in work engagement and are at risk of burnout (Marsh et al., 2022). Promoting flow, which is the experience of complete absorption and fluency in the current activity (Engeser & Rheinberg, 2008), has the potential to counteract these negative trends (Aust et al., 2022; De Fraga & Moneta, 2016; Mosing et al., 2018; Weintraub et al., 2021). Flow at work is associated with individual benefits, such as reduced stress, enhanced energy in leisure time, and increased job satisfaction (Demerouti et al., 2012; Maeran & Cangiano, 2013; Weintraub et al., 2021). Additionally, it produces beneficial outcomes that extend beyond individual well-being, such as improved individual and team performance (Aubé et al., 2014; Engeser & Rheinberg, 2008; Weintraub et al., 2021). Therefore, experiencing flow at work is not only desirable for individuals but also a promising goal for managers and organizations. To harness this potential of flow promotion, this dissertation develops and evaluates a smartphone-based intervention with an adaptive mechanism (a so-called JITAI) that promotes flow in everyday knowledge work.

To achieve this objective, this dissertation includes three RQs outlined in Chapter 1. RQ 1 focuses on the modes of action of flow-promoting interventions and a systematic agenda for intervention development. RQ 2 addresses the relevant methodological decisions required to adaptively provide the intervention and evaluate its effectiveness. Finally, RQ 3 asks about the actual effectiveness of the smartphone-based JITAI for promoting flow in everyday knowledge work. To answer these RQs, a conceptual analysis (see Chapter 2) and two experimental field studies (for Study 1, see Chapter 3; for Study 2, see Chapter 4) were conducted. Both studies were administered in everyday knowledge work instead of in the laboratory to enhance external validity of the findings because flow experiences may differ significantly when artificially evoked compared to occurring in everyday life.

In the following, the main findings of the conceptual analysis and the experimental field studies will be summarized with regard to the respective RQs and discussed in terms of their theoretical and practical contributions. Additionally, limitations of the dissertation will be addressed and avenues for future research will be derived. Finally, a comprehensive conclusion of the dissertation will be provided.

5.1 Main Findings and Contributions

This dissertation follows a sequential order, answering the RQs one after the other. This is necessary because developing the JITAI and evaluating its effectiveness requires establishing the overall potential modes of action of flow-promoting interventions and determining how to measure flow in everyday life. Thus, each RQ, along with its corresponding findings and contributions will be addressed sequentially in the following sections.

5.1.1 Aim, Target, and Executor of Flow-Promoting Interventions

The first RQ addresses the modes of action that interventions can generally follow to promote flow in everyday knowledge work, and how researchers can determine which one to apply. To answer it, a conceptual analysis based on a narrative review of research on the sequence of experiencing flow and the current availability of suitable interventions was conducted (see Chapter 2). The review reveals a fragmented empirical field rooted in various disciplines, including psychology, IS, and HCI. In contrast to other domains, such as sports and exercise (Goddard et al., 2021), there are only a limited number of interventions available so far to promote flow in knowledge work. Additionally, there is a lack of guidance on how to systematically proceed with intervention development to address this gap.

Based on this state of the theoretical and empirical field, a three-dimensional framework is presented (see Chapter 2) that provides three guiding questions for researchers who wish to promote flow in knowledge work but are uncertain about where to start. These questions aim to clarify the intervention's goal (entering, boosting, or maintaining flow), target (context, individual, or group), and executor (bottom-up or top-down). It is argued that the answers to these questions largely depend on the flow baseline of the planned sample (i.e., whether individuals in the planned sample experience flow before intervention), organizational conditions (e.g., the possibility to induce contextual changes), as well as the organizational involvement and the desired impact (e.g., whether the intervention shall be applied across various organizations). Guided by these questions, researchers have a starting point for systematically pursuing flow-promoting approaches in future studies. In the course of the present dissertation, these guiding questions are also consulted for the development of a flow-promoting JITAI, resulting in the decision to develop a JITAI that utilizes bottom-

up execution, targets the individual, and aims to assist individuals in transitioning to a state of flow (see Chapter 4). This approach enables self-initiated, autonomous promotion of flow independent of context and managerial engagement and is based on the recommendation to first ensure the establishment of the flow preconditions. While the JITAI evaluated in this dissertation aims to do so by using a metacognitive strategy to foster a balance between skills and demands (see Chapter 4), the developed framework generally allows for the evaluation of various intervention contents within the same dimensional subcategories. For example, another intervention that also fits the aim of entering flow, targets the individual, and allows for bottom-up execution could teach individuals to identify their strengths. This would help them choose tasks that match their skills, thereby also establishing a skill-demand-balance and fostering flow emergence (Liu et al., 2021; van Woerkom et al., 2016).

In addition to providing inspiration for developing flow-promoting interventions, the framework assists researchers in determining which effect of their intervention on flow can be expected. Specifically, the intervention's categorization in the first dimension, the intervention's aim, determines whether the intervention can increase the duration, intensity, or frequency of flow. This is important because certain effects may be more beneficial depending on the circumstances. For instance, increasing the frequency of flow may be helpful for samples in which individuals do not often experience flow, while increasing intensity may be beneficial for professions where individuals tend to experience flow but have difficulty maintaining the state. By addressing the skill-demand-balance, the JITAI evaluated in this dissertation (see Chapter 4) mainly aims to help people enter flow, which implies that it can impact flow frequency. Additionally, it is meant to enhance individuals' autonomy by allowing goal disengagement. Since autonomy moderates the emergence of flow (de Sampaio Barros et al., 2018), the JITAI also follows the aim of boosting flow. Hence, it can also affect flow intensity.

5.1.2 Measuring Flow Without Disrupting Everyday Experiences

The second RQ directly addresses how to measure the actual effect of a flow-promoting intervention. For answering that, Chapter 3 presents the results of Study 1 which evaluates how to capture flow in everyday knowledge work by applying AA over six days. In Study 1,

the observation approach was experimentally manipulated within-subject, so that each of the $N = 39$ participants provided self-reports about their flow with a momentary states approach and a coverage approach for three days respectively. Because collecting self-reports may disrupt everyday life, Study 1 applied a particularly short flow operationalization consisting of three items from the FKS (Engeser & Rheinberg, 2008; Rheinberg, 2015). Although we expected differences in compliance between the observation approaches due to the higher observation frequency in the momentary states approach, both approaches yield similarly high compliance. The only differences between the observation approaches are higher perceived burden and greater within-subject variability in flow reports in the momentary states approach and higher flow probability in the coverage approach.

Based on these findings, the momentary states approach is recommended for studies interested in intraindividual variability in flow. Capturing these fluctuations in detail may be necessary, for example, for building real-time flow classifiers based on neurophysiological data (e.g., as in Rissler et al., 2018). If researchers solely need to capture interindividual differences, the coverage approach is more recommendable though as it is less burdensome for participants. To further reduce the intrusiveness and burden of AA, the findings of Study 1 also suggest using the reduced version of the FKS to measure flow in AA, as its psychometric properties were comparably good to the full version of the scale. However, the findings also support the argument that using cut-off values to dichotomize continuous measures such as the FKS may impose flow on participants (Abuhamdeh, 2020; Moneta, 2012).

Therefore, overall, Study 1 contributes to facilitating the measurement of flow in everyday life by providing recommendations for the choice of observation approach and by offering a shortened measure of flow for future research. The results of Study 1 are also used directly in the design of Study 2. For example, due to the risks associated with dichotomizing continuous measures (Abuhamdeh, 2020; Moneta, 2012), Study 2 bases the decision rule of the JITAI on the categorical FQ instead of on the FKS. Since the findings of Study 1 indicate difficulties when combining the FQ with the FKS due to the distinct underlying flow concepts (Moneta, 2021), Study 2 addresses this issue by applying the measures separately and using them for different purposes. In Study 2, the reduced version of the FKS was

repeatedly administered throughout the day to evaluate the effectiveness of the intervention in increasing flow intensity. In contrast, the FQ was administered daily in the evening and provided the decisive value for the adaptive decision rule. The results of Study 2 and its contributions will be summarized in the following section.

5.1.3 Prompting Metacognitive Strategies Adaptively to Promote Flow

Study 2 aims to answer the third RQ, investigating whether a smartphone-based JITAI that encourages the use of a metacognitive strategy promotes flow in everyday knowledge work. It involves $N = 59$ knowledge workers who participated in an AA study over five days. In Study 2, the type of the intervention (prompting the use of MC or a control metacognitive strategy) and its adaptivity (prompting the metacognitive strategy depending on the individual's state or statically) were manipulated between-subjects. Contrary to our expectations, the JITAI does not outperform the static intervention in terms of its effectiveness in promoting flow. However, the results of Study 2 as presented in Chapter 4 confirm that metacognitive strategies increase flow, and MC may even have a long-term advantage over other strategies such as setting SMART goals.

While Study 2 focuses on the effect of MC on flow, MC has already been successfully used to positively influence other work-related behaviors. For example, it has been shown to motivate individuals to make an effort in other tasks (Sevincer et al., 2014), to improve time management (Oettingen et al., 2010), and to facilitate integration of feedback to support performance (Oettingen et al., 2012). Therefore, applying MC in knowledge work may be promising for inducing behavioral changes beyond promoting flow. This may be especially helpful for real-world application since organizational resources are often limited, increasing managerial preference for interventions that serve more than one purpose. Study 2 also highlights that traditional, user-independent interventions to induce these behavioral changes should not necessarily be replaced by interventions with adaptive mechanisms based on individual states. Instead, the findings of Study 2 suggest that statically prompting the intervention may facilitate repeated application. Indeed, research encourages the use of regular reminders for habit formation (Lally & Gardner, 2013; Stawarz et al., 2015). However, when applying reminders, desired behavior may not become automatic. Instead, it may disappear when reminders are not presented anymore (Renfree et al., 2016;

Stawarz et al., 2015). This is especially concerning when applying smartphone-based interventions because people tend to disengage from app usage after a while (Christensen & Mackinnon, 2006; Eysenbach, 2005).

Therefore, comprehensively, the findings of Study 2 suggest that the use of JITAIs for promoting flow should not be abandoned yet since they may be beneficial in the long run. JITAIs may be particularly helpful in promoting autonomy and reducing dependence on repeated reminders of the intervention. Regardless of the intervention's adaptivity, Study 2 highlights that individuals can quickly, easily, and autonomously foster their flow in knowledge work by mentally contrasting expected inner obstacles with promising outcomes of their work-related wishes.

5.1.4 Contributions for Practitioners

Building on the aforementioned contributions to research at the intersection of psychology, IS, and HCI, this dissertation also provides valuable insights for practitioners. For instance, people development professionals or managers can use the framework for classification and development of flow-promoting interventions to identify pathways to foster employees' flow. By utilizing the framework's three dimensions (aim, target, and executor of the intervention) organizations can clarify their specific needs, such as fostering flow in specific jobs or teams, while also considering limiting factors like budget size and number of persons involved. Additionally, organizations typically require data on the actual changes in expected outcomes after deployment of the chosen intervention to determine whether financial resources should be allocated to these projects again. It is important to gather this data quickly and unobtrusively to limit expenses and prevent employees from being disrupted from their job. Therefore, practitioners can benefit from the methodological recommendations and the short measure presented in this dissertation for capturing everyday flow. This dissertation also demonstrates that providing the metacognitive strategy MC as a smartphone-based intervention is easy, cost-efficient, and does not require managers' engagement. Instead, employees can use the strategy on their own after a short learning session. Furthermore, adapting the support provision to the individual may not be necessary to induce increases in flow. This is a promising conclusion for organizations because adapting interventions to each employee bears various disadvantages. For example, this requires

tracking employee's flow in real-time, which can be complex, costly, and demands extensive data protection. In summary, practitioners can learn from this dissertation that flow in knowledge work can be supported quickly and effectively by individuals themselves without requiring significant changes in employees' tasks or setting.

5.2 Limitations and Avenues for Future Research

While each article included in this dissertation discusses study-specific limitations (see Chapters 2, 3, and 4), there are also general limitations to this dissertation. These limitations arise from the subjectivity and intrusiveness of self-reports, the lack of contextual information, the neglect of flow duration, the absence of knowledge on further consequences, and the focus on the individual. These limitations may provide interesting starting points for future research, which will be discussed in detail in the following paragraphs.

5.2.1 Combining Objective Data and Self-Reports

As a first limitation, both empirical studies rely on self-reports to infer flow experiences. However, it is important to note that self-reports presume that "participants are both *able* and *willing* to observe and report" (Larsen & Fredrickson, 1999, p. 48). In flow research, both aspects may need to be questioned, as some participants may not recognize flow experiences as such, especially due to the flow-characteristic loss of self-consciousness (Nakamura & Csikszentmihalyi, 2012), and may be subject to conscious or unconscious biases, such as social desirability bias (Ganster et al., 1983; Moorman & Podsakoff, 1992). Social desirability bias is the tendency for individuals to engage in impression management or self-deception (Paulhus, 1984). For example, if individuals believe that reporting periods with absence of flow may have negative consequences, such as this information becoming available to their managers, they may exaggerate the frequency of flow at work. As described in Chapter 1, research has also found that individuals often would not consider work-related activities as flow-evoking, although they are actually more conducive to flow than leisure activities (Csikszentmihalyi & LeFevre, 1989; Engeser & Baumann, 2016). This may then lead individuals to underestimate their flow at work. Additionally, especially in AA with its repeated measurements, participants become used to answering self-reports. They may then tend to provide similar responses, which can compromise measurement

independence required for statistical analyses. Multilevel modeling can account for autocorrelation, i.e., for higher similarity between consecutive reports (Bolger & Laurenceau, 2013). However, it is difficult for researchers to determine whether a participant showing a response pattern actually had similar experiences or simply answered monotonously.

Due to these potential biases in self-reports, future research should consider using more objective measures for flow in addition to the self-reports. Recently, wearable sensors for capturing (neuro-)physiological data in real-time have become increasingly applicable in everyday life. For example, smartwatches that monitor health data or portable systems for measuring electroencephalography have been developed and applied for research purposes (Alugubelli et al., 2022; Debener et al., 2015; Dobbs et al., 2019). However, even though (neuro-)physiological data becomes more accessible in everyday life, a reliable biomarker for flow that can be measured outside the laboratory without substantial artifacts has not yet been identified (Peifer et al., 2022; Peifer & Tan, 2021). Behavioral data may be more readily available since it is often captured alongside the use of digital tools. For example, computers commonly save log data, and researchers have already used this data to infer participants' flow (Züger et al., 2017). This approach may also be convenient when applying smartphone-based interventions. For example, researchers could evaluate the frequency of smartphone use or track which apps are opened. This data may indicate whether individuals momentarily interrupt their work-related tasks, leaving a state of flow. Importantly, the aforementioned limitations of self-reports and presentation of potential objective measures should not be interpreted as a general advice against using self-reports to measure flow. Instead, the combination of both subjective and objective indicators of flow may improve the reliability and validity of flow measurements in future research.

5.2.2 Enhancing Self-Efficacy with Self-Tracking

Apart from their subjectivity, another important issue regarding the use of self-reports is measurement reactivity (Arslan et al., 2021; French & Sutton, 2010). To provide a self-report, participants must interrupt their current task, even if only briefly. This interruption can be considered as an intervention in that it may directly influence the variable of interest. As previously mentioned when introducing JITAIs and AA, a major concern with both of them is that participants may experience an abrupt decline in flow due to the interruption

(Bartholomeyczik et al., 2022; Züger et al., 2017). However, interrupting participants to provide a flow report may also increase their awareness of their flow experiences throughout the day, which could motivate them to engage in flow-promoting tasks more frequently. Then, interrupting participants to provide a self-report may eventually enhance flow. Unfortunately, these potential biases when asking for self-reports concurrent with daily life cannot be completely eliminated, as requests for self-reports will always require participants to interrupt their momentary activities.

While future research can consider these biases by involving additional, more objective indicators of flow (see section before), researchers could also use the provision of self-reports as an opportunity for providing feedback about individual flow experiences at work. For instance, future research could incorporate a smartphone-based self-tracking feature into the JITAI, enabling participants to access their flow reports. This self-tracking feature could be effective in promoting flow in two ways. First, participants could then refer to their own reports as confirmation that they do indeed experience flow at work. This may increase individuals' job satisfaction and motivation to engage in their job-related tasks again. Indeed, research on gratitude suggests that consciously recalling positive experiences is a powerful method for inducing changes in well-being (Alkozei et al., 2018; Davis et al., 2016; Geier & Morris, 2022; O'Connell et al., 2017). Access to individual flow experiences can also serve as positive feedback, thereby increasing perceived self-efficacy (Achterkamp et al., 2015; Dimotakis et al., 2017). Self-efficacy refers to an individual's belief in their ability to handle challenges (Bandura, 1977). Specific self-efficacy (i.e., the belief in one's ability to deal with a specific task) can be enhanced by providing positive feedback about task performance, thereby promoting flow in this task (Lambert & Csikszentmihalyi, 2020; Peifer et al., 2020). Wilson and Moneta (2016) found that individuals who have a higher level of confidence in their overall ability to induce flow also experience more frequent and stronger flow. Therefore, providing individuals with feedback on their flow experiences in the past may enhance their self-efficacy, thus encouraging future flow experiences. The second reason for why the self-tracking feature may be an effective tool for promoting flow is that it increases autonomy, allowing for efficient self-help. For example, the feature could highlight activities that particularly promote flow, motivating individuals to engage in certain work tasks more frequently or helping them to communicate

their strengths and task preferences to their managers. In sum, this dissertation encourages future research to provide individuals with access to individual flow reports as a promising method to stimulate awareness of flow experiences and increase individuals' autonomy and perceived self-efficacy in promoting flow.

5.2.3 Using Contextual Information to Improve Adaptivity

In the studies presented in this dissertation, each request for a self-report is limited to a small number of items to reduce invasiveness in everyday life. However, this limits the amount of information available about the individual's context at the time of providing the self-report. Contextual information may be of great interest for investigating flow-promoting interventions for two reasons. First, context may contribute to inter- and intraindividual differences in flow. For example, external factors such as social interaction, noise, or working in digital environments may affect current flow (Ruvimova et al., 2020; Schutte, 2020; Walker, 2010). Second, availability of contextual information would allow to avoid interrupting individuals who are currently unable to apply the intervention, such as during sleep. Acknowledging these contextual fluctuations is necessary to ensure consistent application of the intervention, as daily schedules vary greatly among individuals and may even differ for the same person depending on the day of the week. However, individual availability for applying the intervention is not assessed in the studies presented in this dissertation.

Enlarging the adaptivity of the JITAI to the individual's context could be a promising area for future research. Future studies could leverage the smartphone-based provision of the JITAI to track and use contextual information without increasing the intrusiveness of measurement. Smartphones have the advantage of being able to consistently collect data without requiring explicit individual input. For example, smartphones can provide information about contextual noise through built-in microphones or inform about usage through access to log data (Mahalingham et al., 2023; Padilla-Ortiz et al., 2023; Ryding & Kuss, 2020; Zamora et al., 2017). This data can then be used to improve the adaptivity of the JITAI to the individual's context. For example, researchers could access the information on smartphone usage, tracking when participants use the smartphone first in the morning. Then, they can prompt the application of the intervention only after this time to ensure that the participant is awake yet. Thereby, participants do not need to provide exact information

about their daily schedules, as suggested in Chapter 4. Instead, researchers can automatically adapt the provision of support to the individual's circadian rhythm. This enhancement of adaptivity by utilizing the built-in sensors of smartphones presents an exciting opportunity for advancing the development of flow-promoting JITAIs for everyday use.

5.2.4 Considering Further Indicators of Intervention Effectiveness

While this dissertation assesses inter- and intraindividual differences in flow intensity and frequency, it does not examine flow duration, i.e., how long participants remain in a state of flow. Even if the JITAI increases flow frequency or intensity, it may interrupt momentary flow by requesting self-reports or application of the intervention, thereby reducing the total length of flow experiences. However, longer episodes of flow may be more conducive to intrinsic motivation than shorter ones with a higher frequency (Peifer & Engeser, 2021). Importantly, Peifer and Engeser (2021) argue that targeting the longest flow duration as possible may also be detrimental, as it can lead to negative side-effects such as exhaustion or risk-taking (Schüler & Nakamura, 2013; Zimanyi & Schüler, 2021). Thus, to ensure that the JITAI does not decrease or increase flow duration excessively, it is important to gather information about changes in flow duration when applying the JITAI. Additionally, this dissertation does not consider how other work-related factors may be affected by the JITAI through its effect on flow intensity. As stated in the introduction, flow is associated with a range of positive effects relevant to work, such as enhanced performance, work engagement, creativity, and individual well-being (e.g., Demerouti et al., 2012; Engeser & Rheinberg, 2008; Weintraub et al., 2021; Zubair & Kamal, 2015). While Study 1 evaluates the association between flow reports and stress to validate the r-FKS, Study 2 neglects to consider the benefits of the JITAI-evoked increases in flow intensity. Based on Weintraub et al. (2021), our original plan for Study 2 was to collect self-reports on work performance and stress at the end of each day, in order to evaluate how the JITAI's effect on these variables was mediated by flow. However, due to the short observation period of only five days, we had severely limited statistical power to conduct mediation analyses with stress and performance as the dependent variable.[23]

[23] For these mediation analyses, the sample size on Level 1 would have been much smaller (n = 244) than in our original analyses (n = 1886, as reported in Chapter 4) because the dependent variables, stress and performance, were only assessed daily for five days in total (in contrast to flow, which was assessed multiple times per day).

Building on the aforementioned limitations, future research should evaluate potential JITAI-evoked changes in variables beyond flow intensity and frequency. Currently, research on the duration of flow episodes is still limited (Peifer & Engeser, 2021). Therefore, before assessing the effect of the JITAI on flow duration, a measurement method is required to capture this variable. For that, future studies could use the measurement methods applied in this dissertation. For example, researchers could increase the number of observations per day to estimate the duration of flow episodes based on reported presence of flow over multiple observations. As an alternative to this time-based sampling, event-based sampling of observations could be applied to reduce the burden on participants. To implement this, researchers could ask participants to provide a self-report each time they leave a state of flow and recall the length of the preceding flow episode. However, this approach has significant limitations in terms of required compliance and recall bias. In event-based sampling, participants do not receive reminders to provide self-reports, which may cause them to forget study participation, especially since flow is characterized by loss of self-consciousness (Nakamura & Csikszentmihalyi, 2012). Additionally, the distorted experience of time during flow may bias the retrospective reports of flow duration (Nakamura & Csikszentmihalyi, 2012). The results presented in Chapter 3 indicate that higher frequencies of observations, while increasing participants' burden, do not necessarily affect compliance or introduce bias into self-reports. Therefore, using time-based sampling to approximate flow duration based on reported flow presence may be preferrable compared to event-based sampling. Future research should proceed with evaluating measurement methods for flow duration and assessing the JITAI's effect on this outcome variable. To enable mediation analyses, i.e., for assessing the effect of the JITAI on other work-relevant factors mediated by its effect on flow, future research could implement follow-up evaluations of these variables. For example, the Perceived Stress Questionnaire (Fliege et al., 2005; Levenstein et al., 1993) could be used to assess stress on a monthly basis, eliminating the need for daily self-reports of this variable. This approach would reduce participants' burden while still allowing for conclusions to be drawn about the comprehensive and long-term effect of the JITAI on work-related variables.

5.2.5 Transitioning from Promoting Solitary Flow to Investigations in Teams

While flow experiences in knowledge work may be intuitively associated with solitary tasks such as writing or programming, researchers are increasingly recognizing the importance of flow in social conditions (Aubé et al., 2014; Knierim et al., 2019; Walker, 2010, 2021). For example, Demir and Seferoglu (2021) found that flow was higher in a pair programming condition than when individuals programmed alone. However, research indicates that the presence of others is not generally helpful for fostering flow. Instead, in a study comparing an open office to a shared office, Ruvimova et al. (2020) discovered that flow was higher in the solitary condition, implying that interruptions and noise may impede flow experiences when others are present. In accordance with these findings, Walker (2021) differentiates between co-active and interactive forms of social flow. Co-active flow involves flow experiences in the presence of others without actively engaging with them, while in interactive flow, activities become reciprocally synchronized so that individuals become "agents of each other's flow experiences" (Walker, 2021, p. 264). This differentiation between co-active and interactive social flow relates to the distinction between groups and teams (Fisher et al., 1997; Katzenbach & Smith, 1993). Teams are defined as a "small number of people with complementary skills who are committed to a common purpose, set of performance goals, and approach for which they hold themselves mutually accountable" (Katzenbach & Smith, 1993, p. 112). This is in contrast to groups that assign individual responsibility and lack the cohesiveness between members (Fisher et al., 1997). Therefore, the emergence of interactive flow in teams requires additional preconditions, such as a common goal, complementary and integrated skills of team members to deal with task demands, and interdependent tasks that require cooperation (van den Hout et al., 2016; Walker, 2021). Importantly, the studies in this dissertation neglect whether these preconditions were currently met when participants answered the self-reports about flow. Therefore, social and solitary flow experiences cannot not be distinguished. Additionally, the JITAI targets the individual by encouraging participants to identify work-related wishes or goals that are relevant to themselves. Although these wishes or goals may also be relevant to others with whom participants may be working, this is not assessed in Study 2.

Future research should address both of these limitations. First, future studies examining everyday knowledge work should measure the presence of the additional prerequisites

required for the emergence of interactive flow. To do so, they should first evaluate the presence of and interaction with others as indicators of whether social flow would be possible in the first place. Using conditional branching in self-reports (Messmer & Seymour, 1982), follow-up items can then be presented to comprehensively assess the preconditions for interactive flow, such as complementarity of individual skills and interdependence in current tasks (van den Hout et al., 2016; Walker, 2021). It is important to note that the presence of these preconditions does not necessarily indicate the presence of interactive flow. Therefore, it is necessary to also examine whether the momentary experience includes specific characteristics of interactive flow, such as a sense of unity and joint progress (van den Hout et al., 2016). Evaluating the preconditions and characteristics of interactive flow, in addition to those of solitary flow, would enable researchers to determine which type of flow individuals experience more frequently in their everyday work. This information may be important because individuals can profit from different types of interventions depending on whether they lack interactive or solitary flow experiences (see Chapter 2; Bartholomeyczik et al., 2023). This leads to the second potential avenue for future research. Based on the finding that using MC for individually relevant work-related wishes enhances flow (see Chapter 4), future studies should evaluate whether prompting use of MC with regard to team goals enhances collective goal commitment. Since van den Hout et al. (2016) suggest presence of a common goal as a precondition for interactive flow, fostering commitment to this goal may facilitate interactive flow. This would not only be interesting for flow research, but also for general applicability of MC since MC has so far mainly been examined in solitary contexts (for an exemption see for example Kirk et al., 2013). It is worth noting the finding by Aubé et al. (2014) that team goal commitment acts as a mediator between flow and team performance, rather than team goal commitment being an antecedent to the emergence of flow. This finding may argue against the suggested effect of MC on interactive flow through an increase in team goal commitment. Thus, future research should experimentally manipulate team goal commitment and examine how this affects flow to clarify the exact sequence of effects. In summary, transitioning from research on the individual to investigations in groups and teams appears to be a promising way to progress with research on flow-promoting interventions since everyday work rarely comes without social interactions.

5.3 Concluding Thoughts

In conclusion, this dissertation contributes to interdisciplinary research on promoting flow in everyday knowledge work by offering a holistic research agenda for developing flow-promoting interventions, methodological guidance for measuring flow in everyday life, and a concrete intervention that fulfills this purpose. Until organizations generally recognize the importance of flow and begin to apply flow-promoting interventions themselves, this intervention prompting the use of MC is a promising self-help tool for employees that does not require monetary resources, large time commitments, or managerial involvement.

To conclude this dissertation, I would like to remind the reader of Csikszentmihalyi's words that "however well-intentioned, books cannot give recipes for how to be happy" (Csikszentmihalyi, 2002, p. 5). I hope that this dissertation will inspire the reader to take matters into their own hands and actively work towards achieving a flow state in their work. I am enthusiastic that in this way each of us can have more engaging experiences at work and contribute to nourishing our mental health.

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APPENDIX

A1 Overview of Research Articles Included in this Dissertation

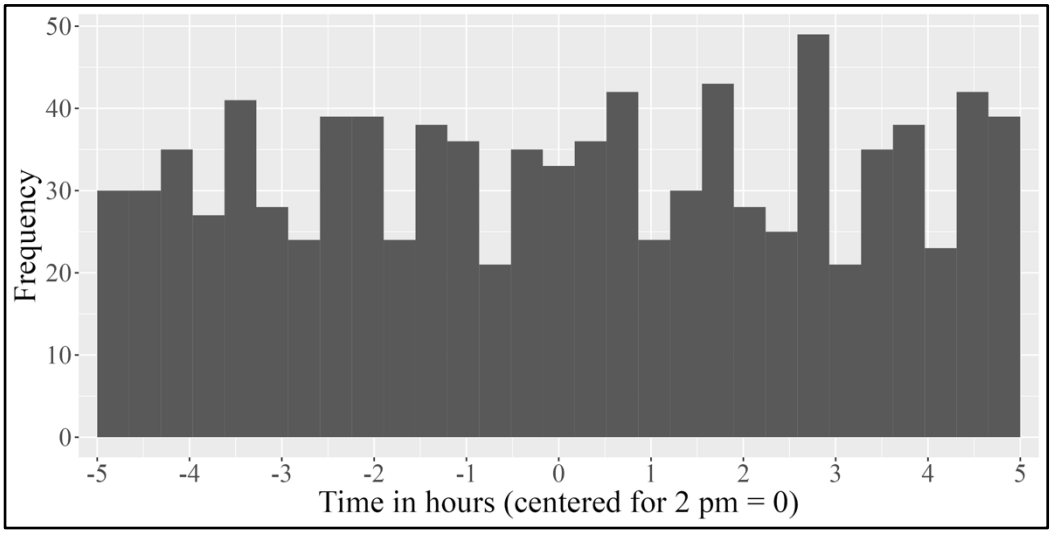
	Article 1	Article 2	Article 3
Title	Fostering flow experiences at work: A framework and research agenda for developing flow interventions	Capturing flow experiences in everyday life: A comparison of recall and momentary measurement	Using mental contrasting to promote flow experiences in knowledge work: A just-in-time adaptive intervention
Authors	Karen Bartholomeyczik, Michael T. Knierim, Christof Weinhardt	Karen Bartholomeyczik, Michael T. Knierim, Christof Weinhardt, Gabriele Oettingen, Ulrich Ebner-Priemer	Karen Bartholomeyczik, Michael T. Knierim, Christof Weinhardt, Gabriele Oettingen
Research Question	What modes of action can interventions use to promote flow in everyday knowledge work, and how can researchers determine which one to apply? (RQ 1)	What is the most informative and least invasive method of measuring flow in everyday knowledge work to evaluate and adapt a flow-promoting intervention? (RQ 2)	Can a smartphone-based JITAI that encourages the use of a metacognitive strategy promote flow in knowledge work? (RQ 3)
Type	Conceptual analysis	Experimental field study (Study 1)	Experimental field study (Study 2)
Sample/ Methods	Narrative review of literature on conceptualizing and promoting flow Development of a three-dimensional framework	AA study over 6 days *N* = 39 knowledge workers, 1442 observations	AA study over 5 days JITAI compared to non-adaptive intervention *N* = 59 knowledge workers, 2178 observations
Contributions	Provides three guiding questions for systematic development of flow-promoting interventions Sheds light on when interventions can increase duration, intensity, or frequency of flow Proposes which flow operationalization to use when evaluating the effectiveness of an intervention	Provides recommendations for choice of observation approach when measuring flow with AA Introduces a shortened flow measure to ease obtrusiveness and burden of AA Empirically evaluates whether flow can be conceptualized and measured as a yes-or-no continuous phenomenon	Introduces MC as a user-friendly and digitally applicable tool for promoting flow Highlights that a JITAI does not outperform a non-adaptive intervention in terms of short-term flow promotion

	Article 1	Article 2	Article 3
Outlets	Published in Frontiers in Psychology	Submitted to the Journal of Happiness Studies (currently R&R) Presented at the Society for Ambulatory Assessment (SAA) Conference 2023 Presented at Motivation Lab research seminar at New York University	Submitted to Computers in Human Behavior Reports Presented at the Association For Psychological Science (APS) Annual Convention 2023 Presented at Motivation Lab research seminar at New York University

A2 Supplementary Material Chapter 3

A2.1 Further Analyses of Time of Observation

A2.1.1 Distribution of Observations over Time in Momentary States Condition



A2.1.2 Influence of Day on Time of Observation in Momentary States Condition

	Estimate	(*SE*)	95 % CI [LL, UL]
Intercept	0.15	0.53	-0.90, 1.19
Day	-0.07	0.42	-0.89, 0.76

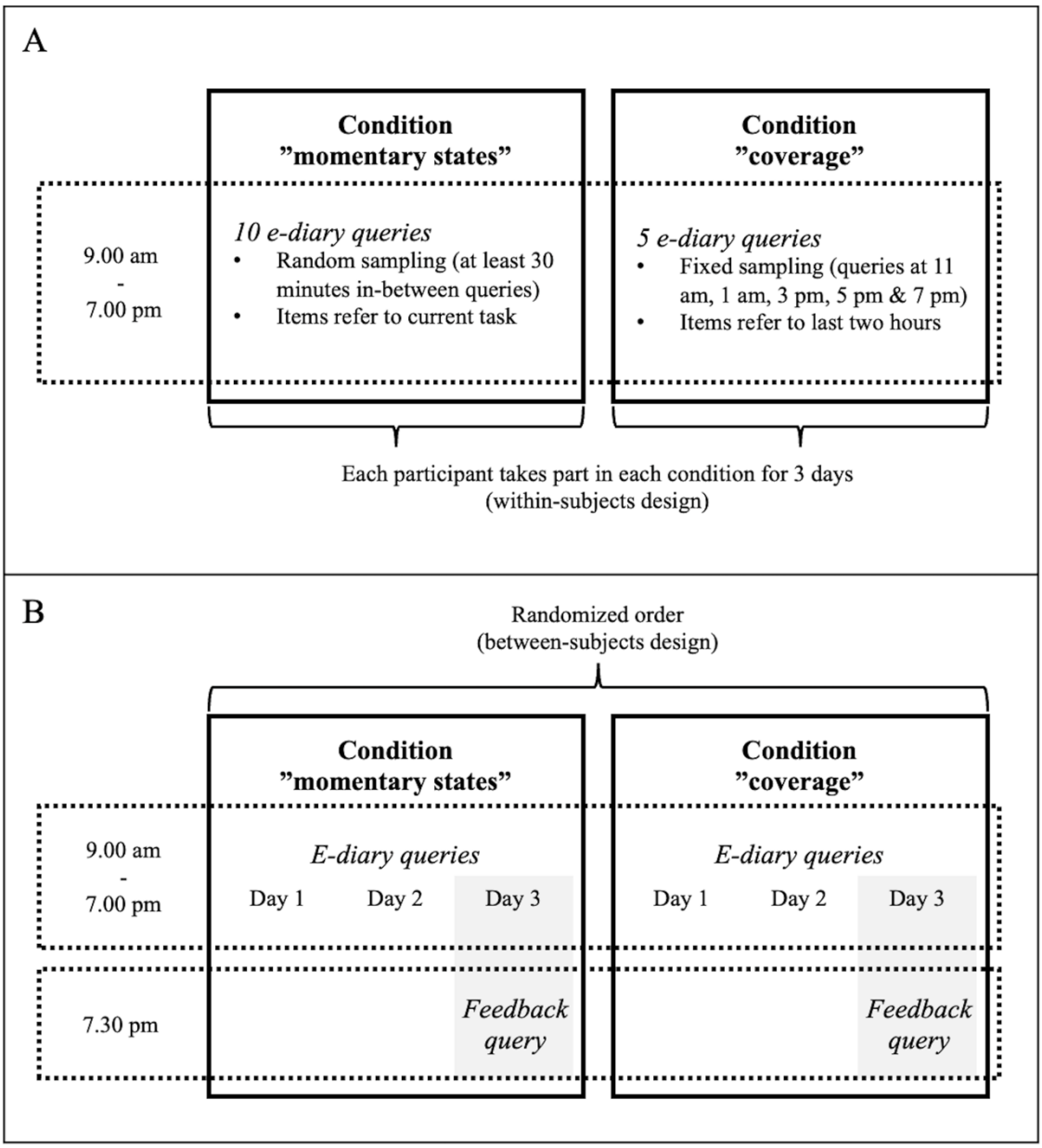
Note. Time of observation centered for middle of observation period (0 = 2 pm). Level 1: n = 955 observations; Level 2: n = 133 days, Level 3: N = 38 participants. CI = Confidence interval, LL = Lower level, UL = Upper level.

A2.1.3 Influence of Condition on Time of Observation

	Estimate	(*SE*)	95 % CI [LL, UL]
Intercept	0.09	0.13	-0.16, 0.34
Condition	0.88***	0.21	-0.46, 1.29

Note. Time of observation centered for middle of observation period (0 = 2 pm). Level 1: n = 1442 observations; Level 2: N = 38 participants. Dichotomic variable for condition (0 = momentary states, 1 = coverage). CI = Confidence interval, LL = Lower level, UL = Upper level. $^{***}p < .001$

A2.2 Visualization of (A) Differences in E-Diary Queries between Momentary States and Coverage Condition and (B) Overall Sampling Procedure



A2.3 Influence of Time on Flow Intensity (FKS) Separately for Momentary States and Coverage (Controlling for Order Effects)

	Momentary states			Coverage		
	Estimate	(*SE*)	95 % CI [LL, UL]	Estimate	(*SE*)	95 % CI [LL, UL]
Intercept	4.99***	0.19	4.62, 5.37	4.67***	0.17	4.34, 5.00
Time	-0.01	0.01	-0.02, 0.01	0.00	0.02	-0.04, 0.03
Order	-0.23	0.27	-0.78, 0.31	-0.36	0.24	-0.85, 0.13
Time x Order	0.01	0.01	-0.02, 0.03	-0.01	0.02	-0.04, 0.06

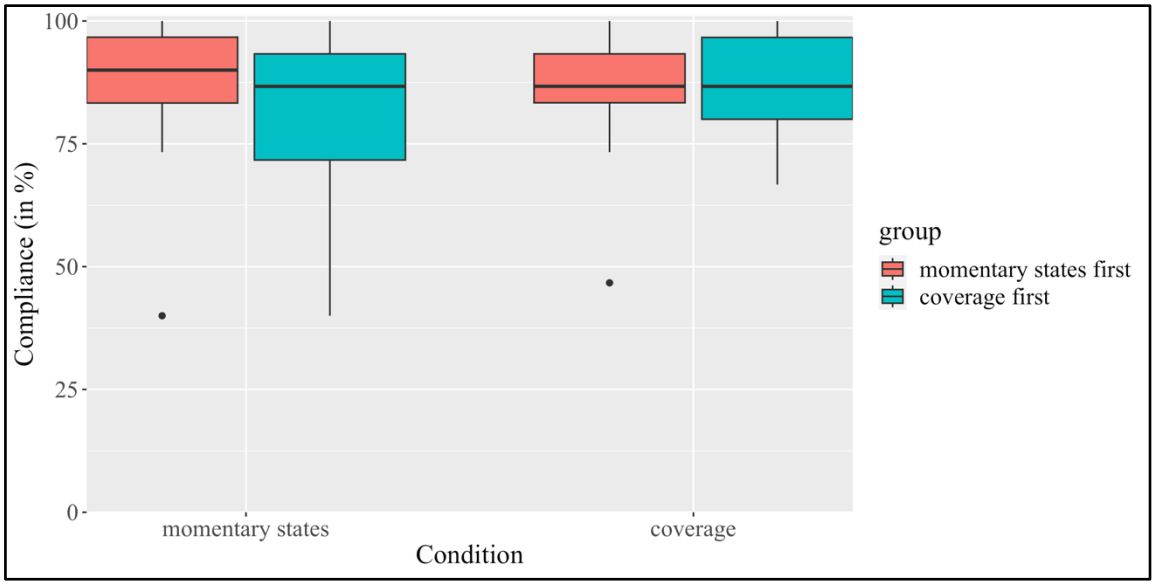
Note. Level 1: $n = 955$ observations; Level 2: $N = 38$ participants. Continuous variable for time (query number 0 to 29, ten per day, three days in total). Dichotomic variable for order of conditions (0 = group that participated in momentary states condition first, 1 = coverage condition first). CI = Confidence interval, LL = Lower level, UL = Upper level.
***$p < .001$

A2.4 Influence of Time on Flow Probability (FQ) Separately for Momentary States and Coverage (Controlling for Order Effects)

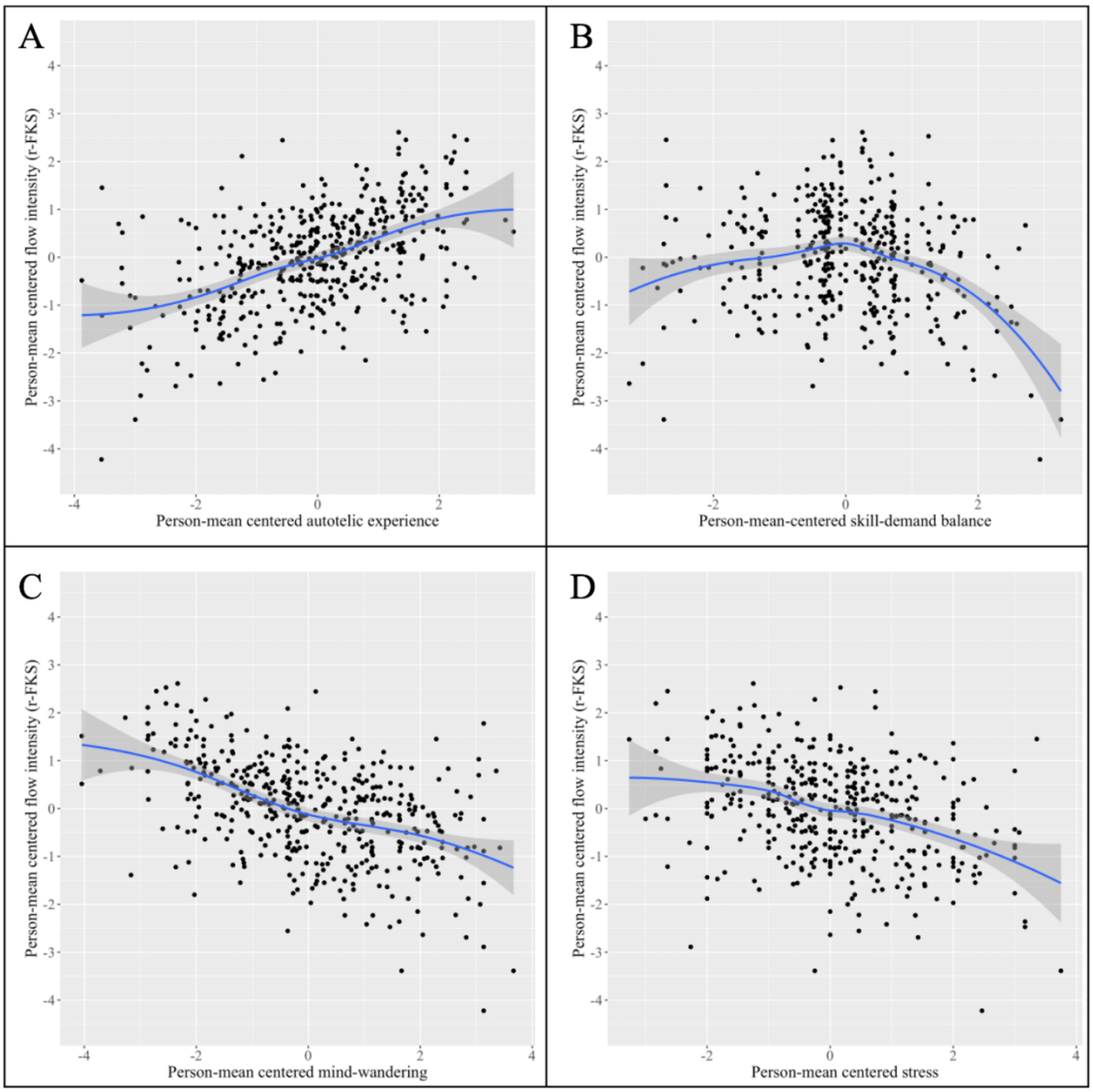
	Momentary states			Coverage[a]		
	Estimate	(*SE*)	95 % CI [LL, UL]	Estimate	(*SE*)	95 % CI [LL, UL]
Intercept	-0.47	0.29	-1.07, 0.11	1.18***	0.34	0.52, 1.87
Time	0.02	0.01	0.00, 0.05	-0.06	0.03	-0.13, 0.00
Order	-0.54	0.43	-1.45, 0.30	-1.69***	0.47	-2.65, -0.78
Time x Order	-0.04	0.02	-0.08, 0.00	0.07	0.05	-0.03, 0.16

Note. Level 1: $n = 955$ observations; Level 2: $N = 38$ participants. Continuous variable for time (query number 0 to 29, ten per day, three days in total). Dichotomic variable for order of conditions (0 = group that participated in momentary states condition first, 1 = coverage condition first). CI = Confidence interval, LL = Lower level, UL = Upper level.
***$p < .001$
[a] Due to problems with model fit, the random effect for time was not included in this model.

A2.5 Compliance (Percentage of Responses to E-diaries) Compared Between Conditions by Order



A2.6 Visualization of Association between Flow Intensity (r-FKS) and Autotelic Experience (A), Skill-Demand-Balance (B), Mind-Wandering (C), and Stress (D) in the Coverage Condition



Note. Blue lines indicate mean with confidence intervals.

A2.7 Reported Presence of Flow (FQ) as a Predictor for Absorption (FKS Factor)

	Momentary states			Coverage		
	Estimate	(*SE*)	95 % CI [LL, UL]	Estimate	(*SE*)	95 % CI [LL, UL]
Intercept	4.01***	0.15	3.71, 4.31	4.33***	0.11	4.13, 4.54
Presence_w	1.73***	0.16	1.40, 2.05	1.20***	0.14	0.93, 1.47
Presence_b	2.49***	0.56	1.36, 3.62	1.54***	0.32	0.88, 2.19
Order	0.47*	0.23	0.01, 0.92	0.09	0.16	-0.23, 0.41
Daytime	0.03*	0.01	0.00, 0.06	-0.02	0.01	-0.04, 0.01

Note. Level 1: $n_{momentary}$ = 955 observations, $n_{coverage}$ = 487 observations; Level 2: N = 38 participants. Variable for flow presence split into within- (presence_w) and between-subjects (presence_b) components. Dichotomic variable for order of conditions (0 = group that participated in momentary states condition first, 1 = coverage condition first). Centered variable for daytime (0 = middle of observation period, 2 pm). CI = Confidence interval, LL = Lower level, UL = Upper level.
*p < .05, **p < .01, ***p < .001

A2.8 Reported Presence of Flow (FQ) as a Predictor for Fluency (FKS Factor)

	Momentary states			Coverage		
	Estimate	(*SE*)	95 % CI [LL, UL]	Estimate	(*SE*)	95 % CI [LL, UL]
Intercept	4.95***	0.18	4.59, 5.30	4.65***	0.17	4.38, 4.92
Presence_w	0.11	0.13	-0.14, 0.36	0.78***	0.15	0.50, 1.07
Presence_b	1.80*	0.67	0.43, 3.16	1.04*	0.42	0.19, 1.90
Order	0.21	0.28	-0.35, 0.77	-0.03	0.21	-0.45, 0.39
Daytime	-0.01	0.01	-0.04, 0.01	-0.03	0.01	-0.05, 0.00

Note. Level 1: $n_{momentary}$ = 955 observations, $n_{coverage}$ = 487 observations; Level 2: N = 38 participants. Variable for flow presence split into within- (presence_w) and between-subjects (presence_b) components. Dichotomic variable for order of conditions (0 = group that participated in momentary states condition first, 1 = coverage condition first). Centered variable for daytime (0 = middle of observation period, 2 pm). CI = Confidence interval, LL = Lower level, UL = Upper level.
*p < .05, **p < .01, ***p < .001

A2.9 Item Overview

	Items	Answer scale	Sources
Flow[a]			
Intensity	*FKS[b]: for items, see sources*	Likert scale from "not at all" (1) to "very much" (7)	Engeser & Rheinberg (2008), Rheinberg (2015)
Presence	Do you experience flow right now?	Yes (1), No (0)	Csikszentmihalyi & Csikszentmihalyi (1988); Moneta (2012)
Flow-associated constructs[a]			
Stress	I feel stressed.	Likert scale from "not at all" (1) to "very much" (7)	Linnemann et al. (2018)
Mind-wandering	I am thinking about something other than my current activity. My mind has wandered to something other than what I am currently doing.	Likert scale from "not at all" (1) to "very much" (7)	Killingsworth & Gilbert (2010); Lambert & Csikszentmihalyi (2019); Kane et al. (2007); McVay et al. (2009)
Autotelic experience	I find my activity interesting. I find my activity exciting. I am enjoying myself.	Likert scale from "not at all" (1) to "very much" (7)	Abuhamdeh & Csikszentmihalyi (2012)
Skill-demand-balance[a]	For me personally, the task's demands are generally …	Likert scale from "too low" (1) to "too high" (7)	Engeser & Rheinberg (2008)
Task[a]	Which category does your activity belong to?	Single choice (Work, Obligations, Leisure, Other)	-
Burden	Please refer to the past three days (including today) for which you answered the alarms on this smartphone.		
Observation frequency	The number of alarms was …	Likert scale from "very low" (1) to "very high" (5)	-
Interruption of flow	The alarms interrupted my flow.	Likert scale from "never" (1) to "always" (5)	-
Interruption of work	The alarms interrupted my work.		-

Note. At the beginning of an e-diary query, participants received instructions for which reference to use. Momentary states condition: "For the following questions of this alarm, please always refer to what you were doing right before the alarm." Coverage condition: "For the following questions of this alarm, please always refer to the past two hours." Additionally, items were formulated in the fitting tense.

[a] In the coverage condition, items were formulated in the past tense.

[b] The r-FKS consisted of items 6, 8, and 9 of the original English scale (Engeser & Rheinberg, 2008; Rheinberg, 2015; highest loading items for each factor with 2:1 ratio, Rheinberg et al., 2003).

A3 Supplementary Material Chapter 4

A3.1 Written Computer-Based Instructions for Practice Session of the Intervention Type

MC Condition:

To get to know how the mental strategy works, please think about your upcoming week at work: What is the one dearest wish related to your work tasks that you would like to fulfil in the upcoming week? If you have several wishes regarding your work tasks in the upcoming week, select the one that is most important to you.
Please note your wish in a few words: XXX

What would be the best outcome of fulfilling your wish? Please note your best outcome in one or two sentences: XXX
Now take a moment and imagine this best outcome as vividly as possible in your thoughts. Please take as much time as you need to imagine it as fully as you can.
Now please write down all the thoughts and images you had regarding the best outcome: XXX

Sometimes, our wishes are not fulfilled. What is it within you that holds you back from fulfilling your wish in the upcoming week? What in you might stop you? It might be an emotion, an irrational belief, or a bad habit. Think more deeply – what is it really? Please note your main inner obstacle in one or two sentences: XXX
Now take a moment and imagine your main inner obstacle. Please take as much time as you need to imagine your main inner obstacle as fully as you can.
Now please write down all the thoughts and images you had regarding your main inner obstacle: XXX

This was the first round of learning the mental strategy. It always involves three steps:

- First, you name a wish that is challenging, but feasible.
- Second, you find the very best outcome of your wish and imagine it vividly.
- Last, you find your main inner obstacle for fulfilling your wish and imagine it vividly.

The mental strategy can be used for all areas of behavior change. To learn how to apply it with regard to different topics, please think again about your upcoming week at work:
What is the one dearest wish related to your interpersonal relations at work that you would like to fulfil in the upcoming week?
... (analogously to first learning round)

The mental strategy can be applied as often and wherever you want. Also, you do not need to write down your thoughts as long as you imagine them as vividly as possible in the sequence you have just learned (1. wish, 2. outcome, 3. obstacle). If you want to, you can close your eyes to help you with your imagination. The mental strategy can also be used for other timeframes, for example for wishes that are related to the very close future. Thereby, you can apply it on your everyday concerns (which can be as minor as for example an overdue phone call). To try this, please think about the next 24 hours. What is the one dearest wish related to your work tasks that you would like to fulfil in the next 24 hours? If you have several wishes regarding your work tasks in the next 24 hours, select the one that is most important to you. Find this one specific wish, summarize it in one or two sentences, and keep it in the front of your mind.

What would be the best outcome of fulfilling your wish? Summarize it in one or two sentences and keep it in the front of your mind.
Now take a moment and imagine this best outcome as vividly as possible in your thoughts. Please take as much time as you need to imagine it as fully as you can.

What is it within you that holds you back from fulfilling your wish in the next 24 hours? What in you might stop you? Find your main inner obstacle, summarize it in one to two sentences, and keep it in the front of your mind.
And again, take a moment and imagine your main inner obstacle. Please take as much time as you need to imagine your main inner obstacle as fully as you can.

Now, you have learned how to use the mental strategy. As you have seen, it can be applied to different timeframes and areas of behavior change.

Control Condition:

In today's session, you will learn how to set goals with regard to your work. For that, you will get to know the concept of SMART goals. This concept entails that each goal must be specific, measurable, attainable, relevant for you and time bound. For example, rather than setting the goal "I will read as many papers as possible", a specific, measurable, attainable, relevant and time bound goal would be: "I will identify 10 relevant journal articles and read two of them per day in the upcoming week." This goal is specific in that it specifically mentions prospects (reading relevant journal articles), measurable in that it mentions identifying and reading 10 articles, attainable in that it is possible to accomplish in a week, (hypothetically) relevant in that accomplishing this task would be helpful for your studies, and time bound in that it defines a particular timeframe for completion.

Now please think about your upcoming week at work.
What is a specific, measurable, attainable, relevant, and time-bound goal you would like to attain with regard to you work tasks? If you have several goals regarding your work tasks in the upcoming week, select the one that is most important to you. Please note your goal in a few words: XXX

The mental strategy can be used for all areas of behavior change. To learn how to apply it with regard to different topics, please think again about your upcoming week at work.
What is a specific, measurable, attainable, relevant and time bound goal with regard to your interpersonal relations at work you would like to attain?
Please note your goal in a few words: XXX

The mental strategy can be applied as often and wherever you want. Also, you do not need to write down your goal and you can use it for other timeframes, for example for goals that are related to the very close future. Thereby, you can apply it on your everyday concerns (which can be as minor as for example an overdue phone call). To try this, please think about the next 24 hours. What is a specific, measurable, attainable, relevant and time bound goal related to your work tasks that you would like to fulfil? If you have several goals regarding your work tasks in the next 24 hours, select the one that is most important to you.

Find this one specific goal, summarize it in a few words, and keep it in the front of your mind.

Now, you have learned how to use the mental strategy. Again, the goals should be specific, measurable, attainable, relevant, and time bound. As you have seen, the strategy can be applied to different timeframes and areas of behavior change.

A3.2 Two Excerpts of Formulated Wishes, Outcomes, and Obstacles by Participants in the Mental Contrasting Condition

Example 1:

Wish: “Study as good as possible for the upcoming statistic exam”

Outcome: “Party with friends, enjoying the summer break”

Obstacle: “going out with my girlfriend, doing fun stuff rather than focusing on the upcoming exam”

Example 2:

Wish: “finish my programming task”

Outcome: “feeling extremely relieved, …, very proud of myself ”

Obstacle: “think of myself badly (that I’m not capable of doing anything, ...)"

A3.3 Model Overview

	Levels	Fixed effects	Random effects
Model 1	Repeated observations (Level 1) within participants (Level 2)	Level 2: Intervention type, Decision rule Level 1: Skill-demand-balance, Flow proneness	Random intercept, Random slope for skill-demand-balance
Model 2	Repeated observations (Level 1) within participants (Level 2)	Level 2: Intervention type, Decision rule Level 1: Skill-demand-balance, Flow proneness Decision rule x Time, Intervention type x Time	Random intercept, Random slopes for skill-demand-balance and time
Model 3	Repeated observations (Level 1) within participants (Level 2)	Level 2: Intervention type, Decision rule Level 1: Skill-demand-balance, Flow proneness, Time, Task type Decision rule x Time, Intervention type x Time	Random intercept, Random slopes for skill-demand- balance, time, and task type
Model 4	Repeated observations (Level 1) within participants (Level 2)	Level 2: Intervention type, Decision rule, Level 1: Skill-demand-balance, Flow proneness, Time, Task type Decision rule x Time, Intervention type x Time, Decision rule x Flow proneness, Intervention type x Flow proneness, Time x Flow proneness, Decision rule x Time x Flow proneness, Intervention type x Time x Flow proneness	Random intercept, Random slopes for skill-demand- balance, time, and task type
Model 5	Repeated observations (Level 1) within participants (Level 2)	Level 2: Intervention type, Decision rule, Level 1: Skill-demand-balance, Flow proneness, Time, Task type Decision rule x Time, Intervention type x Time, Intervention type x Decision rule	Random intercept, Random slopes for skill-demand- balance, time, and task type
Model 6	Repeated observations (Level 1) within days (Level 2) within participants (Level 3)	Level 3: Intervention type, Decision rule, Level 2: Day, Prompt Level 1: Skill-demand-balance, Flow proneness Decision rule x Day, Intervention type x Day	Random intercept, Random slopes for skill-demand- balance, day, and prompt

A3.4 Results from Model 4 Including Moderating Effects of General Flow Proneness at Baseline

	Estimate	(*SE*)	95 % CI [LL, UL]
Intercept	5.21***	0.14	4.94, 5.49
Rule	-0.38*	0.16	-0.70, -0.06
Content	0.11	0.16	-0.20, 0.42
Time	0.01+	0.00	0.00, 0.01
Skill-demand-balance	-0.21***	0.04	-0.30, -0.13
Flow proneness (baseline)	0.22	0.25	-0.28, 0.70
Work	0.13	0.08	-0.03, 0.28
Rule x Time	-0.01**	0.00	-0.02, -0.01
Content x Time	0.01+	0.01	0.00, 0.02
Time x Flow proneness	0.00	0.01	-0.01, 0.01
Rule x Flow proneness	-0.31	0.23	-0.76, 0.14
Content x Flow proneness	0.18	0.21	-0.24, 0.60
Rule x Time x Flow proneness	-0.01	0.01	-0.02, 0.00
Content x Time x Flow proneness	0.00	0.01	-0.01, 0.01

Note. Level 1: n = 1886 observations over day; Level 2: N = 59 participants. Dichotomic variable for decision rule (0 = static, 1 = adaptive), intervention content (0 = control, 1 = MC) and task (0 = work, 1 = other). Time centered for end of observation period (0 = last observation). Person-mean centered variable for skill-demand-balance. Grand-mean centered variable for flow proneness at baseline. CI = Confidence interval, LL = Lower level, UL = Upper level.
$^{+}p < .10$, $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$

A3.5 Further Analyses of Changes in General Proneness to Experiencing Flow

To assess differences in general proneness to experiencing flow between baseline and follow-up over all participants independent of condition, we first computed a one-tailed t-test for paired samples (Shapiro-Wilk: $p = .073$) assuming that flow proneness would be higher after the intervention compared to baseline. To evaluate further whether this change was influenced by condition, we next computed a linear regression model with decision rule (0 = static, 1 = adaptive) and intervention type (0 = control, 1 = MC) as predictors for the difference in flow proneness from baseline to follow-up. We included mean-centered flow proneness at baseline as a covariate in the model.

In line with our expectation, mean flow proneness was higher at follow-up compared to baseline over all participants ($M_{Difference} = 0.27$, $SD_{Difference} = 0.63$). A one-tailed t-test for paired samples (Shapiro-Wilk: $p = .073$) confirmed significantly higher flow proneness at follow-up compared to baseline independent of conditions, $t(57) = 3.31$, $p = .001$. In contrast to what we expected, the regression analysis revealed no significant effect of the decision rule ($\beta = -0.12$, $SE = 0.16$, $p = .457$) and the intervention type ($\beta = -0.20$, $SE = 0.15$, $p = .197$) on difference in flow proneness between baseline and follow-up when controlling for flow proneness at baseline ($\beta = -0.33$, $SE = 0.10$, $p = .002$). We exploratively computed an additional linear regression model including a two-way interaction between decision rule and intervention type. However, this model did not fit the data better than the original model (original: $R^2_{adj.} = 0.17$, including interaction: $R^2_{adj.} = 0.16$; $F(1, 0.12) = 0.35$, $p = .557$) and indicated no significant interaction between type and rule ($\beta = -0.18$, $SE = 0.30$, $p = .557$).

A3.6 Descriptive Statistics of Variables Assessed in Feedback Questionnaire Compared Between Intervention Type (M = MC, C = Control)

	M_{Total} (*SD*)	M_M (SD_M)	M_C (SD_C)
Satisfaction with strategy			
Use again	3.19 (0.95)	3.00 (1.02)	3.39 (0.83)
Recommend to a friend	3.00 (1.03)	2.73 (1.05)	3.29 (0.94)
Strategy use[a]	65.5 %	50.0 % yes	82.1 % yes
Goal fulfillment[a]	60.3 %	50.0 % yes	71.4 % yes

Note. $N = 58$ participants, $n = 30$ for MC and $n = 28$ for control. Items for satisfaction with strategy were rated on a five-point Likert scale from completely disagree (0) to completely agree (4). Strategy use and goal fulfillment were reported on single-choice items with 0 indicating "No" and 1 indicating "Yes".

[a] Proportion of "Yes" responses reported instead of mean scores and standard deviations due to the dichotomic variables

A3.7 Descriptive Statistics for the Time Spent with the Morning Prompt in Seconds (A) and Model Results for the Influence of the Decision Rule and Intervention Type on Time Spent with the Morning Prompt in Seconds (B)

A	*M*	*SD*
Decision rule		
Static	37	46
Adaptive	37	42
Groups		
Control-static	18	24
MC-static	55	55
Control-adaptive	16	20
MC-adaptive	59	48

B	Estimate	(*SE*)	95 % CI [LL, UL]
Intercept	30.97***	7.25	5.00, 5.62
Rule	0.50	7.30	-0.76, -0.12
Type	38.69***	7.26	-0.19, 0.12
Day	-7.09***	1.79	0.01, 0.16

Note. Observations excluded if no prompt received on that day or no reply to prompt. Level 1: $n = 231$ observations; Level 2: $N = 57$ participants. Dichotomic variable for decision rule (0 = static, 1 = adaptive) and intervention type (0 = control, 1 = MC). Day centered for beginning of observation period (0 = first day, Monday). CI = Confidence interval, LL = Lower level, UL = Upper level. $^{***}p < .001$

A3.8 Results from Model 6

	Estimate	(*SE*)	95 % CI [LL, UL]
Intercept	5.32***	0.15	5.00, 5.62
Rule	-0.43**	0.16	-0.76, -0.12
Type	0.10	0.15	-0.19, 0.43
Day	0.06+	0.03	-0.01, 0.13
Prompt	-0.09	0.10	-0.27, 0.10
Skill-demand-balance	-0.22***	0.05	-0.29, -0.12
Flow proneness (baseline)	0.26**	0.08	0.12, 0.44
Rule x Day	-0.17***	0.04	-0.23, -0.08
Type x Day	0.08+	0.04	0.01, 0.16

Note. Observations from adaptive condition for days when prompt was provided because no answer to tailoring variable was given in the preceding evening were excluded (exclusions only for adaptive condition since prompt was provided every morning independent of tailoring variable in static condition). Level 1: $n = 1635$ observations over day; Level 2: $n = 267$ daily observations, Level 3: $N = 59$ participants. Dichotomic variable for decision rule (0 = static, 1 = adaptive), intervention type (0 = control, 1 = MC), and prompt (0 = no, 1 = yes). Day centered for end of observation period (0 = last day). Person-mean centered variable for skill-demand-balance. Grand-mean centered variable for flow proneness at baseline. Model includes random effects for all Level 1 variables. CI = Confidence interval, LL = Lower level, UL = Upper level. $^{+}p < .10$, $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$

A3.9 Item Overview

	Items	Answer scale	Source
Flow			
Proneness	*FKS (full ten item version)* *Answered with regard to general experiences at work* *For items, see source information*	Likert scale from "not at all" (1) to "very much" (7)	Engeser & Rheinberg (2008), Rheinberg (2015)
State	*FKS (reduced three item version)* *Answered with regard to momentary experience* *Items 6, 8, and 9 of the original English scale* *(for items, see source information)*		
Daily flow	Have you experienced flow today?	Yes, more than once (2); Yes, once (1); No (0)	Csikszentmihalyi & Csikszentmihalyi (1988)
Skill-demand-balance	For me personally, the task's demands are generally …	Likert scale from "too low" (1) to "too high" (7)	Engeser & Rheinberg (2008)
Task	Which category does your activity belong to?	Single choice (Work, Obligations, Leisure, Other)	-
Feedback			
Satisfaction	I will use the strategy again.	Likert scale from "completely disagree" (0) to "completely agree" (4)	-
Goal fulfillment	Have you fulfilled all the wishes/goals that you formulated yet?	Yes (1), No (0)	-